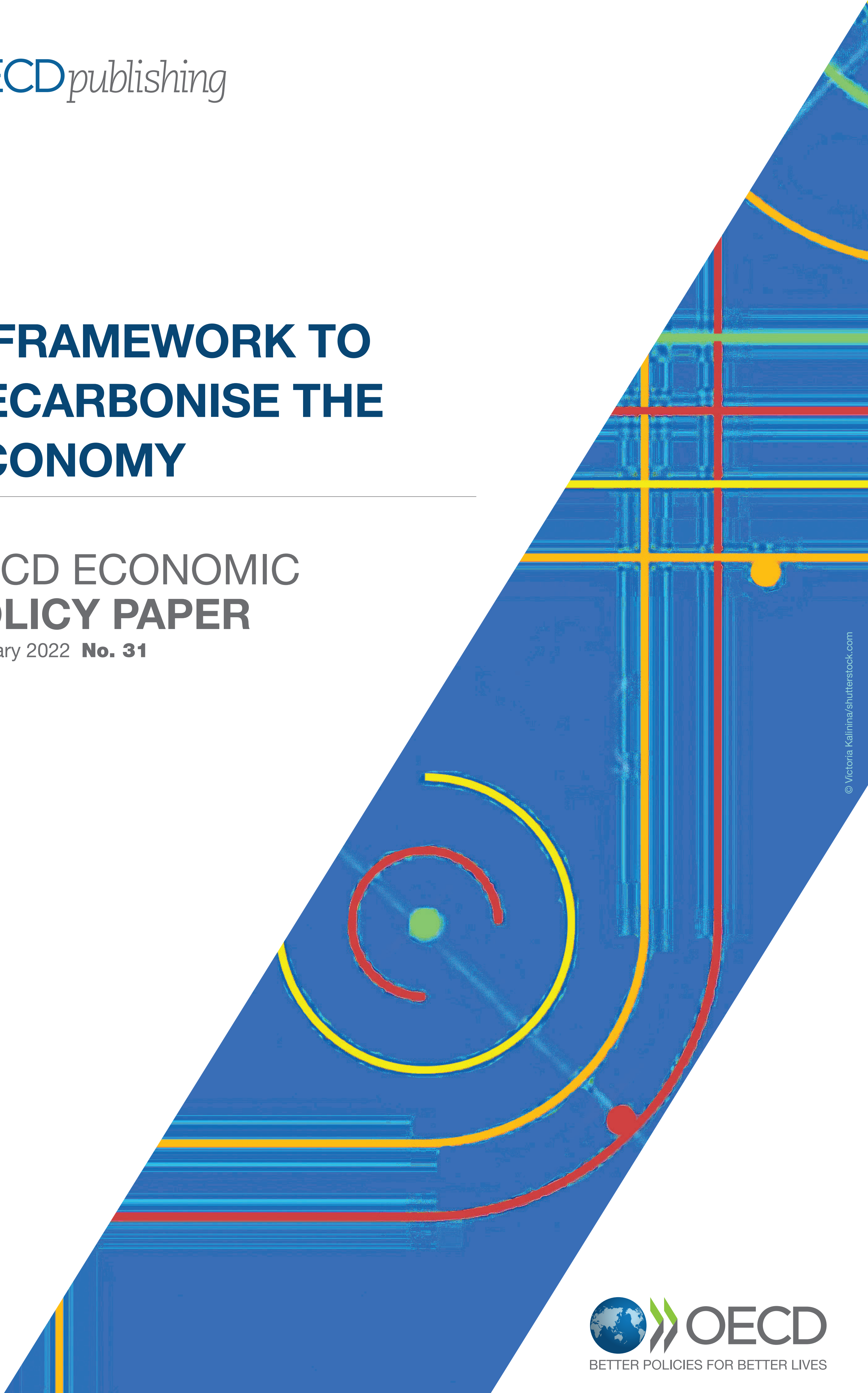
OECD*publishing*

A FRAMEWORK TO DECARBONISE THE ECONOMY

OECD ECONOMIC
POLICY PAPER
February 2022 **No. 31**



OECD
BETTER POLICIES FOR BETTER LIVES

Economic Policy Paper No. 31

A FRAMEWORK TO DECARBONISE THE ECONOMY

Designing and monitoring strategies to achieve climate change targets while boosting growth and social cohesion

This paper has been prepared by:
Filippo Maria D'Arcangelo
Ilai Levin
Alessia Pagani
Mauro Pisu
Åsa Johansson

Authorised for publication by Luiz de Mello
Director, Policy Studies Branch, Economics Department

OECD

A previous version of this paper was released on February 4, 2022. This version updates the following: Page 9 (footnote 1), Page 10 (Figure 1), Page 28 (Figure 14).

Series: *OECD Economic Policy Papers*

ISSN 2226583X

This policy paper has been prepared under the framework of the OECD Horizontal Project on Climate and Economic Resilience. An earlier version was discussed at a meeting of Working Party No.1 (WP1) of the OECD Economic Policy Committee. The authors would like to thank the meeting participants, as well as Laurence Boone, Luiz de Mello, Alain de Serres, Douglas Sutherland, Jon Pareliussen, Zuzana Smidova, Kurt Van Dender and Sirini Jeudy-Hugo for comments on earlier versions of the paper; Tomasz Koźluk and Assia Elgouacem for their early contributions to the paper; Agnès Cavaciuti for her help with data, figures, and graphs; Antonin Tavernier for contributing to Boxes 6, 11, 18 and 21 and Mathilde Sonne for contributing to Box 8; OECD Country Desks for their valuable feedback and insights; and Michelle Ortiz, Dacil Kurzweg and Sarah Michelson Sarfati for excellent editorial assistance.

Table of contents

Tables

Figures

Boxes

Abstract/Résumé

A framework to decarbonise the economy: Designing and monitoring strategies to achieve climate change targets while boosting growth and social cohesion

Global progress towards tackling climate change is lagging. This paper puts forward a framework to design comprehensive decarbonisation strategies while promoting growth and social inclusion. It first highlights the need of evaluating a country's national climate targets and current policy mix, in conjunction with facilitating monitoring tools to assess current and future progress, as a key step to design effective decarbonisation strategies. It then provides a detailed comparison of several policy instruments across different assessment criteria, which indicates that no single instrument is clearly superior to all others. This highlights the need for developing decarbonisation strategies based on a wide policy mix consisting of three main components: 1) emission pricing policy instruments; 2) standards and regulations; 3) complementary policies to facilitate the reallocation of capital, labour and innovation towards low-carbon activities and to offset the adverse distributional effects of reducing emissions. However, there is no one-size-fits-all policy mix, as feasible policy choices depend on countries' industrial structure, social preferences and political constraints. A robust and independent institutional framework, stakeholders engagement and credible communication campaigns are key to managing these constraints and ultimately enhancing public acceptance of climate mitigation policies.

Keywords: Climate change, growth and inclusion, mitigation policies, emission pricing, green standards and regulations, green R&D and innovation, green investments, political economy of climate policy

JEL Classification: H54, P48, Q42, Q52, Q54, Q55, Q58

****

Un cadre pour la décarbonation de l'économie : concevoir et suivre des stratégies pour atteindre les objectifs climatiques tout en stimulant la croissance et la cohésion sociale

L'action mondiale face au changement climatique est à la traîne. Ce document propose un cadre pour concevoir des stratégies globales de décarbonation tout en promouvant la croissance et l'inclusion sociale. Il commence par montrer qu'une étape essentielle pour assurer l'efficacité de ces stratégies consiste pour chaque pays à évaluer ses objectifs climatiques et mesures en vigueur, et à favoriser parallèlement des outils de suivi pour apprécier les progrès actuels et futurs. Il établit ensuite une comparaison détaillée de plusieurs moyens d'action à l'aune de différents critères d'évaluation, de laquelle il ressort qu'aucun d'eux n'est clairement supérieur aux autres. Ce constat souligne la nécessité d'asseoir les stratégies de décarbonation sur une large panoplie de mesures comportant trois grands volets : 1) les instruments de tarification des émissions ; 2) les normes et règlements ; et 3) des politiques complémentaires pour faciliter le redéploiement du capital, du travail et de l'innovation dans les activités bas carbone et pour compenser les effets redistributifs défavorables de la réduction des émissions. Il n'existe toutefois pas une panoplie de mesures universellement applicable : les solutions réalisables dépendent de la structure industrielle, des préférences sociales et des contraintes politiques de chaque pays. Un cadre institutionnel solide et indépendant, la mobilisation des parties prenantes et des campagnes de communication crédibles sont autant de facteurs essentiels pour gérer ces contraintes et, au bout du compte, rendre les politiques de lutte contre le changement climatique plus acceptables aux yeux de l'opinion publique.

Mots-clés : changement climatique, croissance et inclusion, politiques d'atténuation, tarification des émissions, normes et réglementations vertes, R-D verte et éco-innovation, investissements verts, économie politique de l'action climatique

Classification JEL : H54, P48, Q42, Q52, Q54, Q55, Q58

Main findings

Global emissions continue to rise and are inconsistent with limiting the rise in global temperature to 2°C and avoiding catastrophic consequences of climate change. Reversing these trends and reaching climate neutrality by mid-century, in line with the 2015 Paris Agreement's goal of limiting global warming to well below 2°C compared to pre-industrial levels, will demand deep transformations of economies and societies. Meeting this epochal challenge requires the development and implementation of long-term, country-specific decarbonisation strategies going well beyond narrow environmental matters and encompassing economic, social, innovation, and fiscal policies to drive transformational change.

Drawing from past and ongoing OECD work, academic evidence, and numerous country examples, this paper provides a framework for designing and implementing country-specific decarbonisation strategies. Such strategies need to be comprehensive, cost-effective and inclusive:

- **Progress towards climate change mitigation targets is heterogeneous across countries but lagging overall.** Slow progress towards national targets is a symptom of uncoordinated and inconsistent policies, timid and delayed implementation, and structural impediments, including low public acceptability of effective policy instruments (e.g. carbon tax).
- Establishing transparent and participative institutions and governance frameworks would facilitate the design and implementation of decarbonisation strategies and bolster public acceptability. Developing data and indicators comparable across countries taking into account the past, present, and future trends in emissions would allow for a more systematic evaluation of countries' performance and monitor progress. International benchmarking efforts, such as those proposed by the OECD International Programme for Action on Climate, provide a useful platform in this direction.
- **Cost-effective and inclusive decarbonisation strategies cover numerous policy areas.** No single policy instrument clearly dominates the others across all desirable assessment criteria (emission reductions at minimum economic cost, low administrative complexity, strong incentives to spur innovation, predictability and ability to deal with uncertainty, progressive distributional effects, public acceptability).
- A well-designed and comprehensive policy mix should combine emission pricing, standards and regulations and enabling complementary policies (including innovation support mechanisms, infrastructure investment, and others to offset adverse distributional effects and help people in transition). Such a policy mix can exploit synergies and manage trade-offs among policy instruments, thus enhancing overall cost-effectiveness and strengthening public acceptability.
- Emission pricing and standards and regulations can complement each other, enhancing the cost-effectiveness of decarbonisation strategies. Emission pricing provides incentives to decarbonise while providing flexibility to do so, and it can accelerate the deployment of low-carbon technologies and products, by providing clear price signals. Standards and regulations can encourage or mandate technology adoption, as well as provide incentives to reduce emissions when firms and individuals are unresponsive to price signals.
- Enabling complementary policies are key to support the transition to a low-carbon economy:
    - *Redistributive policies*, such as cash transfers and progressive tax shifts, can offset the regressive effects of mitigation policies, where these disproportionally affect low-skill workers and low-income households, while building social and political support for decarbonisation policy packages.

  - *Labour market and reskilling policies* are key to supporting workers in transition, reducing the decarbonisation impact on jobs in emission-intensive industries and regions, while helping low-carbon firms and sectors to hire and expand.
  - *Policies encouraging the development and adoption of green technologies* can complement those enhancing business dynamism thus supporting the emergence and adoption of promising low-carbon technologies, including those that are still far from the commercialisation stage.
  - *Long-term infrastructure planning and public investment* can crowd-in private capital to upgrade infrastructure networks, especially the transport and electricity networks. Adopting a more precise and consistent definition of a 'green' project, strengthening the regulatory environment for securitised/structured products, and clarifying the relationship between fiduciary duty and duty of care, can facilitate green infrastructure investment by unlocking capital managed by institutional investors.
- **Public acceptability factors should be an integral part of the policy package design**. This requires narrowing knowledge and information gaps, engaging with stakeholders and interest groups transparently in the design of climate policy packages, and addressing perceptions of distributional fairness.

A framework to decarbonise the economy: Designing and monitoring strategies to achieve climate change targets while boosting growth and social cohesion

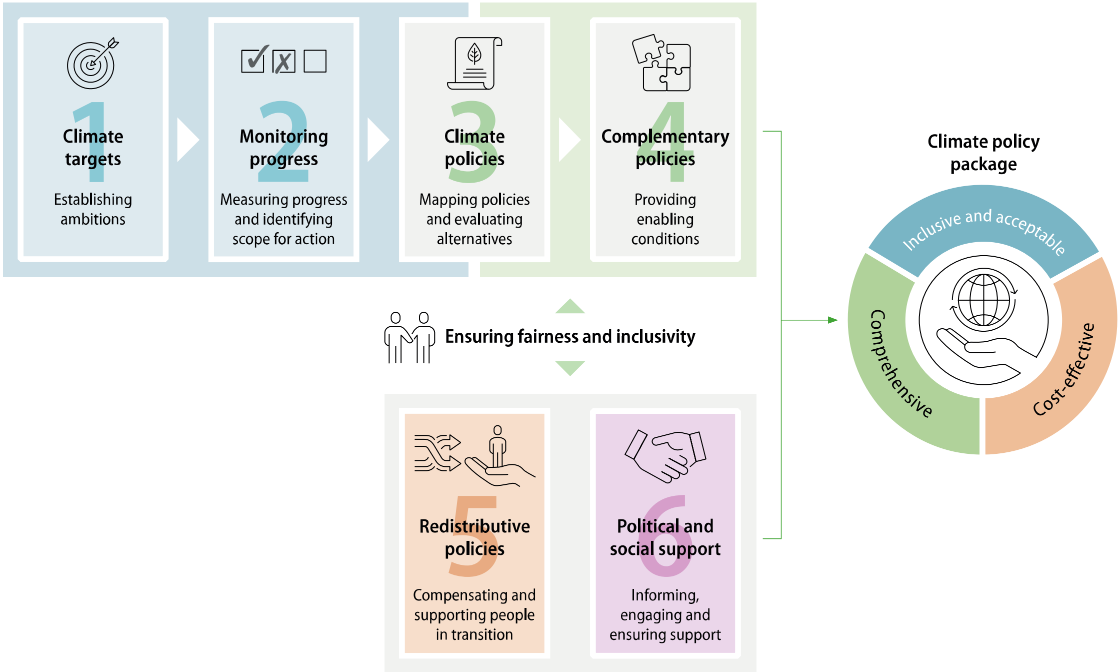
1. Climate change action is currently on top of political agendas in many countries, pushed by the increasing recognition of global warming as a planetary emergency. Following the 2015 Paris Agreement, many countries have announced ambitious targets to reduce GHG emissions, including reaching net-zero emissions in 2050 and intermediate targets in 2030-40 (Jeudy-Hugo, Lo Re and Falduto, 2021[1]). However, such national targets are still inadequate to put global emissions on a downward path before 2030 (UNFCCC, 2021[2]). Global emissions would need to decline on average by over 7% per year in the ten years to 2030 to reach emission levels that are consistent with limiting the increase in global temperature to 1.5 C compared with pre-industrial levels (United Nations Environment Programme, 2019[3]).

2. Building on previous and ongoing OECD work, relevant academic evidence, and several country examples, this paper provides a framework for designing and implementing decarbonisation strategies while considering broader economic and social issues. The aim is to provide country desks of the Economics Department with key elements to deepen the analysis and integrate recommendations on climate change mitigation in OECD Economic Country Surveys. The analysis does not deal with adaptation policies as it squarely aims at helping countries to meet their emission reduction targets in a cost-effective and socially acceptable way. However, properly designed mitigation policies can strengthen adaptation to climate change, such as with forest and mangrove restorations, which increase carbon sequestration while reducing risks due to landslides or coastal storms (OECD, 2021[4]).

3. The methodological framework consists of a series of steps to design country-specific decarbonisation strategies and monitor efforts (Figure 1). The steps are organised in two main stages: i) a 'diagnostic' stage to identify priority areas; ii) an 'action' stage to devise and evaluate concrete policy interventions. The paper provides the main elements of each step to understand and assess the main concepts. The online Annex provides further technical details.[1] The final objective is to develop decarbonisation strategies that are comprehensive, cost-effective, inclusive and socially acceptable.

[1] The online Annex is available on the OECD webpage of *A Framework to Decarbonise the Economy* (at https://www.oecd.org/economy/greeneco/framework-to-decarbonise-the-economy/).

Figure 1. A methodological framework to design country-specific decarbonisation strategies



4. The paper highlights that insufficient progress towards climate change targets is attributable to uncoordinated and inconsistent policies, timid and delayed implementation, and structural impediments, including low public acceptability of effective policy instruments. The promising experience of some countries that have made more progress so far, such as Denmark and the Netherlands, points at the importance of transparent governance and trusted institutions. However, the lack of detailed comparable data and indicators on emissions and discrepancies in how countries define emission targets make comparisons difficult. International benchmarking efforts, such as the OECD International Programme for Action on Climate, provide a useful platform to ameliorate reporting and to systematically evaluate countries' performance vis-à-vis targets. The paper draws from this and other OECD efforts to measure countries performance and policies, providing a background for policy recommendations.

5. Policymakers have at their disposal a large array of policy instruments to encourage emission reductions, such as carbon taxes, renewable portfolio standards, performance standards, feebates and others (de Serres, Murtin and Nicoletti, 2010[5]). The analysis shows that no single policy instrument dominates the others across the desirable assessment criteria considered. Effective and socially acceptable decarbonisation strategies need to limit costs for firms and households (i.e. low abatement costs), be manageable from an administrative perspective (i.e. low administrative costs), encourage the development and deployment of new technologies (i.e. spurring innovation), contribute to wider socio-economic objectives including Sustainable Development Goals (SDGs) and not increase poverty and inequality.

6. Several trade-offs emerge between these objectives. For instance, emission pricing schemes lower the economic cost of reducing emissions, but they often face strong opposition (in the case of carbon taxes) or are administratively complex (in the case of emission trading schemes). Performance standards and input requirements can help to bring the necessary technologies to maturity and coordinate their adoption but risk picking winning technologies and imposing high costs on some firms and households.

7. This calls for a comprehensive policy mix encompassing different policy instruments (Stiglitz et al., 2017[6]), falling into three broad categories: 1) emission pricing and other incentive-based instruments; 2) regulations and standards; and 3) enabling complementary economic, social and fiscal policies. Deploying several policy instruments in a coordinated manner would allow for exploiting synergies and managing trade-offs, thus enhancing the overall cost-effectiveness of decarbonisation strategies and bolstering their inclusiveness and public acceptability (Stiglitz, 2019[7]; OECD, 2015[8]).

8. High and uniform emission pricing is a cost-effective way to reduce emissions (Baumol and Oates, 1971[9]; Goulder and Parry, 2008[10]). However, its implementation may be difficult (Aldy and Stavins, 2012[11]) due to strong public opposition, and it might be ineffective when firms and households do not respond much to price signals (e.g. in electricity consumption) (Weber and Johnson, 2011[12]), and it can entail high administrative costs when emission monitoring is difficult (e.g. in agriculture). Moreover, emission pricing is not as effective as subsidies in addressing coordination failures in innovation and licensing, especially in basic research, thus limiting knowledge spillovers and technological developments (Popp, 2019[13]).

9. Standards and regulations, such as performance standards, generally entail higher emission-reduction costs than emission pricing. However, if properly designed, they can lower uncertainty and accelerate the development and deployment of clean technologies. Where firms and households respond little to price signals, standards and regulations can complement emission pricing, and in some cases substitute it altogether. For instance, they can be particularly effective in restricting and phasing out, over a precise period, high-emitting activities or technologies for which alternative technical solutions exist.

10. Enabling complementary policies are key to supporting decarbonisation efforts and reduce their social cost, thus bolstering public acceptance. Structural policies in various areas are necessary to support those households and workers whose income and jobs are negatively affected by mitigation policies, alleviating adverse distributional effects. The late-2021 spike in energy prices is a reminder of the importance of such policies to ensure energy affordability while continuing to decarbonise energy systems (Boone and Elgouacem, 2021[14]). Policies that encourage innovation and the upgrade of network infrastructures enable the emergence and adoption of promising low-carbon technologies, including those that are still far from the commercialisation stage, especially in the electricity and transportation sectors. In parallel, policy design should integrate public acceptability considerations by increasing knowledge and providing accurate information, engaging with stakeholders and interest groups in a transparent manner, and addressing perceptions of distributional (un-)fairness.

1. Taking stock of the national climate targets

1.1. National climate targets reflect country differences in economic structures and social preferences

11. By agreeing to the Paris Agreement in December 2015, most OECD and key partner countries have committed to the collective goal of limiting global temperature rise to “well below 2°C and as close as possible to 1.5°C relative to pre-industrial levels” (Paris Agreement, 2015[15]). Achieving this target implies reaching global carbon neutrality by mid-21st century, with parallel deep reductions in other GHG emissions, such as methane (IPCC, 2021[16]).

12. To reach net-zero in 2050, many countries have set specific intermediate national targets, most of which feed into their nationally determined contributions within the Paris Agreement (Box 1; Table C.1, Annex). For example, the 2021 EU Climate Law introduces a binding commitment to reduce EU-wide GHG emissions by 55% in 2030 relative to 1990, whereas the Effort Sharing Regulation sets country-specific binding targets (Table C.2, Annex). The United States has announced a reduction target of 50% by 2030 relative to 2005. Some countries such as Germany, Sweden and the EU have

also committed to achieve negative emissions after reaching net-zero targets (Jeudy-Hugo, Lo Re and Falduto, 2021[1]).

Box 1. The Paris Agreement cycle and its cooperation mechanisms

The Paris Agreement prescribes that each country "prepares, communicates and maintains successive nationally determined contributions" (NDCs) to reduce global emissions. Under the agreement, countries agree to submit updated NDCs every five years and undergo an assessment process (Feedback Mechanism). In year one, the UNFCCC Secretariat prepares a synthesis report of the newly submitted NDCs ahead of the annual Conference of the Parties (COP). The Feedback Mechanism includes a Global Stocktake of collective efforts to take place in 2023, as well as the review of individual progress according to codified procedures every two years, starting with the 2022-2024 cycle (Enhanced Transparency Framework).

To facilitate the attainment of NDCs, the Paris Agreement (Article 6) envisages international cooperation mechanisms to transfer mitigation outcomes internationally and to promote capacity building, technology transfer and financial support, especially towards developing countries, including the use of carbon credits generated under the Kyoto Protocol and partially carried-over at the COP26 in Glasgow.

13. Some countries have included emission-reduction targets into law while in many others they are in national policy documents. Setting legally binding emission-reduction targets is a way to enforce these targets, strengthen policy signals and translate climate change ambitions into policy action. In many countries the gap between intermediate targets and the 2050 goal of carbon neutrality is large. The recent pronouncement of Germany's Constitutional Court highlights the importance of including climate change targets into laws.[2] Setting legally binding targets can strengthen government accountability, as seen by the increasing number of climate change litigation cases in recent years. As of June 2021, 194 countries have included such targets into law (Table 1 below).

14. National targets are also a gauge of countries' ambitions and their commitments *vis-à-vis* their current policy settings. National targets differ along several dimensions, such as the emission reductions level (Figure 2), conditionality, time-horizon, and whether they are binding or have strong enforcement mechanisms. Though almost all countries have clear, quantifiable, numerical targets (measured against a base year or in terms of the absolute level of emissions in the target year), they differ in the way they are stated (Table C.1. Annex).[3] The 2021 COP in Glasgow encouraged all parties to submit five-year pledges every five years.

15. Some targets include conditional elements aimed at supporting developing countries, such as access to financial resources, technology transfer, technical cooperation and capacity-building (UNFCCC, 2021[2]). In order to help countries to achieve such conditional targets, it is important to strengthen international cooperation and ensure that development aid is consistent with the goals of the Paris agreement (OECD, 2019[17]). Climate finance towards developing countries is rising but in

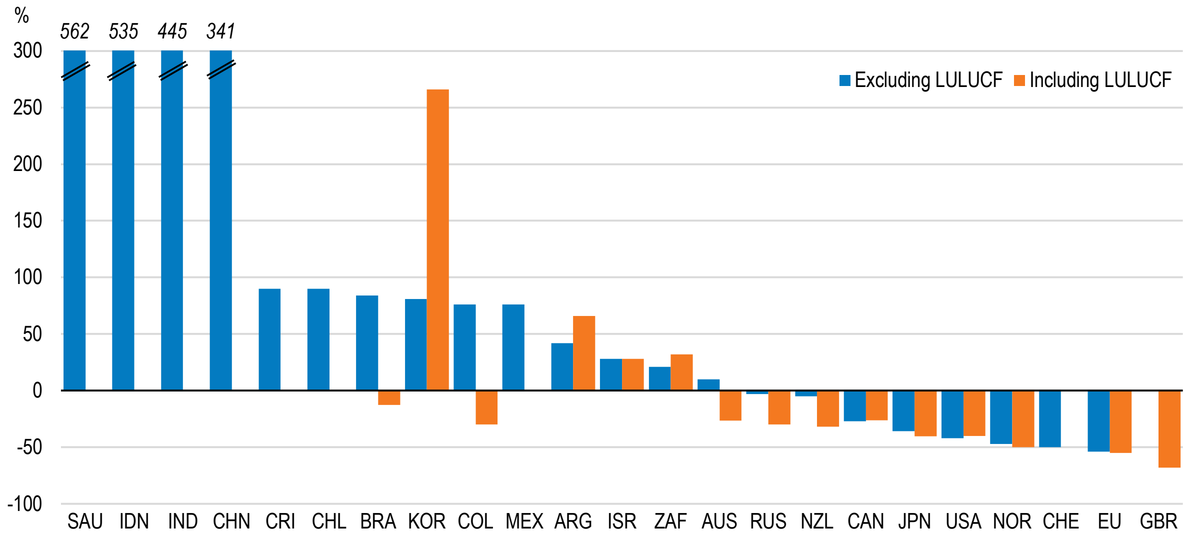
[2] In May 2021 Germany's Constitutional Court ruled that the 2030 target included in the 2019 Climate Law (reduction of GHG emission by 55% with respect the 1990 level) was insufficient to reach carbon neutrality by 2050. Following this the government has raised the 2030 GHG reduction target to 65%. A similar case is provided by the Netherlands, where in 2015 the government was ordered by the Hague Court to increase emissions reduction ambition from -17% to -25% with respect to 1900 by 2020, after being sued by the Urgenda Foundation and a group of 900 citizens.

[3] The Paris Agreement does not set any standard or criteria on how to define and report emission reduction targets.

2019 it still was 20% below the goal of mobilising USD 100 billion a year by 2020 (UNFCCC, 2009[18]; OECD, 2021[19]).

Figure 2. Intermediate GHG emission-reduction targets vary greatly across countries

% change in emissions consistent with achieving 2030 emission target levels



Note: Values are calculated from unconditional 2030 emissions targets (expressed as relative to 1990 emission levels), as expressed in the updated Nationally Determined Contributions (NDCs) submissions. For countries that do not report official targets excluding land use, land use change, and forestry (LULUCF), the blue bars show estimates by Climate Action Tracker. Countries whose official targets include LULUCF are: ARG, AUS, BRA, CAN, COL, CRI, EU, GBR, ISR, JPN, KOR, NOR, NZL, RUS, USA, ZAF. Countries whose official targets exclude LULUCF are: CHE, CHL. Other calculation methods: CHN, IDN, IND, SAU. Israel target is expressed relative to 2015 level. SAU target is conditional. How to read this chart: Australia has pledged to reduce emissions (relative to their 1990 level) including LULUCF by 26.6% in 2030; excluding LULUCF, Australia 2030 target is estimated by Climate Action Tracker to be equal to a 10% emission increase.
Source: Climate Action Tracker (https://climateactiontracker.org/) and UNFCCC NDC Registry (https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx).

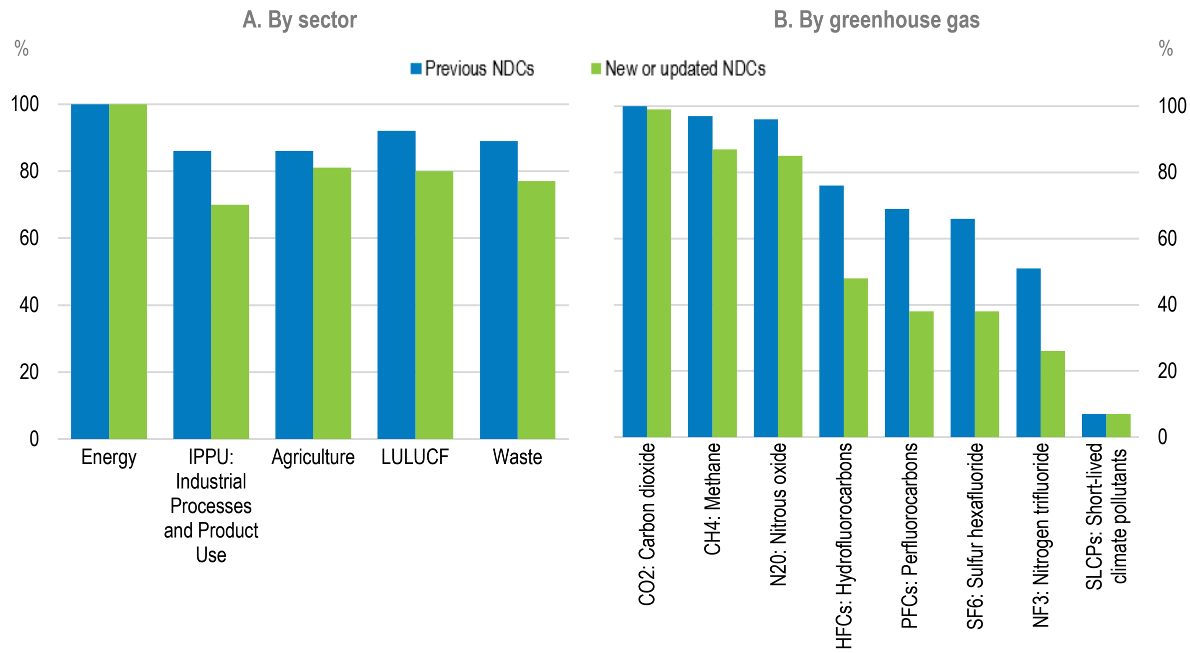
1.2. Sectoral and sub-national targets complement national ones

16. Collecting national targets requires taking into consideration sectoral goals and others that are specific to the different greenhouse gasses, such as hydrofluorocarbons and methane. A clear breakdown of targets by sector and type of GHGs can facilitate the design of specific climate change mitigation strategies as emissions vary greatly across sectors and types of greenhouse gases. However, badly designed sectoral targets might raise the cost of decarbonisation for the whole economy. Many factors, such as lobbying and limited knowledge on sectoral abatement costs and their evolution over time, can lead to set sectoral emission targets that are far from the least costly combination.

17. Countries are also progressively increasing the coverage of sectors and GHGs in their targets (UNFCCC, 2021[2]). As of July 2021, targets cover 93.1% of countries' total GHG emissions in 2019, as gases other than CO_2 are fairly covered in NDCs (Figure 3) (UNFCCC, 2021[2]). The Global methane pledge announced at the 2021 COP in Glasgow asks countries to cut their methane emissions by 30% over 2020-30. Targets cover only emissions produced within the borders, so they do not account for emissions generated abroad as a result of consumption in the country, nor those produced by maritime and air transport.

Figure 3. Sectoral and emission-specific goals are common in both rounds of nationally determined contributions (NDCs) submission

Share of countries covering specific sectors and GHGs in their NDCs



Note: Data in green refer to the incomplete second round of NDCs submission as of July 2021.
Source: NDCs synthesis report by the UNFCCC Secretariat, September, 17th 2021.

18. Several voluntary agreements at various sub-national levels, including initiatives by the Covenant of Mayors, also complement national targets. As of 2020, 826 cities worldwide have set net-zero targets, and 4500 non-state actors have already joined the “Race to Zero” campaign to accelerate the transition to net-zero (Jeudy-Hugo, Lo Re and Falduto, 2021[1]).

19. The majority of countries and parties have set sectoral goals (Table 1), with energy, transport and agriculture (including also Land Use, Land Use Change, and Forestry) being the most covered sectors (UNFCCC, 2021[2]). Examples of targets specific to the energy sector include minimum renewables share, a reduction in the coal share, power system performances (losses, smart grids, metering, and storage). Industry targets can cover circular economy objectives as waste recycling, electrification, and emission intensities for production processes. Agriculture targets may include limits to emissions from synthetic fertilisers or increasing the forest stock volume. Residential sector targets can concern waste reduction and targets on building efficiency. Transport targets can include goals for electric vehicles and bans on internal combustion engines. At the 2021 COP in Glasgow, 130 countries committed to halt and reverse forest loss and land degradation by 2030.

Table 1. Most targeted sectors within the Paris Agreement and national laws

Sector	% of countries setting sectoral targets within the Paris Agreement (out of 196)	% of countries with sectoral climate change mitigation national laws (out of 194)	% of OECD countries with sectoral climate change mitigation national laws
Power Generation	89%	71%	100%
Industry	39%	31%	55%
Agriculture/Land[1]	67% / 75%	38%	53%
Buildings (residential and commercial)	72%	21%	66%
Transports	80%	54%	92%

Note: Includes all LULUCF (Land use, land use change, and forestry) activities. Source: NDCs synthesis report by the UNFCCC Secretariat, September, 17th 2021 (https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf); Climate Change Laws of the World (https://climate-laws.org).

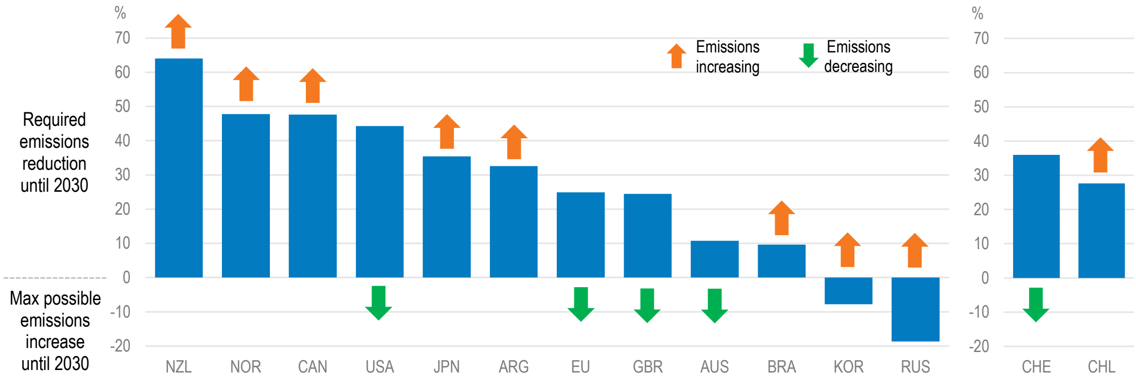
2. Monitoring progress towards national climate targets

2.1. Progress towards climate change targets is lagging

20. Most countries are still far from their intermediate targets and overall the world's GHG-emission trajectory is not yet in line with reaching carbon neutrality by 2050 (Figure 4). Some large emitters, such as the United States and the European Union, are gradually progressing (though at different paces) towards their intermediate targets (as shown by the green arrows in Figure 4). In many emerging economies, such as Brazil and Russia, emissions are have not yet reached their expected peak (as shown by the orange arrows), unlike the majority of advanced economies, which are already past their peak. Many emerging economies have set a year or a time frame when their emissions will peak. Overall, to achieve intermediate targets in the next 10 years countries will have to reduce emissions or restrain their increase to a much larger extent than they did over the past 30 years. Beyond intermediate targets, achieving the net-zero target by 2050 will require significant additional efforts in terms of emission reductions, removals and offsets (Figure 5, Figure 6) and further technological developments (IEA, 2021[20]).

Figure 4. All countries will need to improve climate performance to meet their 2030 targets

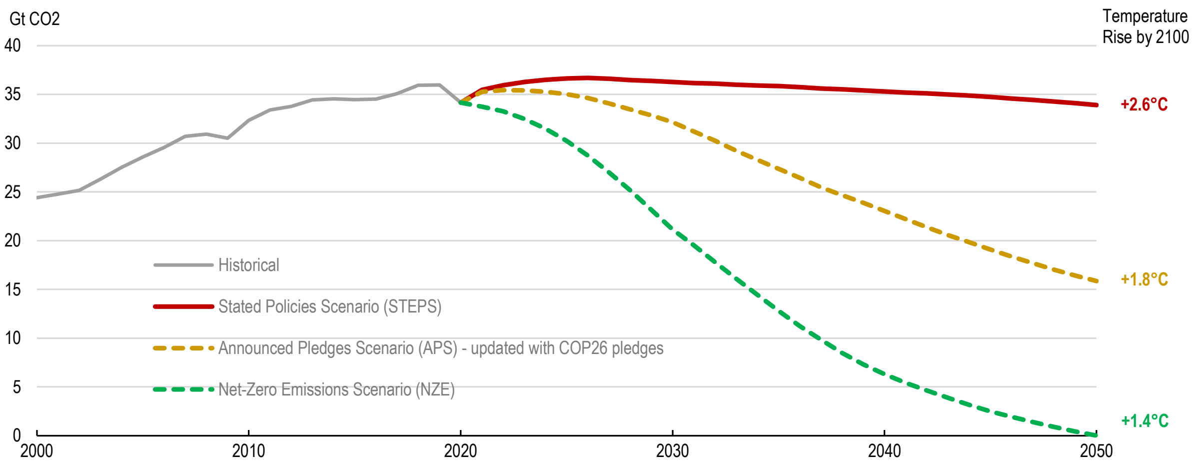
Percentage point differences between 2019 (or latest available year) emissions and the 2030 estimated targets, selected OECD and partner countries



Note: Orange arrows (upwards) identify countries whose emissions are increasing and green arrows (downwards) identify countries whose emissions are decreasing in the last 10 years. The figures represented by the blue bars are calculated as the percentage point differences between the level of emissions in 2019 or latest available year (ARG: 2012; BRA, CHL, KOR: 2016, MEX: 2013) and targeted level of emissions in 2030 (expressed with respect to the 1990 level). A positive blue bar shows the minimum required emission reduction for the country to meet its stated 2030 target. A negative blue bar shows the maximum possible increase in emissions for the country to meet its stated 2030 targets. For example, for the EU there is a 25 percentage point difference between the 2019 emission level and the 2030 estimated targets (height of blue bar). This results from the difference between the stated target of reducing emissions by 55% by 2030 relative to the 1990 level and the 30% reduction in emissions already achieved between 1990 and 2019. **Left panel**: Emissions and targets include land use, land-use change and forestry (LULUCF). **Right panel**: Emissions and targets exclude LULUCF.
Source: Calculations based on UNFCCC National Inventory Submissions.

Figure 5. The world's GHG emissions are not in line with net-zero by 2050

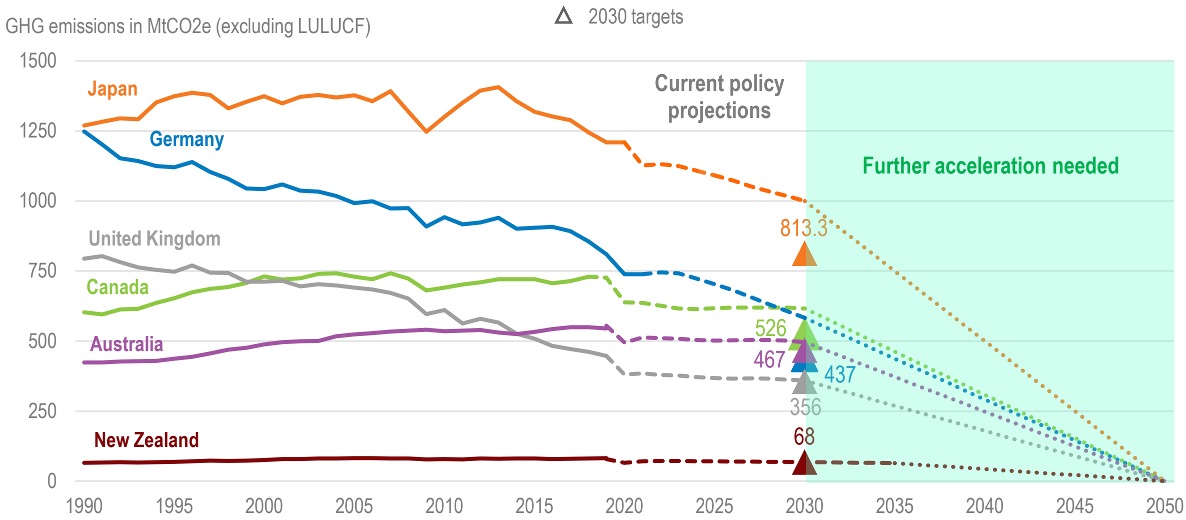
Scenarios of CO2 emissions over time (2000-2050) and respective expected temperature rise by 2100



Note: The Announced Pledges Scenario (APS) is updated with COP26 pledges as of November 3rd, 2021; The Net-zero Emissions Scenario (NZE) shows the global energy-related emission pathway developed by the IEA where technology, investments and policies are deployed in line with the objective of reaching net-zero emissions by 2050. Expected temperature rises by 2100 are relative to pre-industrial levels, and are subject to an upward risk due to uncertainties in the estimate and possible future changes in policy.
Source: IEA (2021[21]; 2021[22]; 2021[23]).

Figure 6. Decarbonisation requires a drastic acceleration in performance

GHG emissions (excluding land use, land-use change and forestry) in selected countries



Note: Solid lines represent past GHG emissions excluding land use, land-use change and forestry (LULUCF) in million tonnes of CO_2; dashed lines are post-covid current-policy scenario extrapolations estimated by Climate Action Tracker (average of 'min' and 'max' estimates); triangles represent NDCs or national targets at 2030; dotted lines are interpolations to zero GHG emissions in 2050, including carbon capture, but excluding LULUCF. In the presence of negative contribution of LULUCF to emissions, the gross-zero scenario considered here is more ambitious than net-zero, and less ambitious if LULUCF emissions are positive.
Source: OECD calculations based on data from Climate Action Tracker.

2.2. Indicators to measure climate-related performance

21. A systematic and regular assessment of countries' progress towards climate change mitigation targets is key to identifying laggards and leaders and spreading best practices. Such an assessment requires the following:

- Collecting past emission trends and current performances using economy-wide indicators, such as GHG emissions and emission intensity, and comparing such trends across countries and national targets;
- Collecting and comparing sectoral indicators to assess critical areas of underperformance and best practices;
- Extrapolating trajectories under separate scenarios, e.g. building on the IEA's World Energy Outlook or the OECD Environmental Outlook to 2050. The Climate Action Tracker[4] provides policy scenarios based on current policies that can inform such assessments (Figure 6);
- Identifying the main areas of economic and technological uncertainty and their potential impact on emissions.

22. Benchmarking countries progress towards climate change mitigation targets hinges on a suite of reliable and timely indicators. The OECD, together with the IEA and ITF, are at the forefront of collecting and processing such data (Table 2). The recently established International Programme for Action on Climate (IPAC) plans to build on these data repositories and sets of indicators (e.g. Environment at a Glance, Green Growth Indicators, Core Set of Environmental Indicators) to assess countries' progress towards climate change mitigation targets (OECD, 2021[24]).

[4] https://climateactiontracker.org/

Table 2. An inventory of OECD emission indicators

Indicator	Disaggregation	Source	Name of database	Time coverage	Countries	DOI
GHG emissions and emission intensities	By source By gas	UNFCC; OECD/ENV	Air and climate: Greenhouse gas emissions by source	1990 onwards	OECD and other G20	10.1787/data-00594-en
GHG emissions by industry	By industry By gas	OECD/ENV	Air and climate: Air and greenhouse gas emissions by industry	2000 onwards	EU + few others	10.1787/data-00735-en
CO_2 emissions from fuel combustion and CO_2 emission intensities	By product/fuel By industry	IEA	IEA CO_2 Emissions from Fuel Combustion Statistics	1960 onwards	186 countries, including all OECD	10.1787/CO2-data-en
GHG emissions from fuel combustion	By gas	IEA	Emissions of CO_2, CH4, N2O, HFCs, PFCs and SF6	1990 onwards	143 countries, including all OECD	10.1787/data-00431-en
CO_2 demand-based emissions (carbon footprint)	By industry	OECD/STI	Carbon dioxide emissions embodied in international trade	2005-2015	OECD + G20 + other countries	OECD.Stat
CO_2 emissions from transport	Mode of transport	ITF	Transport performance indicators	2000 onwards	54 countries, including all OECD	10.1787/2122fa17-en

Note: Further OECD indicators are collected and discussed in OECD (2021), "Climate change", in *Environment at a Glance Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/5584ad47-en.
Source: OECD.

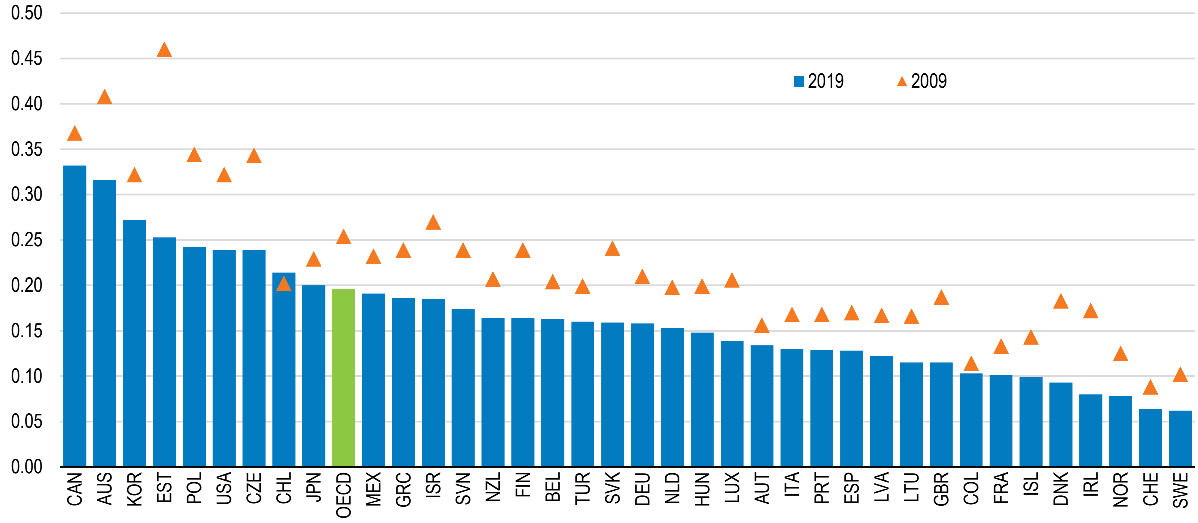
2.2.1. Economy-wide indicators

23. Total GHG emissions and GHG emission intensity (emissions per unit of GDP or per capita) are the two most salient indicators. Total GHG emissions are expressed in CO_2-equivalent (CO_2e) metric tons as they also include the contribution of GHG gases other than CO_2 such as methane (CH_4), nitrous oxide (N_2O), and others.[5] There are large differences in emission intensities across countries (Figure 7). These differences largely reflect pre-existing conditions (e.g. domestic endowment of fossil fuels) and past policy choices. The large reductions in emission intensity that occurred in several countries between 2009 and 2019 highlight that major improvements are possible, although some of these reductions might be the result of displacing emissions to trade partners.

[5] These gases are important as they have strong greenhouse effects. Methane (a gas produced mainly from natural gas and oil systems, livestock, landfills and agriculture) is 25 times more efficient than CO_2 in trapping radiation over a century (despite having a lifetime in the atmosphere of only 12 years against centuries for CO_2). Nitrous oxide (emitted mostly from agriculture and land use) is a greenhouse gas 300 times more powerful than CO_2.

Figure 7. There are large differences in carbon emission intensities across OECD countries

CO_2 per unit of GDP in PPP ($kgCO_2$ per 2015 USD PPP)



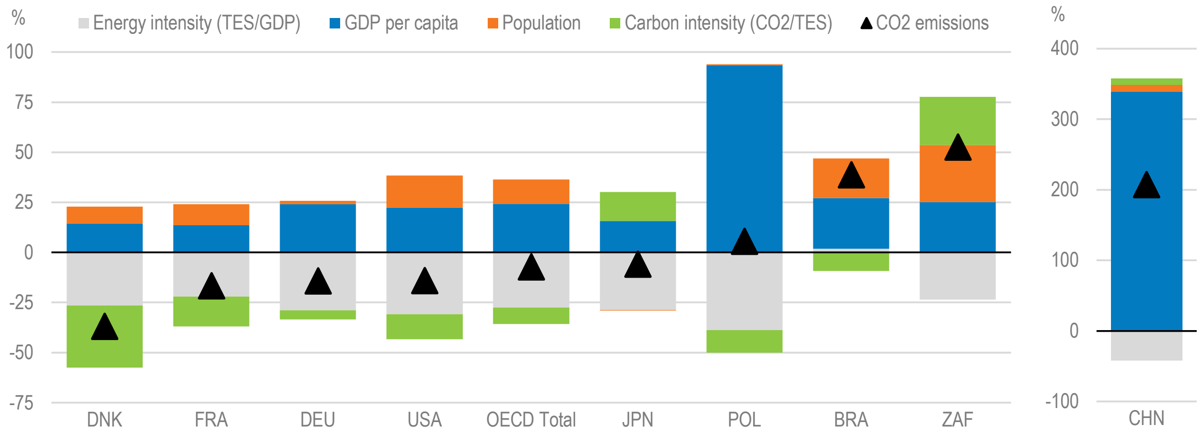
Source: IEA, CO_2 Emissions from Fuel Combustion Statistics.

24. In countries such as Germany, Japan, and the United States, the decoupling of CO_2 emissions from economic activity (i.e. lowering emission intensity) has so far been achieved by reducing energy intensity (grey bar in Figure 8). In some emerging economies, such as China and South Africa, the reduction in emissions due to lower energy intensity has been more than offset by increases attributable to GDP growth (blue bar in Figure 8) and population growth (orange bar). Further reductions in energy intensity, while desirable and achievable, will be insufficient to put emissions on a path to reach net-zero targets.

25. Reaching net-zero will require a drastic reduction in emission intensity through transformative changes of energy and production systems. Some countries, such as Denmark, are on the right path, although still far from their targets (Box 2). For instance, investments in long-lived GHG-emitting capital need to decline or stop, as in the case of coal power plants (IEA, 2021[20]). Increasing the share of non-fossil energy sources in the energy mix and lowering the GHG emissions of production activities, such as agriculture, steel and cement production is key to realising such transformative changes. Some sectors have made more progress than others. For instance, in many countries the share of non-fossil energy sources in electricity generation has increased drastically over the past few years and continues to increase. In the transport sector, instead, combustion engines still play a dominant role, with the share of electric vehicles and other low-emission modes of transport rising but still small. In addition, realistic alternatives to combustion engines in maritime, aviation and freight transport have yet to be developed (IEA, 2021[20]). Likewise, the decarbonisation of steel and cement production requires significant technological innovation.

Figure 8. Reductions in energy intensity will not suffice to lower emissions

Drivers of CO_2 emissions for selected countries, % change over 2000-18



Note: TES is total energy supplied. Emissions are disaggregated into the contribution of population growth, GDP per capita growth, energy intensity (energy per unit of GDP) and emission intensity of energy (emissions per unit of energy) or Total emissions = Population × (GDP / Population) × (Total energy consumption / GDP) × (Total emissions / Total energy consumption). GDP is expressed in PPP. The sum of (positive and negative) components is approximately equal to the variation in CO_2 emissions. See Ang (2004[25]) for details on these decompositions.
Source: IEA, CO_2 Emissions from Fuel Combustion Statistics Database.

Box 2. Effective combination of governance and policy choices support Denmark's decarbonisation performance

By 2018, Denmark succeeded in cutting its emissions by 30% relative to 1990 and currently has one the lowest carbon intensities among OECD countries. While much ground still needs to be covered for Denmark toward net-zero emissions, its frontrunner performance is due to a strategy that combines good governance and policy choices. Some ingredients of success include:

- **A comprehensive policy mix**: Denmark complements emission pricing policies (a carbon tax of DKK 178.5 per ton of CO_2 on transport fuel and non-district heating, excise taxes on fuel, and the EU ETS), with several regulatory measures such as a ban on new fossil fuel explorations by 2050 and on all new fossil fuel cars by 2035. Moreover, the government has used public investment to expand the network and quality of infrastructures and to encourage R&D. For example, it heavily invested in the Danish Green Investment Fund, an independent state loan fund that offers risk capital to promote green innovation.
- **Stakeholder involvement**: For example, business-government climate partnerships were developed in thirteen sectors and with private actors like the cement producer Aalborg Portland, along with an advisory citizen assembly with 99 randomly chosen members to increase grassroots support.
- **Targeted policies to attract private investments**: R&D funding, streamlined planning processes, subsidies and ambitious national targets for renewables have contributed to significant reductions in the costs of renewables and increases in private investments in green technologies. For example, the world's first offshore wind farm was realized in Denmark thanks to significant subsidies and increasing public funding peaking at DKK 618 million in 2013.

- **Framework policies that favour labour reallocation**: a system based on 'flexicurity' ensures mobility between jobs while providing a comprehensive safety net for the unemployed and strong active labour market policies. At the same time, the strong involvement of trade unions and the private sector in skill development is key to support workers' transition to low-carbon jobs.
- **Intermediate ambitious and quantifiable targets**: the new Climate Law voted in December 2020 steps up ambition through a legal commitment to climate neutrality by 2050 and a 70% reduction of GHG emissions in 2030 relative to 1990 levels. In May, a trans-partisan agreement also set a 50-54% intermediate target for 2025.

Source: OECD (2021[26]).

2.2.2. Sectoral indicators

26. Sectoral indicators provide further information on the areas in which there is the largest potential for further emission cuts. Table 3 provides an overview of selected indicators that can help to measure and monitor progress on intermediate sectoral milestones and identify policy gaps.

Table 3. Potential sectoral indicators that can be used to track performance

Sector	Milestones to meet net-zero	Potential indicators
Energy industry	Electricity should increasingly be generated by low- and zero-carbon sources and substitute other energy sources, for example in heating (residential furnaces) and transport (combustion engines).	• Renewables penetration • Coal share in energy mix • Power system performance (e.g. losses, outages, voltage drops)
Manufacturing and industry	Energy and material intensity of manufacturing should decrease. Production processes, especially of cement, steel, plastic, ceramics, and aluminium must be decarbonised.	• Electrification rates • Adoption of best available techniques • Circular economy indicators (e.g. share of recycled waste) • Penetration of new technologies (e.g. green hydrogen and carbon capture)
Transportation	Domestic vehicles use should be more efficient and progressively substituted by non-carbon transport modes. Airplanes, trucks and ships must become less carbon-intensive.	• Size, age and performance (e.g. CO2 per km) of fleet • Electric and alternative-vehicles penetration • Availability of shared mobility options • Long-distance freight/shipping performance
Residential use and buildings	Efficient (new or retrofitted) buildings are necessary to keep energy demand low.	• Performance of buildings (age, heat insulation, energy performance) • Low-carbon heating and cooling (e.g. heat pumps, solar water heating) • Automation and control systems • Efficient lighting and appliances
Agriculture, forestry and land use	Agriculture should become sustainable while satisfying increasing food demand. LULUCF sequestration can play a large role in meeting net-zero targets.	• Incidence of sustainable crop selection and animal farm practices • Fertilisers and nitrate incidence • Afforestation/reforestation and land use • Food loss and diet patterns

Source: OECD.

27. A country's sectoral structure is one of the major determinants of where and how emissions are generated. In all countries, combusting fossil fuels and biomass to produce energy is by far the largest source of GHG emissions (Figure 9). The share of emissions due to electricity production is considerably larger in countries such as Japan, Korea and Poland than in France, Switzerland or Ireland on account of their high reliance on fossil fuels in electricity production.[6]

28. Other main sources of emissions include manufacturing industries, transport, and the residential sector. Agriculture and animal farming entail specific challenges to decarbonisation (Box 3) but are an important source of non-energy emissions only in some countries, such as Ireland (OECD, 2021[27]) and New Zealand (OECD, 2017[28]). Emissions from manufacturing processes, generated for example in the production of cement, steel, and plastic, are a major concern in countries specialising in these sectors.

29. In most OECD countries, land use, land-use change and forestry (LULUCF) often makes a negative contribution to GHG emissions, reflecting the 'carbon sink' effect (i.e. the capacity to absorb and store carbon from the atmosphere). On average across OECD countries, LULUCF sequesters about 10% of GHG emissions (Figure 9). In some countries, its contribution is much larger. LULUCF sequesters more than 30% of emissions generated by other sectors in New Zealand, Norway and Sweden, nearly 20% in the Slovak Republic, and about 5% in Australia. In some other countries, LULUCF is a net-contributor to emissions because of agriculture (such as in Ireland, the Netherlands and Denmark) and deforestation (such as in Brazil).

30. Australia provides a good example of an advanced emission-monitoring system, covering also LULUCF, which is updated on a quarterly basis as part of Australia's National Greenhouse Accounts (Australian Government Department of Industry, Science, Energy and Resources, 2021[29]). For LULUCF, Australia integrates spatial data on key disturbance events such as forest planting and land clearing, derived from satellite imagery and processed by an independent agency, with a carbon cycling ecosystem model (FullCAM) that is continuously updated based on the latest empirical science and data.[7] FullCAM estimates carbon stock changes and LULUCF greenhouse gas emissions across Australia. Estimates of forest loss and land clearing, at a national and regional basis, and by land use type, are also updated and published every year through this system.

31. LULUCF is an area where synergies between climate mitigation and adaptation policies are especially strong and well-designed climate mitigation strategies should aim at exploiting such synergies. For instance, crop varieties with higher drought and pest resistance, and efficient nitrogen use and soil management can lower GHG emissions by reducing energy consumption for irrigation and improve soil quality while enhancing resilience to droughts and floods. Forest conservation and rehabilitation can increase carbon sequestration and lower risks relating to floods and landslides (OECD, 2021[4]).

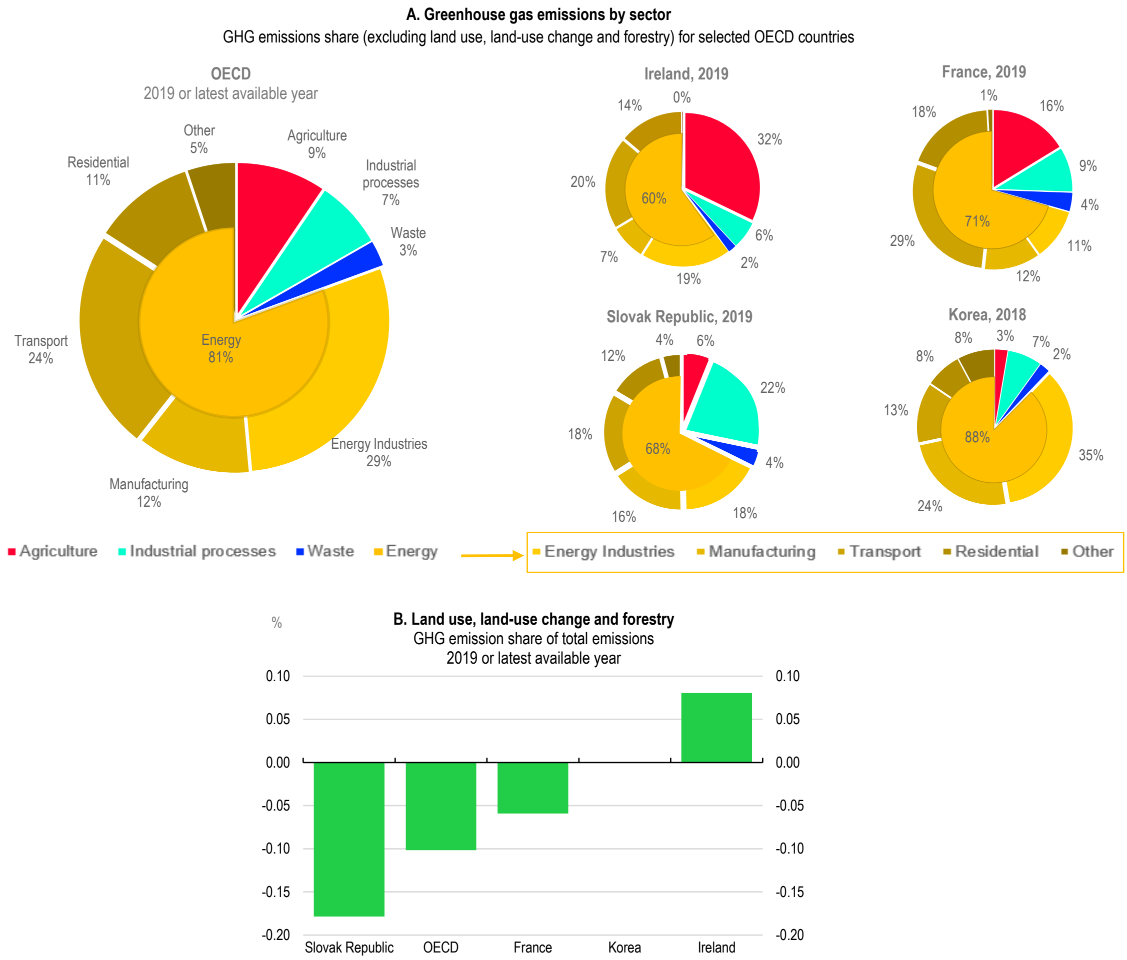
---

[6] The Annex provides charts similar to Figure 9 covering all OECD and partner countries for which data are available.

[7] See https://www.industry.gov.au/data-and-publications/full-carbon-accounting-model-fullcam for a description of the FullCAM model.

Figure 9. Sectoral shares of emissions vary across countries

GHG emissions share (excluding land use, land-use change and forestry) for selected OECD countries



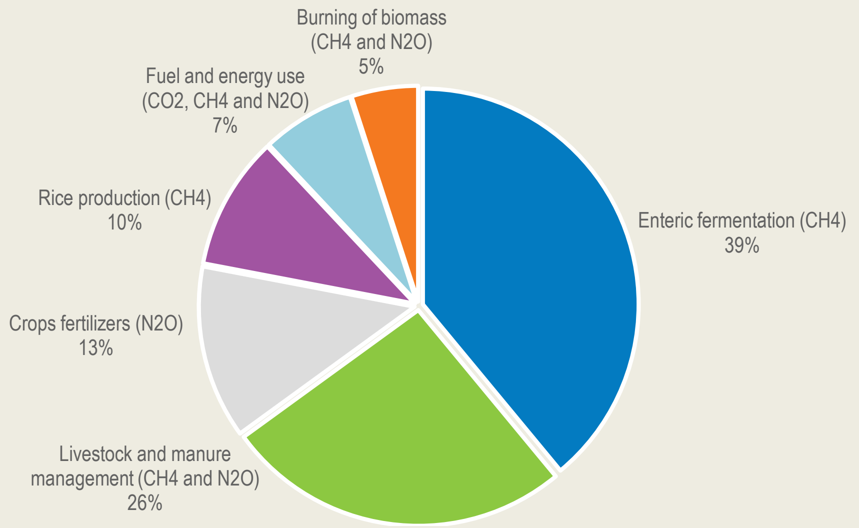
Source: OECD, Green Growth Database.

Box 3. Meeting the challenges of decarbonising the agricultural, land use, and forestry sectors

The agriculture and LULUCF (land use, land-use change and forestry) sectors are a significant net source of GHG emissions. The two sectors are tightly related as the expansion of agricultural land is the main driver of deforestation. Developing countries are the largest and the fastest growing source of agriculture-related emissions. Between 2000 and 2018, global emissions from crops and livestock activities increased by 14%, while emissions from LULUCF decreased (consistent with slowing deforestation). In some countries, LULUCF net-emissions become negative (thus sequestering, instead of emitting, carbon). Agricultural GHG emissions have different sources, adding to the challenge of decarbonising the sector (Figure 10). In the LULUCF sector, deforestation accounts for the bulk of CO_2 emissions (74%), followed by drained organic soils (18%). Organic soils and biomass fires account for the remaining emissions (FAO, 2020[30]).

Figure 10. Sources of agricultural GHG emissions

GHG emissions share, global 2018



Source: (FAO, 2020[30])

A series of technical solutions are available to reduce these emissions. They include: dietary additives and feed quality improvements to reduce enteric methane from ruminants; techniques to reduce methane emissions from manure management (e.g. anaerobic digestion); land use systems (e.g. conservation tillage, rotational grazing on pasture, alternation of forage composition); windbreaks systems, carbon sinks and integrated pest management practices; and drainage management practices to lower methane emissions from paddy rice. Decarbonising agriculture and LULUCF also entails maintaining or increasing forest carbon stocks while exploiting forests products in a sustainable manner (OECD, 2021[31]).

Policies aimed at decarbonising the agricultural and LULUCF sectors face specific challenges: *i)* political sensitivity due to, for example, concerns of a potential loss of farmers' competitiveness; *ii)* low-emission practices are time consuming, expensive and labour intensive; *iii)* difficulties in measuring the gains resulting from low-emission practices, especially from enteric fermentation; *iv)* lack of rewards to farmers' mitigation efforts; and *v*) misalignment of subsidies with decarbonisation. Well-designed policy packages, combining taxes on GHG emissions with subsidies to reward carbon sequestration by forests and encourage the development and deployment of CO_2 abatement technologies in agriculture would contribute to addressing these challenges (OECD, 2021[31]). Improving international cooperation mechanisms, such as the REDD+, aimed at supporting developing countries' efforts to reduce deforestation and forest degradation and foster sustainable forest management practices, can also provide significant support to decarbonising the agricultural and LULUCF sectors.

Source: (OECD, 2019[32]; OECD, 2019[33]; FAO, 2020[30]; OECD, 2021[31]; Larson and al., 2013[34]).

3. Designing decarbonisation strategies

3.1. Stocktaking of current policies to inform decarbonisation strategies

32. Countries can adopt a wide range of policies to address climate change, including emission pricing, incentive-based instruments, standards and regulation. Current policy settings vary greatly across countries (Figure 11), reflecting complex interactions between countries' climate ambitions, pre-existing conditions, political constraints and social preferences. For instance, the use of climate-related taxes (with or without explicit climate objectives), one of the most discussed climate policies, varies greatly across countries, as reflected by the wide variation in the share of climate-related tax revenues in total tax revenues (Figure 12). Several countries price carbon emissions directly or indirectly putting a tax on fuels and polluting goods, but emissions are overall underpriced (Figure 13). Considerable information on current policies can be found in-house (Box 4).

Box 4. The OECD and IEA collect extensive cross-country information on climate policies

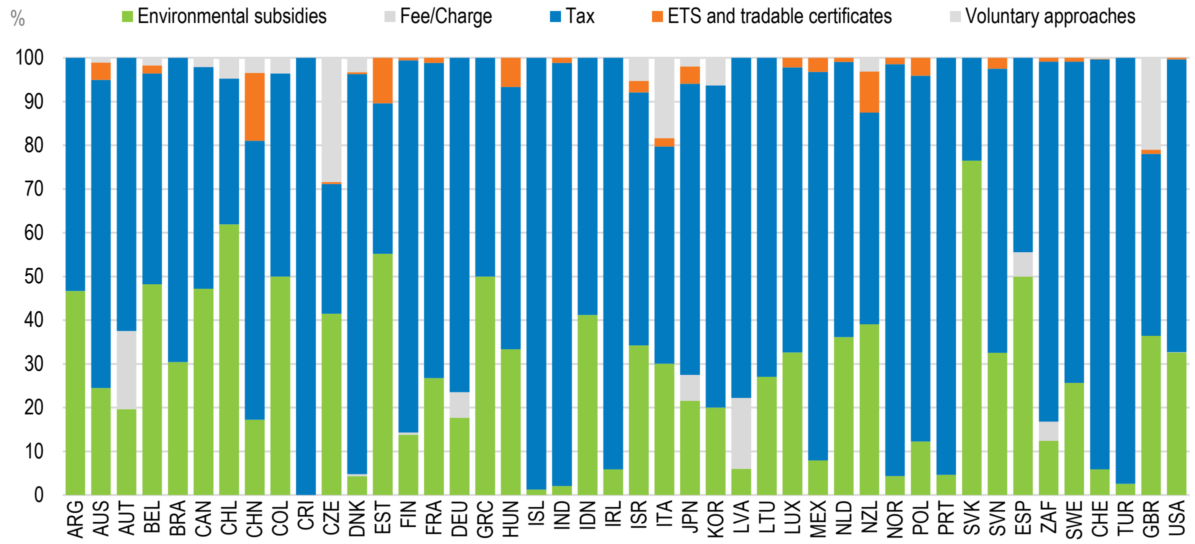
The OECD collects and analyses information on decarbonisation relevant policies, such as the Effective Carbon Rates (ECR) and Taxing Energy Use (TEU) databases, the Inventory of Support Measures for Fossil Fuels and the Policy Instruments for the Environment (PINE). These data repositories use harmonised methodologies that are conducive to cross-country comparisons and benchmarking and thus are suitable for assessing a country's current policy mix. Available data include qualitative and quantitative information on environmental taxation and subsidies (OECD, 2020[35]; OECD, 2021[36]), effective carbon rates, fossil-fuel subsidies (OECD, 2021[37]), selected regulations, and R&D and infrastructure expenditure (IEA, 2020[38]; IEA, 2020[39]).

The Environmental Policy Stringency (EPS) indicator (Botta and Koźluk, 2014[40]) is an index capturing the stringency of several climate and air pollution policies and hence the cost of polluting. The Burden on the Economy due to Environmental Policies (BEEP) (Koźluk, 2014[41]) is a questionnaire-based indicator providing information on how environmental policy and the associated administrative burdens affect competition and market dynamism.

The OECD Environmental Performance Reviews examine how countries' environmental policy frameworks can support several environmental outcomes, including the transition towards climate neutrality. All OECD countries have been reviewed, most of them for the third time and a fourth round is starting. Recently published works include Ireland, Belgium, and Lithuania while the reviews of Finland, the United Kingdom, and Norway are currently in preparation.

Figure 11. Diverse climate policy mixes in OECD and non-OECD countries

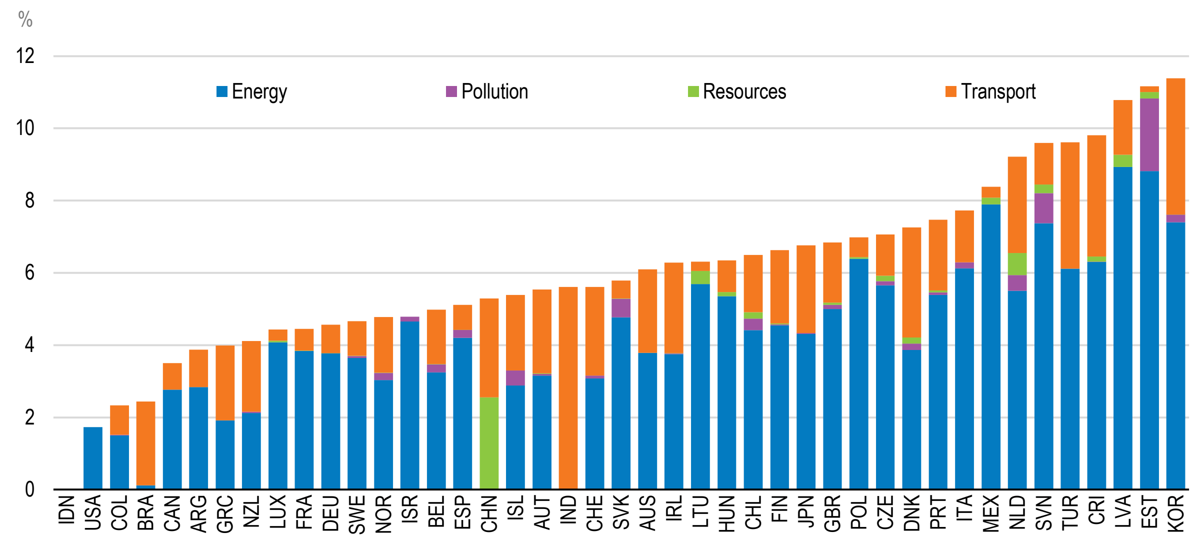
Share of climate-related policy instruments by category, 2019



Note: The figures do not include standards and regulatory instruments. The data on policy instruments is collected through a periodically updated survey and its voluntary nature implies that it is not necessarily exhaustive or up-to-date. The share of a category does not need to map the relative stringency of the policy instruments. *Environmental subsidies*: subsidies that reduce directly or indirectly the use of something that has a proven, specific negative impact on the environment. It can take many forms: VAT exemptions on electric cars, feed-in tariffs on renewable energy generation, or tax credits for environmentally relevant investment; *Fee/Charge*: a required payment to the general government for a good/service; *Tax*: taxes levied on environmentally related tax bases, such as energy products and motor vehicles and transport services; *ETS and tradable certificates*: allocation of emissions or resource exploitation rights; *Voluntary approaches*: not economic instruments, but commitments by firms or industries to improve their environmental performance beyond legal obligations.
Source: OECD, Policy Instruments for the Environment (PINE) Database.

Figure 12. Reliance on climate-related taxes varies across countries

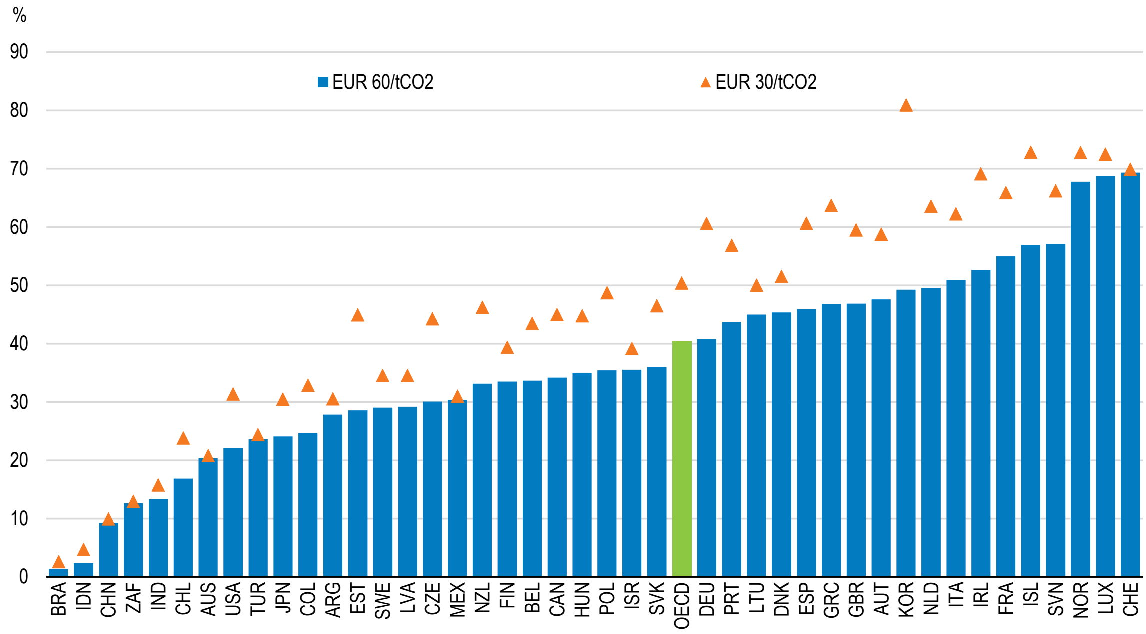
Climate-related tax revenue as % of total tax revenue by category, 2019 or latest available year



Note: Data should be understood as estimated and incomplete. Data refer to 2014 for Korea; 2016 for Australia and the United States; 2017 for Iceland, India and Poland; 2018 for Argentina, Canada, China, Costa Rica and Israel.
Source: OECD, Environment Database.

Figure 13. Most countries under-price their carbon emissions

Carbon pricing score, 2018



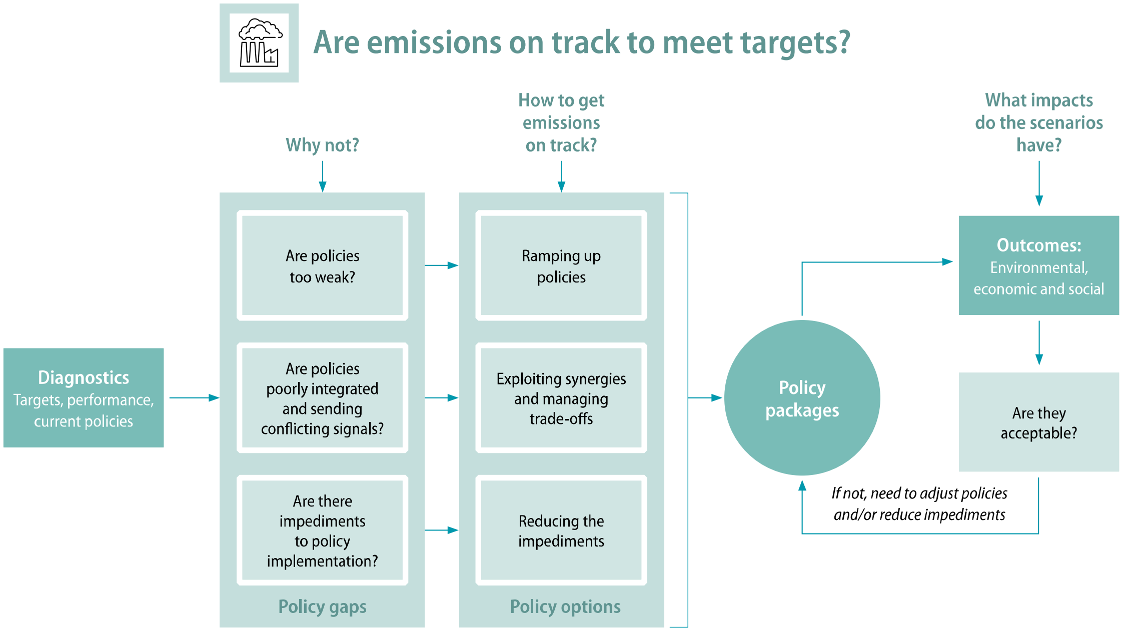
Note: The carbon pricing score (CPS) measures the extent to which countries have achieved the goal of pricing all energy related emissions for carbon costs, at certain benchmark values. For example, a CPS of 100% against a benchmark of EUR 60 per tonne of CO_2 means that the country prices all energy related carbon emissions in its territory at EUR 60 or more. In practice, EUR 60 is a midpoint estimate for carbon costs in 2020, and a low-end estimate for 2030. Pricing all emissions at least at EUR 60 in 2020 shows that a country is on a good track to reach the goals of the Paris Agreement to decarbonise by mid-century.
Source: OECD, Effective Carbon Rates 2021 Database.

33. Assessing the existing policy mix is key to identifying policy gaps and shortcomings and to designing more effective policy packages. Doing so requires considering the following issues (Figure 14):

- **Lack of ambition.** For example: emission pricing is in place but the price is too low or the base too narrow; support for green investments is insufficient when compared with the scale of the decarbonisation challenge; or several polluting activities are insufficiently regulated. In this case, the current stock of policies needs to be ramped up or expanded, more resources mobilised, and new policy instruments introduced (Box 5 provides the example of Germany's increase of emission pricing in non EU ETS sectors);
- **Overlapping and untargeted policies**. Many energy and environmental policies have been designed with different objectives in mind than climate change mitigation (e.g. raising tax revenue, reducing energy prices, lowering inequality, ensuring food or energy security). Policies may be untargeted (e.g. weight-based standards to limit vehicle emissions) and inconsistent with other policies (e.g. imposing a carbon tax with generous fossil fuel subsidies still in place). This problem calls for revising the policy mix in a way to better exploit synergies and manage trade-offs among different policy instruments;
- **Structural impediments hampering the implementation and effectiveness of the climate change policy mix**. Labour and capital market rigidities (such as ineffective public employment services, obstacles to private financing for the development and adoption of low-emission technologies, inadequate legal and physical infrastructures supporting decarbonisation) can stymie the ecological transition. Box 6 details how inadequate grid

capacity blunted the effect of generous subsidies on renewable energy development in China. Specific political and economic challenges to certain policies, such as the risk of carbon leakage or unwanted redistributive effects, can reduce the effectiveness of well-designed policy instruments (such as a carbon tax) or hinder their adoption. Improving policy design, deploying complementary policies and enhancing international cooperation can help to overcome these impediments.

Figure 14. Key elements for designing decarbonisation strategies



Box 5. Ramping up mitigation policies: Germany's increase of emission pricing in non-EU ETS sectors

Germany's Climate Action Plan 2030, agreed in late 2019, included a carbon pricing system in transport and heating that became operational in January 2021. The national emissions trading system for transport and heating exists in parallel to the EU ETS and covers the bulk of emissions not included by it. During the initial phase (2021-2025), emission allowances have a fixed price (equivalent to a tax), starting at EUR 25/tCO_2 in 2021 and increasing to EUR 55/tCO_2 in 2025. In 2026, emission permits will be auctioned with a price range of EUR 55 to 65/tCO_2, transitioning to a market price with an option for price corridors from 2027.

The government expects the system to generate revenue of EUR 40 billion from 2021 to 2024, which will allow for lowering the renewables surcharge on electricity and for other relief measures. The government adopted a regulation in March 2021 to reduce leakage by providing compensation in emission-intensive trade-exposed industries, under the provision that companies undertake emission-reduction measures and invest at least 50% (from 2023) to 80% (from 2025) of compensation payments from the previous year in economically-viable energy-efficiency measures. Compensation payments are between 65% and 95%, calculated on the 10% best-performing plants in the sector with a correction factor based on emission intensity.

Source: (Clean Energy Wire, 2020[42]; Clean Energy Wire, 2021[43]).

Box 6. Renewable energy subsidies in China: significant progress hampered by inadequate grid capacity

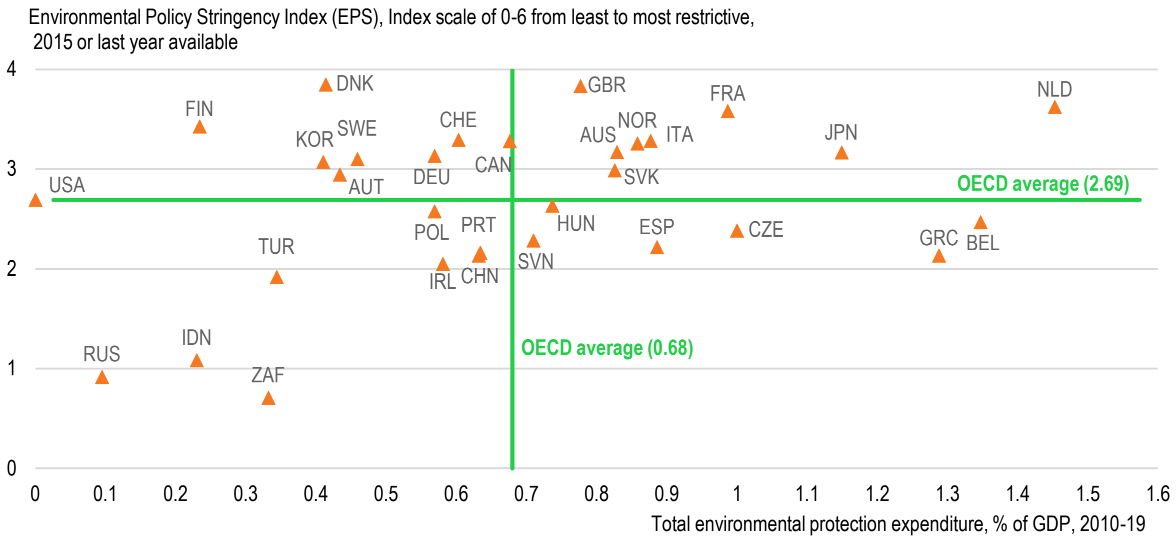
In 2005, the Chinese government passed the Renewable Energy Law, aiming at increasing the use of renewable energy sources, with an emphasis on hydro, solar and wind power. Since then, the country has implemented several related policies and in 2020 it committed to reach net-zero emissions by 2060. Among these policies, are generous subsidies to increase the share of renewables in its energy mix, which reached 22.6% in 2018 (China Energy Portal, 2021[44]). The government subsidies program is very fragmented as several tools are employed, such as VAT rebates, fiscal subsidies, tax incentives for innovation, price controls, land allocation policies, demand commitments and compulsory allocation. Moreover, low-interest loans support green innovation. The most important programmes are the following (IEA, 2021[45]):

- **Guiding Catalogue for the Industry of Renewable Energy**, drafted by the National Development and Reform Commission (NDRC), which includes subsidy programs to reward the production of renewable energies, e.g. by subsidising part of the associated companies' fees and maintenance costs (NDRC, 2021[46]).
- **Regulation on the Implementation of the Enterprise Income Tax Law**, which stipulates that firms in the renewable energy industry may be eligible for corporate income tax reductions.
- **Price controls**, launched by the NDRC in 2005, aimed to increase the revenues of renewable energy producers by setting their prices for a fixed number of years.

These policies have had positive effects on the development of renewable energy sources in China as it is currently the biggest producer in the world of electricity generated with renewable sources (International Renewable Energy Agency, 2021[47]). However, China is still constructing new coal-fired power plants (with typical lifetimes of several decades), and a sizable share of the electricity generated by wind energy is wasted annually due to limited grid capacity and in some cases the lack of grid connections (OECD, 2019[48]). Thus, China's subsidies, while successful in boosting renewable energy sources in the energy mix, have not stopped fossil-fuel use from increasing.

34. Countries differ in the way they pursue their decarbonisation goals (Figure 15). Data on environmental policies can provide some guidance in this respect. Though environmental policies are not the same as climate policies, they are a good proxy. Some countries (top right quadrant) rely on a combination of stringent environmental policies and high environmental protection expenditures. Such a combination can be beneficial if environmental protection expenditures reduce firms and households' compliance costs, for example by facilitating emission abatement. Some other countries rely more on stringent environmental policy and less on environmental protection expenditures (top left quadrant). This can either reduce or increase the overall cost for the economy to decarbonise, depending on the policy implemented and country-specific preconditions. Some countries (bottom right quadrant) opt for large environmental protection expenditures and less stringent environmental policies (bottom right quadrant).

Figure 15. Countries should favour coordination between policy stringency and public expenditures



Note: Environmental protection expenditure covers expenses for activities whose primary objective is to prevent, reduce or treat pollution or other damages to the physical environment. The statistics comprise current expenditure, end-of-pipe investments and investments in integrated technology.
Source: OECD, Green Growth Database.

3.1.1. Criteria to design decarbonisation strategies: addressing market failures while balancing cost-effectiveness with fairness and public acceptability

35. When assessing decarbonisation strategies it is useful to frame the problem in terms of market failures. The major market failures of GHG emissions concern the negative externality they produce and the under-provision by private markets of research and technological innovation to reduce emissions. Other important market failures have to do with unpriced co-benefits of reducing emissions and network effects hampering the deployment of new technologies (Box 7). One key criterion for assessing policy options is how they help to address these market failures in a cost-effective way. In addition, governments may need to consider additional factors, including: reallocation and distributional effects; effects on public budgets; and public acceptability.

Box 7. Main market failures contributing to climate change

One of the major market failures contributing to excessive emissions concerns the negative externalities emissions generate. This creates a wedge between the marginal social costs and the private costs, resulting in product prices that do not reflect their climate damage. A related problem stems from climate being a global public good, thus reducing the incentives for individual countries to unilaterally reduce emissions.

A second market failure concerns the private markets under-provision of research and technological innovation to reduce emissions, due to knowledge being to a large extent a public good. While true in every domain, this market failure is a fundamental challenge for decarbonisation, where spillovers are larger than in other areas (Dechezleprêtre, Martin and Mohnen, 2013[49]) and where the deployment of new and affordable low-carbon technologies is key (Popp, Newell and Jaffe, 2010[50]). Moreover, path-dependency may exacerbate the problem of insufficient investment in 'green' innovation as early investments in polluting industries strengthen their competitiveness, making it more difficult for low-carbon technologies to compete (Acemoglu et al., 2012[51]; Aghion et al., 2016[52]).

Other market failures can worsen these two major problems. For instance, unpriced co-benefits of reducing emissions, such as improved health and biodiversity, weaken incentives to fight climate change; financial frictions can make it difficult to finance investments in low-carbon technologies even when they are profitable (Stiglitz, 2019[7]; Popp, 2019[13]); the existence of network effects and coordination failures in relevant industries (e.g. electricity, transport, recycling) can hinder the adoption of new technologies; split incentives in owner-tenant decisions slows down energy efficiency investments in buildings; lack of information about energy efficiency and products' carbon content can hamper the purchase of low-carbon products; demand-side 'behavioural' effects (e.g. hyperbolic discounting, status quo bias, dynamic inconsistencies) can cause excessive overconsumption of energy and polluting goods in households.

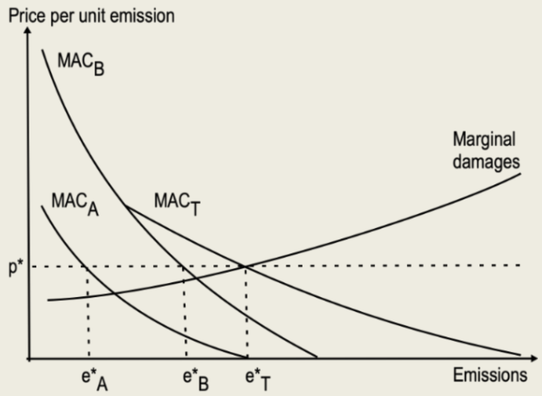
36. Several policy options can help to address these market failures. Their effectiveness varies over the short and long term and can be assessed through the following criteria:

- **Lowering abatement costs in the short term (i.e. static minimisation of abatement costs).** This can be achieved through different channels: *i)* lowering firms' emission intensity through changes in technology and energy sources; *ii)* reallocating production from more polluting to less polluting firms; *iii)* shifting away consumption from more polluting to less polluting goods; and *iv)* reducing consumption and total output. Policy instruments that provide most flexibility in abatement decisions along these channels entail the lowest short term (i.e. static) abatement costs (Box 8).

Box 8. Cost-effective reduction of GHG emissions: the equimarginal principle

Cost-effective climate policy is theoretically founded in the equimarginal principle, which states that when all GHG emitters face the same marginal cost of abatement, then total abatement cost will be minimised. For any given cap on emissions, with two or more polluting firms, the cost of reducing emissions is thus minimised when all the firms face the same unit price on emissions so that no low-cost abatement opportunities are missed (Figure 16). This is most directly implemented through a uniform emissions tax or cap-and-trade system. The same logic applies across countries and regions, or different plants and industries within a country: the cheapest opportunities to cut emissions should be utilised.

Figure 16. Cost-effective emission abatement



How to read: MAC_A is the marginal abatement cost curve for firm A, indicating the firm's emission level for any given price per unit of emission. Costs of reducing emissions are higher for firm B. The aggregate marginal abatement is represented by MAC_T. The socially efficient quantity of emissions is determined by the intersection of the aggregate marginal abatement cost and the aggregate marginal damage from emissions. This determines the optimal quantity of emissions, e^*_T, and the resulting price per unit of emission for all firms, p^*. At this price level, firm A will emit e^*_A which is less than the emission level for firm B at e^*_B. This emission price at p^* is cost-effective as each firm operates such that marginal abatement cost from polluting is set equal to the emission price per unit of pollution. Hence, the two firms face the same marginal cost of abatement which, according to the equimarginal principle, minimises the aggregate abatement cost, as all emissions with a lower abatement cost than p* will cease.

Source: (Kolstad, 2011[53]; Berck and Helfand, 2011[54])

- **Lowering abatement costs in the medium-long term (i.e. dynamic minimisation of abatement costs).** Investments in innovation can improve the overall cost-effectiveness of a policy by reducing abatement costs in the future but without necessarily minimising short-term abatement costs. A strong and time-consistent commitment to decarbonisation is likely to foster early technological changes, reducing abatement costs in the medium and long term. Instruments that provide long-term incentives to firms for innovation and R&D in a flexible way, rather than mandating the adoption of specific technologies are more cost-effective.
- **Administrative costs.** The cost-effectiveness of a policy instrument needs to be judged against the cost of providing the legal and technical infrastructure necessary to measure, monitor and enforce it. Administrative costs also include the compliance costs incurred by consumers and firms on top of those sustained for abating emissions. A more efficient public administration helps to lower these costs (Berestycki and Dechezleprêtre, 2020[55]). In many cases, a trade-off exists between increasing the static economic efficiency of a measure, for example targeting precisely GHG emissions, and the cost of administering it, making the implementation of some ambitious policies more difficult.
- **Capacity to deal with uncertainty.** Estimates of abatement costs and climate change damages are uncertain. Wrong estimates can lead to excessive or insufficient policy stringency, reducing cost-effectiveness. A policy based on wrong estimates of abatement costs (caused by incomplete information on firms and the difficulty of forecasting future prices of fuels and alternative abatement technologies) will impose to firms a cost far from optimal; a policy based on wrong estimates of climate change damages, caused by difficulties in forecasting future effects of climate change on the economy, will cause an impact on the environment far from optimal. A trade-off exists between these two types of error and policy instruments can limit one or the other (Weitzman, 1974[56]; Newell and Pizer, 2003[57]). In the short run, an error in emission prices can be damaging to firms while an error in emissions' quantity will have little impact on climate change in the long run.

Overall, this suggests that among different and otherwise equivalent policy alternatives, policymakers should prefer those involving less uncertainty in abatement costs, such as price, instead of quantity, instruments. Hybrid instruments, such as an ETS combined with a carbon price floor, as in the United Kingdom and the Netherlands (Box 9).

Box 9. Increasing emissions pricing in EU ETS sectors in the Netherlands

The Netherlands has ambitious emission reduction targets (-49% and -95% relative to 1990 by 2030 and 2050 respectively). Much of these reductions will have to come from emission-intensive industries. For these industries, the target is to reduce emissions by 59% up to 2050. Being a small open economy, its climate objectives require strong policies with particular attention to the risk of carbon leakage, i.e. the increase in foreign emissions resulting from more stringent domestic policies.

The first pillar of the Dutch decarbonisation strategy for the industry is a national carbon levy on industrial emissions in EU ETS sectors. This applies if the EU-ETS carbon price falls under a pre-determined threshold, thus acting as a carbon price floor. In this case, emitters pay the difference between the EU-ETS carbon price and the floor price. Implemented in 2021 with a clear price trajectory, it is expected to reach EUR 125 per tCO_2 in 2030 (including the EU ETS price). Less than 10% of emissions in key sectors are subject to the carbon levy in 2021, but coverage in these sectors increases to roughly 45% by 2030. By gradually raising the levy rate over time, the government aims to provide certainty over the carbon price to investors and provide room to adapt and prepare for stronger carbon prices in the future to avoid competitiveness losses.

Beyond the national carbon levy and the EU-ETS, the Netherlands levies fuel taxes and an energy surcharge that effectively put a price on carbon. However, key energy-intensive industries benefit from generous fuel tax exemptions and a regressive energy tax rate as it decreases with energy consumption. This provides for a very heterogeneous carbon pricing signal across industries within the Netherlands benefiting advantages large energy consumers over small ones.

Table 4. The Dutch carbon price floor for industrial emissions

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Floor price (in EUR per tonne CO_2)	30	40.56	51.12	61.68	72.24	82.80	93.36	103.92	114.48	125.04

Note: The figures are domestic price floors, consisting of a floating contribution added on top of the price for emission allowances in the EU ETS. If the price of emissions allowances exceeds the floor price, the floating contribution becomes zero.
Source: adapted from OECD (2021[58]).

The second pillar of the Dutch decarbonisation strategy for industry involves supporting new technology development for climate change mitigation. This focuses on the deployment of new technologies through an abatement payment called SDE++, applying to renewable energy, hydrogen, carbon capture and storage, as well as the increased use of residual heat. Public tenders of the main support programme are based on the lowest abatement cost pooling all technologies in one single tender. While this design feature aims to ensure economically efficient distribution of subsidies, it disadvantages more radical alternatives that are still at an earlier stage of development (e.g., green hydrogen). The development of markets for green hydrogen is a key issue, with the potential to partly replace natural gas and fuels in hard-to-abate sectors (such as shipping and aviation).

Source: (IEA, 2020[59]; OECD, 2021[58]; Anderson et al., 2021[60]).

- **Reallocation and distributional effects.** Climate policies can have heterogeneous effects on firms and households, raising concerns about competitiveness, fairness, and affordability. For instance, they can change the market structure, favour incumbent or foreign competitors and depress economic activity in some sectors, causing a reallocation of economic activity. Moreover, climate policies can impact households heterogeneously. Complementary policies can help to mitigate these reallocation and distributional effects (Section 4).
- **Public acceptability.** A policy that is imperfectly understood, perceived as unfair or too costly by a part of the population will face strong opposition even if it is welfare-enhancing and cost-effective. Specific policy design choices can buttress the public acceptability of certain policy instruments (as detailed in Section 6). For example, broad-based policies spanning several sectors are more likely to be impervious to the lobbying of a few organised interest groups. A carbon tax levied on final consumption is more visible and salient to consumers than one on final production or intermediate goods, despite the tax incidence on final prices being the same, and could thus be more opposed. Effective governance and communication strategies can also bolster public acceptability.
- **Impact on the public budget.** Climate policies can have a large impact on the structure and size of the public budget. Subsidies and complementary policies can strain the public budget. In contrast, recent studies indicate that ambitious emission pricing could raise large amounts of revenue in the short and medium terms (Marten and van Dender, 2019[61]). Choices on how to recycle carbon-pricing revenues include: lowering labour-income taxes and social security contributions, strengthening cash transfer programmes, infrastructure spending, innovation and investment incentives and phasing out fossil-fuel subsides (Marten and van Dender, 2019[61]; OECD, 2021[36]). Given all this, governments should consider emission pricing as a mainstream fiscal policy tool rather than a narrow environmental policy matter. On the other hand, policymakers need to anticipate the progressive reduction of emission pricing revenues as emissions will decline over time.

37. Table 5 summarises how the main climate policy instruments fare across the assessment criteria highlighted above. The Annex contains details on each of these policies. The overarching message is that no single policy instrument is clearly superior to the others along all the assessment criteria. A policy mix can better address the complexity caused by the presence of several market failures, contrasting policy objectives and political constraints (de Serres, Murtin and Nicoletti, 2010[5]; Stiglitz, 2019[7]).

Table 5. Assessment criteria for climate policies

Policy Instruments	Cost-effectiveness: Short term (i.e. static) minimisation of abatement costs	Cost-effectiveness: Medium-long term (i.e. dynamic) minimisation of abatement costs	Cost-effectiveness: Administrative costs	Cost-effectiveness: Ability to deal with uncertainty	Other policy objectives: Reallocation and distributional concerns	Other policy objectives: Political economy and public acceptability	Other policy objectives: Fiscal revenues and expenditures
Emission pricing instruments and other incentive-based instruments							
GHG tax	Highest (especially if broad-based; tends towards equalisation of marginal abatement costs)	High (continuous incentives to reduce abatement costs)	Moderate to high (depending on difficulty of monitoring emissions)	High (deals with abatement costs' uncertainty)	Moderate concerns of competitiveness, job loss and income distribution.	Low (effect on prices are visible; depends on how revenues are used and on flanking measures)	Revenue raising
Emission trading schemes (ETS)	Highest (tend towards equalisation of marginal abatement costs)	High (continuous incentives to innovate to reduce abatement costs; higher price volatility than with tax can discourage investments)	High (requires a new legal framework and institutions; potentially high start-up administrative and transaction costs)	Moderate (deals with uncertainty of climate change damages, but not with uncertainty of abatement costs)	Moderate concerns of international competitiveness, job loss and income distribution. Free allocation can favour only some firms	Low to moderate (like tax, but easier to compensate and communicate the scope of cutting emissions)	Revenue raising when auctioning permits
Taxes on polluting goods or activities (e.g. fuel excise tax)	Low to High (approximates well emission pricing if taxes a good or activity that is a close proxy to GHG)	Low (narrow application, distant proxy to GHG) to High (broad application, close proxy)	Low (can be implemented by adjusting existing taxes)	High (deals with abatement costs uncertainty)	Moderate concerns. Can be progressive or regressive depending on the application	Low (but can be applied selectively where support is higher)	Revenue raising
Regulations, standards, subsidies and hybrid instruments							
Non-tradable performance standards/certificates (e.g. fuel economy standards)	Moderate (does not equalise marginal abatement costs)	Moderate (future standards can be announced to accelerate innovation)	Low (however, significant trade-off with short-term cost-effectiveness, can have certification costs)	Low (deals poorly with uncertainty as it does not cope with future changes in technologies or prices)	Low concerns (but tend to be regressive in practice)	Fairly high (effect on prices hidden)	Neutral

Table 5. (continued)

Policy Instrument	Cost-effectiveness				Other policy objectives		
	Short term (i.e. static) minimisation of abatement costs	**Medium-long term (i.e. dynamic) minimisation of abatement costs**	**Administrative costs**	**Ability to deal with uncertainty**	**Reallocation and distributional concerns**	**Political economy and public acceptability**	**Fiscal revenues and expenditures**
Subsidies to abatement (e.g. financial incentive for carbon capture, tax incentives)	Potentially high (but in applications their additionality is dubious)	Moderate (it can pick winners, penalise entrants)	High (difficult to establish additionality and target the subsidy)	High (deals with abatement costs' uncertainty)	Low concerns for competitiveness. Moderate to High regressivity (subsidised activities undertaken only by those that can afford them)	High (reduce cost for producers or consumers)	Expenditure
Feebates (e.g. feebates on vehicles)	Fairly high (often higher than non-tradable performance standards)	Moderate (if sets a long-term price signal)	Low to Moderate	High (deals with abatement costs' uncertainty)	Low to moderate (low-income households might be disadvantaged); can provide windfall profits to firms if they appropriate the rebate	Fairly high (higher than performance standards)	Neutral (can be revenue or expenditure)
Technology standards	Low	Low (increase adoption of a given technology, but slowdown innovation)	Low	Low (deals poorly with uncertainty as it does not cope with future changes in technologies or prices)	High concerns for competitiveness (favours incumbent firms; picks winners)	Fairly high (effect on prices hidden)	Neutral
Input requirements	Low to moderate (can be effective in promoting renewables)	Low (but it can indirectly stimulate renewables production)	Low	Low (deals poorly with uncertainty as it does not cope with future changes in technologies or prices)	Moderate (risk they favour specific firms or national industries)	Fairly high (effect on prices hidden)	Neutral
Tradable performance standard/certificates (e.g. renewable portfolio standards)	Fairly high (dominates non-tradable performance standards and often better than feebates)	Fairly high (revenues from future certificate sell can stimulate innovation)	High (similar to an emission trading scheme, but lower monitoring costs)	Low (deals poorly with uncertainty as it does not cope with future changes in technologies or prices; more flexible than non-tradable performance standards)	Moderate (impact on final consumption can be relevant)	Moderate (effect on prices are mostly hidden, but the increase can be relevant)	Neutral or Expenditure (tradable credits)
Information and voluntary approaches							
Information and voluntary approaches	Low to moderate	Low (can reduce incentives to innovate beyond the requirement)	Low to Moderate (some information/certification can be hard to produce)	Not applicable (uncertainty is not an issue here)	Low	High	Neutral

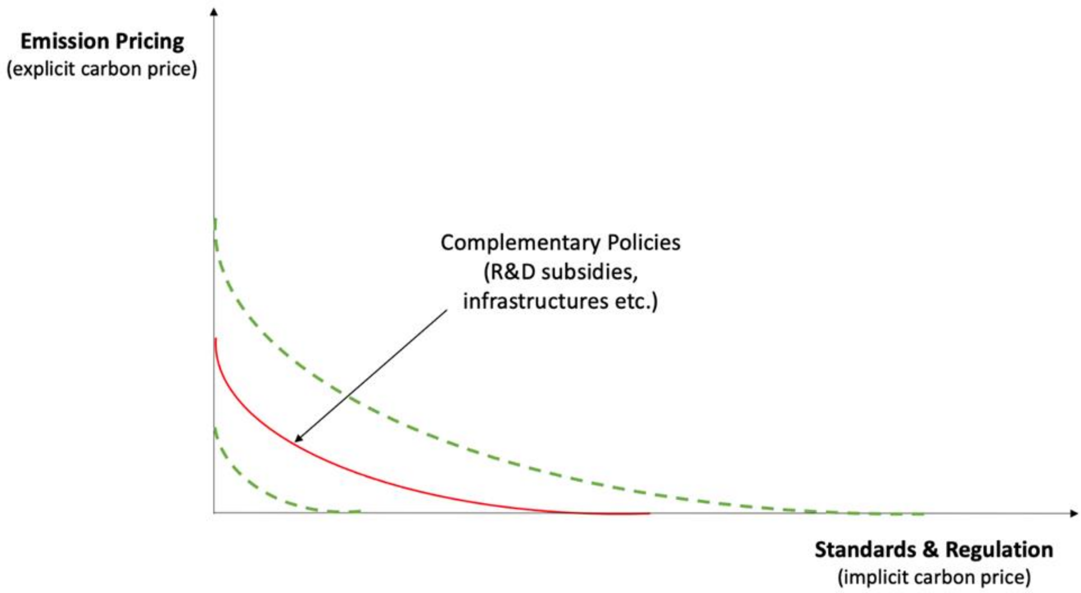
3.2. Effective decarbonisation strategies consist of a comprehensive policy mix

38. The assessment of the different policy instruments to fight climate change suggests that effective decarbonisation strategies need to rely on a comprehensive policy mix (Figure 17).

- **The first broad component of a comprehensive policy mix includes emission pricing instruments**. This encompasses GHG taxes and Emission Trading Schemes (ETS) and other incentive-based instruments, such as taxes on polluting goods. It provides an effective way to reduce emissions, especially in the short run. Emission pricing encourages innovation, but does not suffice to address coordination failures in innovation and licensing (Bessen and Maskin, 2009[62]), especially in basic research, thus limiting knowledge spillovers and technological developments and deployment. However, emission pricing may be more difficult to implement and its administrative costs can be higher than standards/regulations, depending on the circumstances.
- **The second broad component of a comprehensive policy mix are standards and regulations as well as subsidies to encourage the adoption of low-carbon technologies**. These policy instruments may set a wide range of different requirements (such as emission quotas, green certifications, technology mandates and others), and can be especially effective in certain cases, such as restricting and phasing out high-emitting activities or technologies, and accelerating the deployment of low-emitting technologies. The cost to comply with these requirements can be seen as an implicit carbon price, contrary to emission pricing schemes that set an explicit carbon price. Standards and regulations can also encourage the diffusion of network-based innovation by overcoming coordination failures (Katz and Shapiro, 1994[63]). They can thus effectively complement emission pricing and incentive-based policies (Vollebergh and van der Werf, 2014[64]; Stiglitz et al., 2017[6]) especially when they are technology-neutral (e.g. tradable performance standards). Yet, ill-designed and uncoordinated regulations may increase the cost of decarbonisation by complicating performance monitoring, blurring price signals and blunting economy-wide incentives.
- **Complementary and framework policies are the third main component of a comprehensive policy mix.** These include all those policies that do not directly target a reduction in emissions but provide the enabling economic and social conditions to do so, by lowering the economic and social costs of decarbonisation efforts. These fall into two broad categories: 1) policies to improve the cost-effectiveness of decarbonisation strategies, including measures to accelerate the development and deployment of new abatement technologies, support business dynamism, upgrade infrastructure networks and crowd-in private capital (see Section 4); and 2) policies to allay the distributional effects of climate policies and help people in the transition, such as reforms to the tax and benefit system and active labour market programmes (see Section 5).

Figure 17. A comprehensive policy mix is more cost-effective than relying on single policy instruments

Each curve represents policy combinations producing the same reduction in emissions



Note: The axes show the extent to which the policy mix relies on two broad categories of policy instruments: y-axis – emission pricing; x-axis – standards and regulations. Each curve depicts different combinations of emission pricing and standards/regulations yielding a certain reduction in emissions (i.e. similar to an 'isoquant' curve). The curves are convex to represent that a combination of emission pricing and standards (i.e. a comprehensive mix) could be more cost-effective than exclusively relying on one policy. Complementary and framework policies (such as infrastructure and R&D) shift the curves ('isoquants') towards the origin, indicating lower abatement costs for a given reduction in emission (or larger reduction in emissions for given abatement costs). In contrast, country-specific political and social constraints, including redistributive challenges and pubic acceptability, might impose constraints and change the slope of the curves, making certain policy combinations unattainable.
Source: OECD.

39. These three broad components, if deployed together as part of a coherent decarbonisation strategy, can generate significant synergies (OECD, 2007[65]). Standards and regulations can complement or substitute emission pricing where firms and households are unresponsive to prices. For example, they can be effective in bypassing the non-responsiveness of households to changes in prices of electricity, in overcoming coordination problems in housing retrofitting due to conflicting incentives between tenants and landlords, and in dealing with other market failures caused by, for instance, myopic behaviour, financial constraints and risk aversion (Box 7). Examples of synergic use of multiple instruments include: *i)* the use of information instruments, such as energy efficiency labelling, to enhance the behavioural response elicited by incentive-based instruments; *ii)* actively supporting technology development (when a GHG tax is already in place) so as to further encourage green innovation (Fischer and Newell, 2008[66]); *iii)* the hybridisation of 'price' and 'quantity' instruments (e.g. using floors and caps in an ETS) to limit uncertainty about compliance costs and strengthen price signals (Lecuyer and Quirion, 2013[67]); and *iv*) recycling revenues from emission pricing to support growth and social inclusion by for instance lowering highly labour-income taxes, boosting R&D support, or improving and strengthening social transfers to people in need.

40. At the same time, deploying multiple policy instruments risks sending incoherent and conflicting signals. For instance: renewable promotion policies can distort the abatement

incentives of a cap-and-trade system, increasing its cost and lowering effectiveness (Böhringer et al., 2016[68]; Flues et al., 2014[69]); introducing an ETS in the context of imperfect emission standards based on proxies can result in higher emissions (Levinson, 2010[70]; Novan, 2017[71]); and levying a tax on top of an ETS does not usually lead to lower emissions, but it just shifts the burden of payment unless the tax is exceptionally high (Fankhauser, Hepburn and Park, 2010[72]). Moreover, the proliferation of partially overlapping policies at different jurisdictional levels (e.g. federal and state policies) can increase the risk of 'internal leakage' (i.e. emissions shifting from more regulated to unregulated firms without an overall reduction) (Perino, Ritz and van Benthem, 2019[73]).

41. Considering emission sources at the sectoral level can be useful in the design of a cost-effective policy mix. For example, emission pricing is much more effective in the manufacturing sector, where firms respond to price signals, than among households, as behavioural 'inattention' to prices and lack of alternatives lower the acceptability of potentially effective policies and blunt their impact. Tables C.3 to C.7 in Annex show the main considerations to take into account when designing sectoral policies for households, industry, agriculture, power and transport-related emissions. Because of the importance and pervasiveness of the electricity and transport networks, sectoral policies to decarbonise them are analysed in Section 4 under complementary policies.

42. A clear, transparent and independent governance structure can help to exploit the synergies and manage trade-offs among multiple policy instruments and sectors. Such a governance structure can help to coordinate the choice, implementation and monitoring of policies. Conducting climate-policy related regulatory impact assessments (RIAs), pilot projects and consulting with experts, research and civil society bodies and stakeholders, can enrich and tailor the policy design process (Box 10). Such consultations may also help to build public acceptance and trust as discussed in Section 6. The experience of some countries, such as the United Kingdom, Denmark, the Netherlands (Box 11), and New Zealand (Box 19) suggests that independent climate bodies are useful in this respect.

Box 10. Methods to support decarbonisation strategies' design process

Integrating climate change and environmental considerations into regulatory impact assessments (RIAs) can provide ex-ante policy insights and help to align policies in different areas with climate change objectives. Country-specific economic, social and environmental impacts should be comprehensive, preferably quantified in monetised form, while accounting for possible long-term and spatial effects (OECD, 2012[74]; Jacob et al., 2011[75]).

Deploying pilot projects can support learning by doing and help to refine policies before full-scale implementation. An example is the European Commission's Air Implementation Pilot, which sought to improve the implementation and enforcement of EU air quality legislation by collecting insights from 12 European cities (European Environment Agency, 2019[76]; Joint Research Centre, European Commission, 2014[77]). The knowledge gathered in the pilot contributed to the proposed EU's Clean Air Programme (European Commission, 2013[78]).

Taking into account inputs from climate experts can improve understanding and help to design evidence-based policies. These include scientific advisory bodies mandated to address specific matters, academic institutions, or individuals with specific expertise.

Consulting policy-oriented and civil society bodies (e.g. think tanks, politically associated foundations, movements, and government departments) may allow for integrating a broader set of perspectives when designing and implementing policies, thus building trust and improving public acceptance (OECD, 2015[79]; OECD, 2021[80]).

Stakeholder consultation may shed light on their needs and provide valuable knowledge and policy proposals (UNEP, 2019[81]). At the same time, it is important to address the related risks of policy capture (see discussion in Section 6).

Box 11. Independent advisory bodies can help strengthen and coordinate the policy mix

One effective strategy in designing and monitoring climate plans involves the establishment of independent economic advisory bodies on climate change. These bodies provide technical advice and help to coordinate different policy interventions across public and governmental institutions. The United Kingdom, Denmark and the Netherlands offer some examples.

In 2008, the **United Kingdom** established the **Committee on Climate Change (CCC)** as an executive non-departmental public body with the Climate Change Act. It is sponsored by the Department for Business, Energy & Industrial Strategy and works in cooperation with the Department for Environment, Food and Rural Affairs which oversees climate change and sustainable development. The CCC's role is to provide independent analysis and advise the Government on setting legally binding carbon budgets, monitoring the actions of the government and providing policy advice to reach the goals of the Climate Change Act. Each year, the CCC provides an assessment of the progress of the United Kingdom to the parliament. The government must respond to the reports with transparency and produce statements on the policies implemented to meet the carbon budget and emission goals of the country (Climate Change Committee, 2021[82]).

As part of the **Danish Climate Change Act**, The Danish Parliament has established two main independent councils (Danish Economic Councils, 2021[83]):

- **The Environmental Economic Council**, which is part of the Danish Economic Councils, was established by law in 2007. Its main goal is to provide analysis and advice to policymakers on the transition to a low-carbon economy by 2050, in addition to other environmental issues.
- **The Danish Council on Climate Change (*Klimarådet*)**, composed of experts to advise the government on the most cost-effective solutions to lower emissions, was strengthened and expanded with the Climate Change Act. It provides annual recommendations to the Ministry of Climate, Energy and Utilities with the aim of reaching the long-term national climate targets. The Council is tasked with preparing an annual climate status report, which includes a ten-year projection, assesses whether existing policy initiatives are sufficient to meet emission reduction targets, and presents a possible climate policy programme for the Danish Parliament. The government, in turn, has to produce an annual national strategy to ensure progress.

In **the Netherlands**, two independent research institutes are working with the government on climate change:

- **The Netherlands Environmental Assessment Agency** was established in 2008 and it is part of the Ministry of Infrastructure and Water Management. It advises the government on environmental policy, and amongst others releases annually the Climate and Energy Outlook, which reports the expected CO_2 emissions and the progress of the country in reducing them.

- **The National Institute for Public Health and the Environment** is a research institute that helps the Dutch government to coordinate the actions of different ministries and their policies on matters relating to a sustainable, safe, and healthy environment. It is responsible for monitoring the quality of air, water and soil.

3.3. Evaluating the environmental and socioeconomic impacts of decarbonisation strategies

43. Evaluation of climate change policy packages is key to developing and implementing decarbonisation strategies. Beyond affecting emissions, climate policies can have large impacts on public finances, the labour market, firms' competitiveness, international trade, and innovation. These additional effects can generate economic and social costs differing across individuals, firms, sectors and regions. A systematic evaluation is crucial to inform the public debate and to design a policy mix offsetting negative economic and social effects.

44. Different approaches and models exist to evaluate decarbonisation strategies. They share common challenges, such as the treatment of uncertainty, especially regarding technological improvements; heterogeneity and distributional implications; the presence of non-linear responses to economic policies. Employing realistic damage functions for the economic impact of the physical consequences of climate change is also an important modelling challenge. In turn, the choice of a specific model is context-specific and depends on several criteria, including the specific question at hand and the need to provide insights on the underlining economic mechanisms; data requirements and ease of use; the importance of modelling sources of uncertainty and bound possible impacts; and its sectoral and geographical granularity.

45. Table 6 below provides an overview of evaluation tools. Analytical models, including computable general equilibrium (CGE) models, provide useful ex-ante insights based on economic theory and information on the economic structure. They can provide comparisons of policy alternatives before implementation and evaluate how policy affects the economy. Empirical methods provide an estimate of the effects of policies once implemented. Annex B summarises some of this evidence, focusing on competitiveness, trade, and FDIs (OECD, 2021[84]). Empirical methods can also be used, in combination with engineering data, to estimate the least costly technologies or policies to abate emissions. Abatement cost curves can be used to gauge the economic cost of reducing emissions in a certain sector or with a certain technology and are often a key input to analytical models. Annex B also provides more detail on abatement cost curves.

46. The OECD has a long-standing experience in developing and maintaining economic models to assess the socio-economic impact of structural reforms. Country desks have used the Long-Term Model (Guillemette and Turner, 2018[85]) maintained by the Economics Department to simulate the impact of various structural reforms on GDP, employment, investment and productivity growth, with results feeding into medium and long-term public debt simulations. The OECD has different modelling tools for the evaluation of climate-related policies, for example, the sectoral CGE models ENV-linkages and METRO (Box 12). However, none of them can fully assess the impact of climate change policies on emissions and socio-economic variables. Exploiting complementarities between these different models and additional empirical work would allow for creating country-specific policy scenarios and evaluating the joint effect of decarbonisation policies on emissions, growth, budget balances, employment, and household budgets.

Table 6. Main tools to evaluate the effect of decarbonisation strategies

Model type	Characteristics	Typical use	Policy insights	Limitations	Notable examples	OECD resources
Top-down analytical models						
Integrated assessment models (IAMs)	Integrate economics, energy systems and climate physics to provide a quantitative assessment of mitigation strategies	Estimating the social cost of GHG emissions; cost-effectiveness of various decarbonisation strategies.	Costs and benefits of mitigation; Optimal policy to mitigate climate change	Exogenous technological change; deterministic approach to uncertainty (modelled as an ex-ante scenario); no tail risks	DICE (Nordhaus, 2008); IPCC "Shared Economic Pathways" models	
Computable General Equilibrium (CGE) models	Analytical representation of an economy's general equilibrium considering several markets	Investigate the long-term consequences of introducing a policy	General equilibrium effects on the whole economy, disaggregated by sector	Limits in dealing with dynamics, market frictions, dynamics	GTAP-E (Truong et al, 2007); Denmark's GreenREFORM	ENV-Linkages, METRO, MOLES
Dynamic Stochastic General Equilibrium (DSGE) models	Analytical characterisation of an economy's general equilibrium, including dynamics	Investigate the consequences of a policy, with attention to the transition to a new equilibrium	General equilibrium effects including role of dynamics and uncertainties	Simplified structure of the economy (e.g. few sectors)	Angelopoulos et al (2010[86]); Annichiarico and Di Dio (2015[87])	
Partial equilibrium (PE) models	Description of a sector or specific market and its relation with climate, keeping other sectors exogenous	Uncover the cost-effective way to abate or estimate the cost of a climate policy in specific sectors	Sector-specific insights, including the role of new technologies	Underestimate the cost of GHG abatement policies as they ignore feedback loops from other sectors		IEA's World Energy Model The ITF Modelling Framework
Input-output and macroeconometric models	Describes the relationship between sectors using sales and purchases data; often augmented by econometrics	Investigate adjustments and the role of climate policies to reduce market imperfections	They do not assume perfect behaviour, hence allow more realistic simulation of dynamics	Less informative on long-term evolutions; data-intensive	Cambridge Economics' E3ME; the European Commission JRC's FIDELIO.	Trade-embodied CO_2 (Yamano and Guilhoto, 2020[88])
Bottom-up analytical methods						
Marginal Abatement Cost Curves	Use economic and engineering cost of policies and technologies	Guides towards the least costly way to abate	Establish priority areas of intervention; reflect well installation costs	Static snapshot; reflect less well economic costs; ignores equilibrium effects	Gillingham and Stock (2018[89])	
Empirical methods						
Econometric program evaluation	Uses micro-data and quasi-experiment to isolate causal effects of policies	Ex-post estimation of effects of a policy	Impact on several socioeconomic outcomes	Exogenous variation needed; data-intensive		Assessing the Economic Impacts of Environmental Policies (OECD, 2021[84])
Experiments and surveys	Engage with households (and firms) with a series of questions	Uncovers distribution of consumption and behavioural response to climate policies	Estimates preferences and inform policy on most accepted policy	Time and resource-intensive		EPIC Household surveys; Public acceptability of climate policy experiment; (OECD, 2017[90])

Source: OECD.

Box 12. Selected OECD modelling tools for the evaluation of climate policies

ENV-Linkages is a multi-country, multi-sector CGE model providing long-term projections on several macroeconomic indicators. To capture better the environmental dimension, ENV-Linkages models in finer details the agricultural and energy production sectors, e.g. distinguishing between different fuels and electricity production technologies. It can thus be used to formulate a wide array of global scenarios and to study the macro effects of policies aimed at a low-carbon transition. Because of data and computational limitations, countries are grouped in economic areas and not all of them are covered individually in the database used by ENV-Linkages.

METRO is a CGE model featuring a detailed trade structure and commodities differentiation by use (intermediate, household, government and capital). Therefore, it is particularly useful to investigate trade policies, global value chains and policy instruments targeting specific uses, such as resource-based restrictions or local content requirements. While METRO is not devised to investigate directly low-carbon transition policies, it could be useful to study trade policies in resource-intensive industries and other sectors relevant for the low-carbon transition, such as agro-food.

MOLES is a city model, combining a CGE framework with an urban microsimulation module (Tikoudis and Oueslati, 2020[91]). It can be used to project at a fine geographical scale the long-run response of urban areas to an environmental policy. MOLES takes explicitly into account a city's physical morphology, urban lay-out, transport network, and most other geographical features. The model provides projections on variables that are relevant for land use and transportation at the urban level, such as housing typology and density, vehicle ownerships, transport modes, road congestion and the associated emissions. MOLES model heterogeneous spatial effects of urban policies and can thus be used to study distributional effects within a city, for example comparing outcomes in rich and poor neighbourhoods.

The IEA World Energy Model is a global sectoral model providing medium and long-term projections for the energy sector. The model simulates the functioning of energy markets exploiting a wealth of information on energy supply, transformation and demand. The model considers several competing technologies and makes use of cost data to project their deployment. Because of the detailed information on industries and technologies in the energy sector, manufacturing sector, and at end-use consumption, the model can be used to obtain insights on future technological trajectories. The World Energy Model has been used to produce global (rather than country-level) scenarios, such as those contained in the World Energy Outlook, including the Stated Policy Scenario, the Sustainable Development Scenario, and the Net-Zero Emissions by 2050 case.

The ITF Modelling Framework contains four distinct partial equilibrium transportation models: two are dedicated to Freight transport (respectively urban and international), and two to Passenger transport (urban and international). The models can be used to project transport volume by mode and the associated emissions many decades in the future, under different policy scenarios. An attractive feature of these models is the fine network data that underline their calibration, encompassing complex transport alternatives and allowing to study individual countries or sub-country regions. Isolating an individual country is generally a straightforward exercise. All other variables than transport demand and network expansion are treated exogenously so the ITF Modelling Framework cannot investigate the feedback loops with other sectors.

4. Designing complementary policies to encourage innovation and mobilise private capital

4.1. Favouring innovation and business dynamism

47. Mitigation policies can spur investment and innovation if clear long-term signals to abate emissions are in place. Patenting in low-carbon technologies has considerably increased over the last twenty years, also pushed by more stringent regulation (IEA, 2021[92]; Calel and Dechezleprêtre, 2016[93]; Popp, 2003[94]; Dechezleprêtre, Martin and Mohnen, 2013[49]). In some cases, clear policy signals can have a larger effect than direct state support for R&D. For instance, minor changes in performance standards or automotive fuel prices have a larger impact on patented inventions than a similar proportional increase in R&D budgets for some technologies (OECD, 2011[95]). The different degree of success countries have experienced in the development and deployment of green technologies is then attributable to the interaction among price signals, standards and regulations, and R&D support measures.

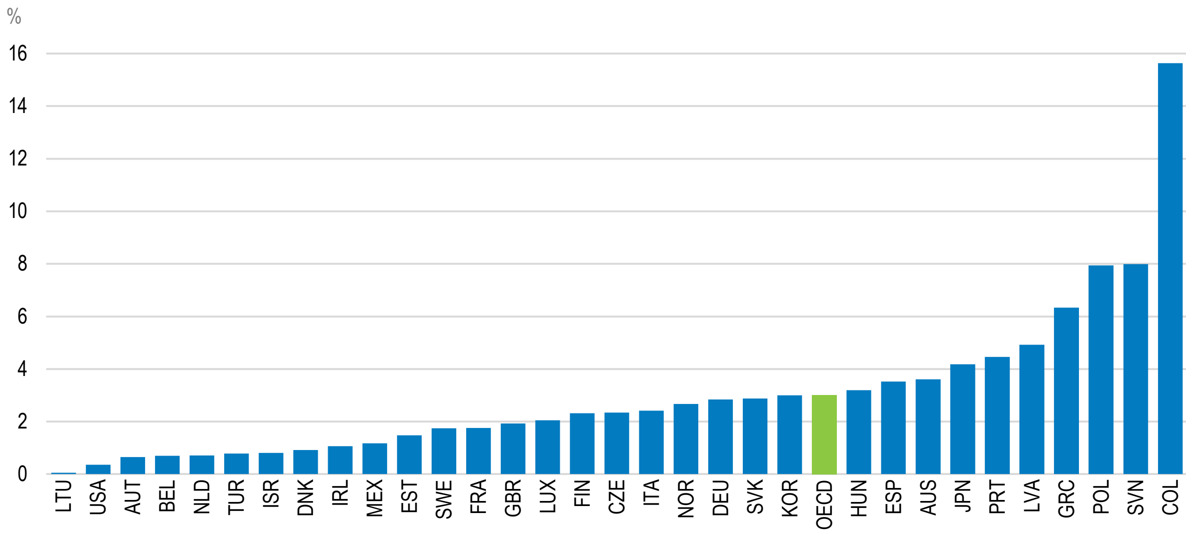
48. Incentives and obligations to abate are generally insufficient to spur innovation to a socially optimal level and they need to be complemented by other specific policies supporting innovation. Public support for innovation can take many forms: fiscal incentives to R&D, direct grants, public research and support for early-stage development (OECD, 2011[96]; Hepburn, Pless and Popp, 2018[97]). R&D and deployment subsidies are especially important given the high costs and uncertainty in green investments (Mazzucato, 2015[98]). Currently, the share of government R&D budget targeting environmental issues is low (below 8% of total government R&D) in most OECD countries (Figure 18) (OECD, 2015[99]). Targeted support to innovation, focusing on promising new technologies that are still far from commercialisation and on organisational changes (e.g. rethinking business models) (OECD, 2011[100]) can provide a 'technology-push' contribution and lower abatement costs in the long run.

49. Public support for basic long-term research is key to advancing knowledge and developing technologies in domains underserved by private R&D because of perceived too low and uncertain returns. Such support has helped to create new markets and transformed many industries, such as the internet, nanotechnology, biotechnology and clean energy (Mazzucato, 2015[101]). More recently, subsidies and loan guarantees have supported technology experimentation and innovation in wind turbines and solar photovoltaic panels, contributing to their deployment and significantly lowering their costs of energy, which is now competitive with those of fossil fuels (IRENA, 2020[102]). The increase in solar-panel installations in the early 2010s in the United States is mostly attributable to public grants and loan guarantees underwriting private loans as the risk was deemed too high for totally private financing schemes (Mendelsohn and Kreycik, 2012[103]). Similarly, many countries have recently launched hydrogen development strategies to explore the opportunity of using hydrogen to decarbonise the economy (IEA, 2019[104]).

50. Public support requires specific governance structures (Mazzucato and Perez, 2014[105]), ensuring a clear, transparent and independent decision-making process. Good governance can be achieved with multi-year budget appropriations, independence of the agencies responsible for funding decisions and using peer reviews. Competitive procedures with clear criteria for project selection and payments based on progress and outcomes rather than cost recovery or choice of technologies is also important (OECD, 2011[96]). Fraunhofer-Gesellschaft in Germany and the Catapult Network in the United Kingdom are two examples of effective governance structures.

Figure 18. Only a small share of government R&D budget focuses on environmental issues

Environmentally related government R&D budget, % of total government R&D, 2019 or last year available



Note: Data refer to 2018 for Estonia, France, Israel, Korea and Poland.
Source: OECD, Green Growth Database.

51. A clear legal framework can enhance interoperability and reduce asymmetric information, further supporting innovation activities. For example, defining who is liable for carbon leaks outside of carbon capture and storage facilities would reduce ambiguity for investors (Anderson et al., 2021[60]). Well-functioning systems of protection and diffusion of intellectual property rights, both at the national and international levels, are important to encourage innovation, though their effects vary across sectors (OECD, 2021[106]).

52. New and highly innovative firms play an important role in providing the radical innovation necessary for decarbonising economies. A dynamic and competitive business framework provides start-ups with the necessary resources to thrive and reallocating resources necessary to develop and commercialise new technologies towards firms best able to do this. Several initiatives can facilitate the reallocation process including: lifting the barriers to entry, reducing economy-wide administrative burdens on firms; reducing barriers to trade, providing firms with business and cross-fertilisation opportunities in international markets; reforming insolvency regimes and promoting access to finance. Encouraging start-up financing and seed funding plays an important role in bridging the gap from ideas to commercialisation, filling the gap in early-stage equity financing (OECD, 2020[107]).

4.2. Decarbonising infrastructure networks

53. Achieving the intermediate CO_2 reduction targets in 2030 and the net-zero target in 2050 requires a large investment to upgrade infrastructure networks, especially the energy and transport networks. The OECD estimates it would take only a 10% increase in yearly investment (from USD 6.3 trillion to USD 6.9 trillion to 2030) to develop infrastructure aligned with the goals of the Paris agreement (OECD, 2017[108]). Making infrastructure networks fit for a zero-carbon economy will require going beyond an incremental approach to deliver a systemic

transformation of existing infrastructures. Many existing infrastructures in the electricity and transport are due for or close to replacement. Decarbonisation provides an additional driver to accelerate their substitution and improve their quality.

54. The electricity and transport networks deserve attention as the energy and transport industries account for over 50% of total GHG emissions on average across OECD countries (Figure 9), being key inputs to all other industries. The electricity network is likely to play an even more important role in the future as many countries decarbonisation strategies rely on 'electrifying everything' based on the projected increase in the share of renewable energy sources in electricity generation. The success of this strategy depends on upgrading the electricity network to manage both the increasing share of electricity produced by intermittent energy sources (e.g., solar and wind) and the increasing load to the grid (as an increasing number of activities are electrified). As regards the transport networks, one of the main challenges involves ensuring enough recharging stations are available to meet the demand of the increasing numbers of electric vehicles (Zhou and Li, 2018[109]). Emerging technologies, such as hydrogen and energy storage, may also require a large investment in production, storage and pipeline infrastructures.

4.2.1. Public investment and sound regulations can help to crowd-in private investment

55. Developing a long-term climate framework signals a long-term commitment to fight climate change, helping to reduce policy and regulatory uncertainty. This is crucial to encourage long-term infrastructure planning and investment. The public sector has a key role to play to align infrastructure investment with the goal of increasing resilience to economic and climate-related shocks, and in catalysing private capital.

56. The public sector needs to establish an infrastructure sector's governance and regulatory framework in line with climate change targets. In addition, comprehensive infrastructure planning needs to become the norm across all countries. According to a 2018 OECD survey, only about half of OECD countries reported having a strategy for infrastructure that covers all sectors (OECD, 2019[110]). To align infrastructure development with national climate change targets and strengthen their credibility, infrastructure planning should be integrated into national long-term decarbonisation strategies, such as the long-term low-emission development plans recommended by Article 4.19 of the Paris Agreement.

Box 13. Green budgeting: aligning public expenditures with decarbonisation

Green budgeting is a set of tools that countries can use to: (a) assess how different budgeting choices impact green objectives, (b) prioritise investments that support a low-carbon recovery and (c) estimate how stimulus packages will impact green objectives. It can thus help governments shape their decisions on expenditure, revenue-raising and resource-allocation and to mobilise public resources towards investments that will contribute to achieve climate goals (OECD, 2020[111]).

Green budgeting includes the use of different tools:

- **Green budget tagging**, which allows countries to identify areas of expenditure and revenue that are helpful or harmful to green objectives. The information from tagging can help governments to improve coherence between budget measures and green goals whilst also improving transparency in relation to the government's budget policy. This, in the context of recovery efforts, can inform allocation decisions and in-year adjustments as well as feed into other budgetary processes, where considerations of efficiency and effectiveness are held in relation to their climate and environmental impacts.
- **Ex-ante or ex-post impact assessments**, which can provide information on the environmental impact of individual policies and programmes and help inform budget decision-making. Where information from impact assessments is provided alongside budget proposals, this can help to inform stimulus packages that have positive impacts on green objectives. The EU directive on Strategic Environmental Assessment (SEA), for example, requests the assessment of the proposed policy plans for likely significant effects on the environment.
- **Green budget statements (GBS)**, which can provide summary information on how recovery measures align with a country's green objectives. Using information from green budget tagging, impact assessments and other tools, a GBS can support greater transparency, accountability and public engagement on budget policy.

The availability of data on environmental impacts of budget choices remains limited or not systematically used. In 2018, 20% of surveyed OECD countries published the environmental and climate impact of individual budget measures. In the case of capital investments, such an environmental assessment is more common. Most OECD countries conduct environmental impact assessments at the beginning of the development of public infrastructure projects, but only 12 OECD countries estimate a project's potential carbon dioxide emission (OECD, 2019[112]).

The case of France

As part of its 2021 budget, France presented a comprehensive approach to green budget tagging initiated from its participation in the OECD's Paris Collaborative on Green Budgeting. This involves classifying budget lines according to their impact on six environmental objectives: climate change adaptation, climate change mitigation, biodiversity and sustainable land use, circular economy and risk prevention, water resources management and pollution abatement.

This approach has helped to assess potentially negative or positive spill-over effects from one environmental sphere to another and to identify expenditure measures that are harmful to France's climate goals ('brown') and the ones ('green') that instead would help to meet them.

However, so far green budget instruments have been used mainly as a communication tool on 'green' and 'brown' expenses. Green budget instruments have not led to any 'brown' expenses related action and no assessment on the efficiency of 'green' budgetary instruments has been performed yet.

Source: (OECD, 2020[111]).

57. More consistency between infrastructure planning and decarbonisation strategies will help to build credible infrastructure project pipelines (i.e. list of specific, investment-ready and bankable infrastructure projects) and to shift private finance towards infrastructure projects contributing to climate change targets. Dedicated project preparation facilities (PPFs) can be useful in this respect to build and concentrate expertise in projects' preparation, including those involving public-private partnerships, and bring forward investment-ready projects. Estimates suggest the costs of project preparation can be substantial, ranging between 2.5% and 10% of total infrastructure investment (OECD, 2018[113]).

Mobilising private capital

58. Delivering on international climate and development goals requires scaling up of private investments in green infrastructure. In many countries, high levels of public debt (compared with historical norms) risk constraining public investment and aggravating the already large investment gap.

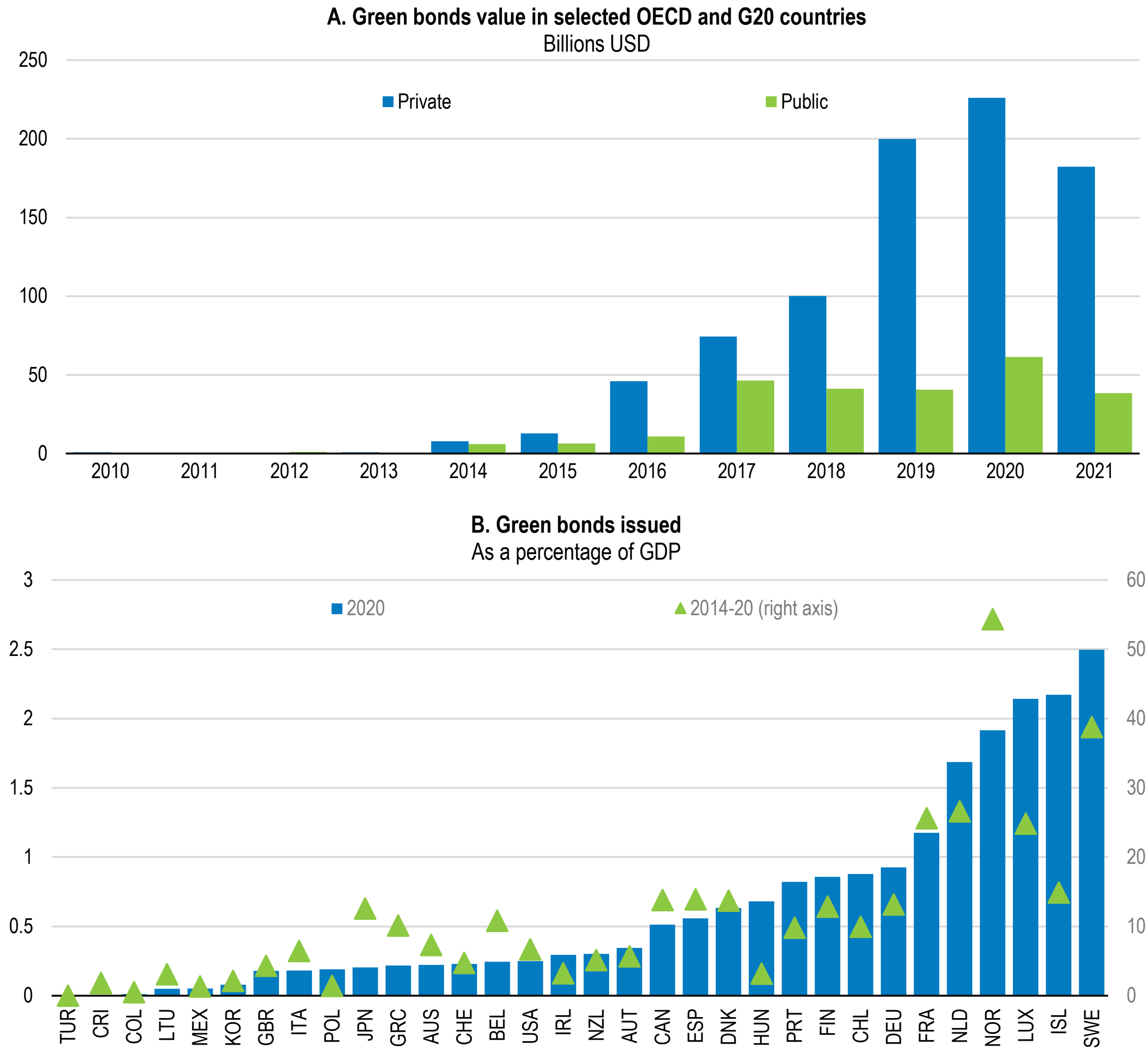
59. In OECD and G20 countries, there is ample scope to increase the participation of institutional investors (i.e. pension funds, insurance companies, asset managers and sovereign wealth funds) in infrastructure financing, especially green infrastructure. According to recent OECD research (OECD, 2020[114]), total assets under management (AUM) of institutional investors in OECD and G20 countries amount to USD 64.8 trillion. However, because of risk diversification and regulatory quantitative requirements, institutional investors can allocate to infrastructure-related projects up to USD 11.4 trillion (i.e. investable AUM). The actual value of institutional investors' infrastructure-related assets (excluding investment in infrastructure-related corporate stocks and real estate) is estimated at about USD 1 trillion (just 10% of the investable AUM). Out of this, only USD 314 billion concern green infrastructure assets (less than 3% of investable AUM).

60. Overall this suggests that, on aggregate, current investment limits are not a main constraint impeding the flow of funds towards infrastructure projects, including green ones. Market-based instruments and other policy measures, such as clear and long-term policy signals, may have an important role in shifting institutional investors' assets under management towards green infrastructure projects.

61. The acquisition of operational projects is the main channel through which institutional investors participate in infrastructure-related projects. The preference for operational projects is entrenched, as the construction phase is perceived as having a high-risk profile. However, investment in projects in the construction phase has increased in recent years as the persistent low yields of traditional assets have induced many investors to pivot towards projects with higher risk-adjusted returns (OECD, 2020[114]).

62. Unlisted funds and direct project-level equity are the main conduits to infrastructure investment while direct debt plays a smaller role. This is true also for green infrastructure projects. Direct infrastructure debt is a relatively new asset type for institutional investors but interest in it has been increasing in recent years. Issuance of green bonds is rising (Figure 19), but to date they have not delivered significant financing for green infrastructure projects.

Figure 19. Green Bonds Value in selected OECD and G20 countries



Note: Data from selected countries (BEL, CAN, CHE, CHL, CHN, DEU, ESP, FIN, FRA, GBR, HUN, JPN, KOR, IRL, ITA, LTU, LUX, MEX, NLD, NOR, NZL, POL, SWE, USA, ZAF) as of June 2021.
Source: Eikon Refinitiv, Green Bonds Guide.

63. Different approaches, lack of comparability and data inconsistencies continue to beset environmental, social and governance (ESG) rating methodologies (including the 'E' pillar), hindering their adoption and blunting their effects on asset-allocation decisions. On a general level, methodological differences result in a lack of correlation among different ESG ratings and 'E' scores may not help to align investors' portfolios with a low-carbon transition. Rating providers do not prioritise carbon footprint or intensity among all the metrics comprising 'E' scores. They appear to place large weights on the existence of climate-related corporate policies and targets rather than assessing their quality and effects. For some ESG rating providers, 'E' scores actually correlate positively with high carbon emissions. Finally, insufficient data – including financial metrics and analytical tools to manage transition risks – and lack of policy clarity regarding emission pricing and support for renewables hamper the market pricing of ESG ratings (Boffo, Marshall and Patalano, 2020[115]).

64. Governments should attempt to mobilise domestic or regional institutional investors as these prefer to invest in assets located within their region of origin. This is especially true for green infrastructure investment, possibly signalling the perceived importance of regulatory risks (which foreign investors are ostensibly less able to manage than domestic investors). Cross-border infrastructure holdings are still limited and tend to concentrate in mature markets.

65. To accelerate institutional investment in green infrastructure, governments should concentrate on the following pathways:

- **Improving green infrastructure project pipelines** (as highlighted above) and enabling investor partnerships involving the public and private sectors. Green infrastructure project pipelines are key to increasing the number of 'bankable' green projects. At the same time, partnerships between asset owners (in particular pension funds and life insurance companies) can be effective in sharing risks, lowering the cost of capital, developing specialised capabilities and unlocking long-term capital. The Danish wind industry offers an instructive example of risk-sharing through partnerships. Government incentives have spurred collaboration among Danish pension funds, which was instrumental in developing collective know-how and expertise in the wind sector. A notable example is the 2011 deal for the 400 MW Anholt offshore wind farm, in which Pension Denmark and PKA together acquired 50% at EUR 900 million (Clean Energy Pipeline, 2014[116]).
- **Clarifying the relationship between fiduciary duty, duty of care and consideration of climate-related risks could encourage asset owners to issue 'green' mandates to asset managers**. This can entice investors who otherwise may be reticent to invest due to the risk of breaching their fiduciary duty (Climate-Related Market Risk Subcommittee, 2020[117]). This is especially important as unlisted funds account for 37% (USD 380 billion) of total infrastructure investment but less than 30% of their capital (USD 93 billion) is allocated to green assets.
- **Strengthening the regulatory environment for securitised/structured products** so as to attract investors with a preference for liquid investment products (such as investors managing defined contribution pension plans as well as passive investment funds).
- **Encouraging private actors to adopt more transparent climate-related disclosures and a more precise and consistent definition of 'green' projects and metrics** so as to improve investors' confidence and facilitate due diligence. Cooperation with private-led initiatives, such as the Task Force on Climate-related Financial Disclosures, Climate Action 100+ and Transition Pathway Initiative, could help to standardise and clarify environmental, social and governance (ESG) ratings and their sub-components.

66. Regulatory capital frameworks have generally required banks and insurers to put aside more capital for infrastructure investments than is warranted by their historical credit performance, according to an analysis recently commissioned by the Global Infrastructure Hub (Risk Control Limited, 2020[118]). However, recent regulatory changes lessen capital charges for infrastructure debt. For instance, the European Union Capital Requirement Regulations (art. 501a) set lower capital charges for infrastructure-related debt under certain conditions, such as meeting climate change objectives. Furthermore, with the implementation of Basel III, high-quality projects financed through project financing, including those towards managing climate risks, get a lower risk assessment. In most cases, however, regulatory authorities do not yet explicitly differentiate infrastructure investments from generic corporate exposures. By applying the historical credit performance of infrastructure investments to the calibration approach

commonly used by regulators, capital charges for infrastructure debt could be reduced by 60% to 70% for banks and insurers. This is true both for high-income and middle- and low-income country infrastructure loans (Boffo, Marshall and Patalano, 2020[115]).

Preserving competition while encouraging new capacity investment in electricity markets

67. The characteristics of electricity generation relying on renewable energy sources (i.e. high capital cost, low marginal costs) exacerbate the 'missing money' problem.[8] Uncertainties on electricity prices over the lifetime of a new plant is a significant barrier for investment in high capital-cost technologies. For this reason, with some exceptions, investments in low-carbon technologies have so far largely relied on support measures and subsidies to lower risks caused by high upfront capital costs.

68. Support measures to boost the electricity generation based on renewable energy include feed-in tariffs (FITs), long-term power purchase agreements (PPAs), contracts for difference (CFD), regulated electricity tariffs, feed-in premiums (FIPs) or even direct capital subsidies through, for instance, loan guarantees. Capacity remuneration mechanisms (CRMs), designed to ensure continuity in electricity supply during the few hours of extreme peak demand, instead favour technologies with low fixed capacity costs, usually combined cycle gas turbine, as they are the only ones willing to invest when the expected operating hours are few every year. All these are appropriate instruments to achieve long-term efficiency and security of electricity supply with low-carbon technologies (i.e. renewable energy sources and nuclear depending on country circumstances) as they can promote capacity investment and market competition at the same time (OECD/NEA, 2019[119]). FIPs or direct capital subsidies have a direct link with wholesale electricity prices, which is important for the efficient dispatch of electricity and value discovery. FITs and other instruments, sharing the key characteristic of long-term contracts guaranteeing a price corresponding to the average cost, entail competition for the market instead of competition in the market.

69. Going forward, as the share of renewable sources in electricity generation increases, these support measures could become a permanent feature of electricity markets (Finon, 2013[120]). Removing them would risk making even mature carbon-free technologies too risky and financially unviable. Their low marginal cost of generation could push down electricity prices below recovery levels for long periods, making it difficult for power plants to recover capital costs. This would discourage investment in new capacity.

70. The regulatory challenge for a decarbonised electricity system then revolves around combining market competition, so as to dispatch electricity at low cost, with explicit mechanisms to foster investments in new capacity and meet future demand needs. Tackling this challenge demands action in two areas (OECD, 2015[8]):

- In the near term, gradual but steady increases in CO_2 prices (through for instance combining an ETS with a gradually increasing carbon price floor as discussed in Box 9) will support electricity prices. In addition, it will grant carbon-free sources a

[8] The 'missing money' problem is due to two main factors. First, pricing electricity on the basis of the variable cost of a marginal power plant does not guarantee the full recovery of capital costs for all power plants (especially of those with high capital costs). Second, allowing prices to reach very high levels when demand is high can help in recovering capital costs, but such events may be too few and uncertain to trigger investments in new capacity. Also, in such events, demand may not be fully met, leading to politically and socially unpopular rolling brown-outs (as it happened in Texas in winter 2021) (Baritaud, 2012[266]; Finon, 2013[120]; OECD, 2015[8]).

cost advantage as fossil-based plants will continue to be marginal suppliers on the market, thus supporting a rising share of free-carbon technologies in electricity generation.

- Over the medium and long-term, organising competition for the investment in new power plants based on the average cost of generated electricity rather than the marginal cost (in contrast with today's practice in which investment decisions are made based on the expected evolution of wholesale prices that depend on the marginal cost of the less efficient plant) will strengthen incentives to invest in new capacity.

Decarbonising the transport infrastructure network

71. Decarbonising the transport sector will be crucial to achieve the Paris Agreement's goal. In many countries and globally, transport is the largest energy end-use sector (IEA, 2020[121]). However, under current policies and commitments, CO_2 emissions from transport are projected to rise by 16% to 2050, compared to 2015 (ITF, 2021[122]). Total transport activity will more than double by 2050 compared to 2015 with economic growth in less developed countries and continued world population growth being the main drivers of rising transport demand.

72. More ambitious policies and further technological developments could lower transport CO_2 emissions by almost 70% in 2050 compared to 2015 and contribute to the goal of the Paris Agreement. Such policies will have to straddle different areas and aim at (ITF, 2021[122]): 1) avoiding unnecessary travel; 2) shifting mobility to sustainable transport options; 3) improving vehicle technologies and alternative fuels (Box 14).

Box 14. Pathways to decarbonise the transport sector

Ambitious and effective policies to reduce transport emissions need to act along three main axes (ITF, 2021[122]): 1) avoid unnecessary travel; 2) shift mobility to sustainable transport options; 3) improve vehicle technologies and alternative fuels. However, these three approaches ("avoid, shift, and improve") are not equally applicable across the whole transport sector.

Urban passenger transport systems can deploy all three approaches by shortening travel distances (through for instance land management and use), offering non-motorised options and achieving high user volumes on public transport. For instance, for longer urban trips, using urban rail instead of private cars delivers a 91% lower final energy use per passenger-kilometre (IEA, 2020[123]).

Decarbonising regional and intercity passenger transport will have instead to rely more on progress in-vehicle technologies (i.e. fuel efficiency and technologies) as demand management is more difficult in this sector than in urban transport. Shifting transport to more sustainable options will also help. High-speed rail's energy use per passenger-kilometre is 93% lower than that of aviation;

Freight transport will have to rely on low-carbon technologies, consolidation and shifting of loads to more sustainable modes as well as rapid digitalisation. For instance, freight rails use 72% less energy per tonne-kilometre than freight trucks; further, digitalisation of the road freight industry could reduce its energy use by 20-25% (IEA, 2017[124]).

73. In the short and medium term, a complete shift away from high-emission modes is not feasible (ITF, 2021[122]). First, the transport sector depends on oil more than any other end-use sector: in 2018 in OECD countries, oil products accounted for 92% of transport's total final energy consumption (IEA, 2020[121]). Potential clean alternatives (i.e. electricity) are already available for cars, but further technological progress is needed to develop and scale-up clean energy sources for sectors such as aviation, shipping, and haulage. Second, shifting transport

to today's more sustainable modes (i.e. rail services), while a necessity, has limits. Rail services can replace air travel on high-demand routes and over a limited distance (IEA, 2019[125]). In the freight sector, road transport offers greater flexibility especially on short distances than rail and inland waterways. Currently, active travel modes and public transport are realistic alternatives to cars only in compact urban areas given the high density of infrastructure services and relatively short trip distances.

74. Stronger collaboration between ministries and agencies involved in transport policies and those with responsibilities over land use management, energy and others is key to decarbonising the transport sector. Integrating land-use decisions and transport planning can reduce transport demand and trip lengths while improving accessibility for citizens in addition to limiting urban sprawls (OECD, 2018[126]). Supporting technological developments in alternative fuels and technologies (such as hydrogen) can contribute to decarbonise aviation, shipping and haulage where electrification is not feasible given the low energy density of batteries. Carbon-free passenger transport systems require clean electricity production.

75. Increasing the stock of zero-emission vehicles in circulation hinges on rolling out publicly accessible recharging infrastructures, in addition to incentives for the purchase of zero-emission vehicles (as their price is still higher than those with internal combustion engines). Currently, most charging of EVs is done at home and work but publicly accessible charging stations are critical to lower drivers' range-anxiety and offering recharging opportunities to users without off-street or reserved parking places (IEA, 2021[127]) The experience of Norway (Box 15) and in-depth studies suggest that the provision of fast charging infrastructure is a strong driver for EV uptake as users prefer fast and ultra-fast chargers for both inter- and intra-urban travel (Neaimeh et al., 2017[128]; Transport & Environment, 2018[129]). Though the installation costs of a fast-charging station are significantly higher than a slow-charging station, building a network of fast chargers may cost less than an equivalent one of slow chargers, provided that grid reinforcement is not required, because of the significantly lower number of stations (Nicholas and Hall, 2018[130]).

76. Norway is a good example of effective policies in both areas, which are contributing to Norway's target of cutting transport emissions by 50% to 2030 (Climate Action Plan (2021[131])), though they are not without challenges (Box 15). The experience of Norway suggests the following lessons to other countries: 1) the transition to zero-emission vehicles is a long-term endeavour, calling for persistent policies; even in Norway, at current trends, greening the entire car fleet would still take decades; 2) structure incentives so as to encourage the replacement of older and more polluting cars instead of simply the purchase of new EVs (i.e. subsidies to encourage the scrap of old and dirty cars when replaced by EVs, such as the *Prime à la Conversion* in France); 3) cap tax incentives or charge taxes on the more luxurious EVs so as to make EVs' incentives more progressive; 4) support investment in recharging stations.

Box 15. Norway continues to adjust its electric vehicle incentives

As of 2020, there were some 340,000 electric cars (EVs) in Norway, the largest number among European countries and representing about 16% of global sales. The share of electric vehicles in the vehicle stock is growing. For instance, the share of battery-only passenger cars increased from 9.3% to 12.1% between 2019 and 2020 (the increase in BEV traffic volume is roughly similar). The impressive outcomes in EV take-up have been driven by substantial tax benefits and privileges, including exemptions from value-added tax and vehicle registration tax, along with cheaper access to toll roads and parking.

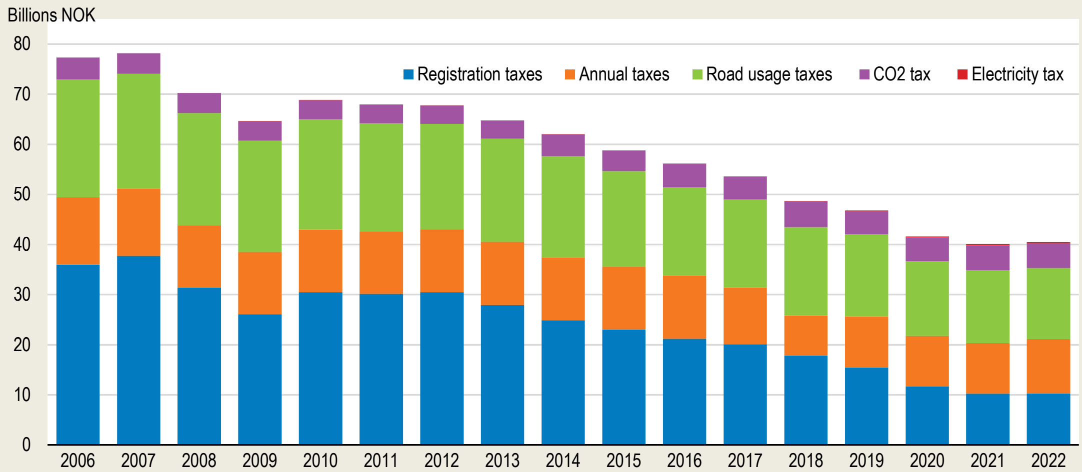
However, the push to encourage households to purchase electric vehicles has come at a cost. The policy has contributed to a sizeable revenue decline from car-related excise duties (Figure 20). This amounts to about 0.1 percentage points of mainland GDP each year. Also, when viewed only in terms of direct CO_2 abatement costs, the policy is not very efficient. For instance, according to Fridstrøm (2021[132]) the tax breaks and the behavioural responses to them imply an abatement cost of EUR 1370 per tonne of CO_2 for battery electric cars (as of 2019) and EUR 640 and EUR 200 per tonne for light and heavy-duty commercial vehicles. A recent OECD study estimates the cost of emission reduction through the tax concessions to be around ten times the EU-ETS quota price – the cost of emitting a tonne of carbon under Europe's emissions trading system (Eskeland and Yan, 2021[133]). As elsewhere, there are valid arguments for EV-subsidy exceeding the abatement cost. The extra subsidy helps the EV market reach critical mass (reducing the need for subsidy in the long term). Also, positive externalities from EVs' reduced noise and air pollution suggest that subsidies are worthwhile. However, these benefits are hard to measure and it is unknown how far they justify the current scale of Norway's EV support.

As the EV market has matured, the government has been scaling back some of the incentives. Provisions allowing free use of bus lanes have been reduced. In addition, as of 2021, electric vehicles have been subject to annual vehicle insurance tax. The rate is set at the same level as for motorcycles (NOK 2 135 per year, i.e. around EUR 214), which is around 70% of the insurance tax rate for cars with internal combustion engines. The Norwegian government is considering replacing the tax with a GPS-based distance, location and time-contingent road charge This type of road charge can reframe vehicle taxation to ensure road users internalise congestion costs and related externalities. It can also help offset the fuel-tax revenue losses arising from the transition to EVs (OECD, 2022[134]).

Government support for charging stations has been in place since 2010 and the current scheme aims for fast charging stations every 50km on around 7,500 km of Norway's road network. In 2021, according to the NOBIL database of the Electric Car Association, there were around 5,700 charging points, up from 800 in 2015. In recent years, charging operators have been building fast-charging stations without subsidies, especially in larger cities and along major highways. While un-subsidised stations will probably become increasingly viable, government support will likely still be needed to ensure availability in remote areas.

Figure 20. Revenue from car-related taxation is declining in Norway

Vehicle-related tax revenue



Note: Adjusted for inflation, estimated 2022 NOK values.
Source: OECD (2022[134]) and Royal Norwegian Ministry of Finance.

Table 7. Key elements of policies encouraging electric vehicle purchase

Tax breaks for EV owners	Taxation of car purchase: - Exemption on VAT (normally 25%) - Exemption from the one-off motor vehicle registration tax (a tax based on vehicle weight emission characteristics). Recurrent taxation: - Favorable treatment in the annual "traffic insurance tax" (a flat-rate tax differing across vehicle types). EVs were previously exempt but as of 2021 are charged at the same rate as motorcycles.
Concessions for EV drivers	Concessionary rates on parking, road tolls and ferry fares. Provisions allowing use of bus lanes (from 2016 these were narrowed to only allowing use by EVs carrying at least one passenger). Urban road-toll concessions are also being reduced. For instance, EVs are now subject to Oslo's congestion charge.
Regulation	There is a target that by 2025 all new passenger cars sold and city buses should be zero-emission.
Support for charging stations	A competitive-bid subsidy program run by Enova covers up to 100% of investment costs, including purchase of a charger, grid connection, shielding and communication and payment solutions.

Source: (OECD, 2022[134]).

5. Designing complementary policies to address distributional and labour transition effects of climate policies

5.1. Climate policies have distributional effects

77. One general empirical finding is that uncompensated climate policies tend to be regressive (Table 8). The extent of these distributional effects depends on the policy design, the price sensitiveness of different consumer groups and their consumption baskets and how costs generated by policies pass-through to the economy (Reguant, 2019[135]; Zachmann, Fredriksson and Claeys, 2018[136]).

Table 8. Distributional effects of selected uncompensated climate policies

Policy type	Distributional impact	Explanation / reservations	Confidence
Carbon pricing: Transport / road fuel	Mixed evidence	The number of low-income households with cars is lower, but those who own a car spend more on gasoline than other households. Heterogeneity between countries.	Medium
Carbon pricing: Electricity	Regressive	Low-income households spend higher shares of their income on electricity, and their demand for it is inelastic (e.g. due to financial limits to buy energy-efficient appliances).	Medium
Carbon pricing: Heating	Regressive	Similar to electricity, but it is less clear whether low-income households are disproportionately harmed by these fees.	Medium
Carbon pricing: Air transport	Progressive	High-income households use air travel at an above-proportionate rate compared to the general population.	High
Carbon pricing: Maritime transport	Regressive	In comparison with wealthier households, low-income households spend a higher income share on imported goods. Nevertheless, fewer maritime trades might be beneficial for manufacturing jobs, associated with low-skilled/low-waged households.	Low
Subsidies on low-carbon technology (e.g. US tax credits for renewables[1])	Regressive	Domestic technology investments (e.g. building insulation, less-emitting vehicles, and solar panels) are usually done by higher-income households, given the financial constraints inhibiting lower-income households from the required upfront investments in new equipment, as well as credit market imperfections and uncertainty. For example, 90% of tax credits on electric vehicles in the US were received by the top income quintile.	High
Public investment in low-carbon technology or complementary infrastructure	Mixed evidence	Contingent on the investments' effect on demand for capital or low-skilled workers, and which households enjoy it most and are the main users (e.g. city buses are mainly used by low-income households, while high-speed trains are used by high-income ones).	Low
Higher tariffs on high-carbon imports	Mixed evidence	Low-income households rely more on high-carbon imports, but local high-carbon industries, associated with low-skill-low-wage workers, may benefit from the induced protectionism.	Low
Energy and vehicle efficiency standards (e.g. the US CAFE[2])	Regressive	More regressive compared to fuel taxes, and likely less efficient. Examples: • Energy efficiency standards: high-income households already buy relatively more efficient versions of appliances and homes, and are thus less affected. • Vehicle efficiency standards: no efficient differentiation between vehicle models with varying average lifespans; producers are encouraged to demand higher prices for less-efficient vehicles, trickling down to the prices of second-hand ones that are sought by low-income households.	Medium
Agriculture related policies (e.g. taxes or standards)	Regressive	Low-income households spend a higher income share on food. However, both low and high-income households spend similar shares on high-emission food, and may hence face a relatively proportionate rise in prices.	Low

Note: The 'Confidence' column is based on the availability of relevant literature, the existence of consensus and the original findings included in the source publication. 1. For instance, the *Renewable Energy Tax Credits* program provides subsidies for investments in 'green' energy, such as solar panels. 2. *CAFE* (Corporate Average Fuel Economy) is a US framework of standards aimed at incentivizing the usage of more fuel efficient or electric vehicles, by introducing penalties on the production of inefficient ones.
Sources: Adapted from (Zachmann, Fredriksson and Claeys, 2018[136]). Additions from (Flues and Thomas, 2015[137]) – carbon pricing: transport/road fuel, electricity, heating; (Borenstein and Davis, 2016[138]; OECD, 2008[139]; Foster and Rosenzweig, 2010[140]) – subsidies on low-carbon technology; (Levinson, 2019[141]; Jacobsen et al., 2020[142]; Davis and Knittel, 2019[143]) – energy and vehicle efficiency standards.

78. Climate policies can affect households differently across the income distribution along three channels:[9]

- *'Source-side' income effects,* arising from uneven remuneration of labour and capital. The consequences of the progressive reduction in the production of polluting goods and services are expected to be shouldered by labour more than capital, through real wage reductions and job losses (OECD, 2012[144]) and especially by low-skilled and low-paid workers (Chateau, Bibas and Lanzi, 2018[145]; Marin and Vona, 2019[146]; Zachmann, Fredriksson and Claeys, 2018[136]). Displaced low-skilled workers may suffer from long-term scarring effects, because of barriers to reskilling, upskilling and geographical mobility (Fullerton, 2011[147]; Phylipsen, Anger-Kraavi and Mukonza, 2020[148]; Zachmann, Fredriksson and Claeys, 2018[136]; Walker, 2013[149]);
- '*Use-side' income effects,* arising from the changes in prices of certain goods (depending on their pollution content) whose consumption vary across the income distribution. In developed countries, such policies are likely to be regressive as lower-income households generally spend a larger share of their income on energy. In developing countries, where energy poverty is an issue, households close to the energy deprivation line spend only a small share of their budget on energy. In these countries, carbon and energy taxation may then be progressive, though it tends to deepen energy poverty (Phylipsen, Anger-Kraavi and Mukonza, 2020[148]; Levinson, 2019[141]; Fullerton, 2011[147]; Zachmann, Fredriksson and Claeys, 2018[136]; Dorband et al., 2019[150]);
- *Non-pecuniary effects,* emerging from asymmetric effects on health and mortality (Chay and Greenstone, 2003[151]), productivity (Graff Zivin and Neidell, 2013[152]; Hanna and Oliva, 2011[153]), human and physical capital accumulation, and property values. Climate change tends to have larger impacts on lower-income groups (Hsiang et al., 2017[154]) because they are less able to adapt and mitigation policies. On the other hand, improvements in environmental conditions, such as air pollution, benefit more homeowners and higher-income households (Grainger, 2012[155]; Cattaneo et al., 2019[156]).

5.2. Utilising revenues to balance distributional 'use-side' income effects

79. Offsetting the regressive impact of mitigation policies by recycling the revenues of some of these policies (such as emission pricing) is key to bolster public acceptability (Section 6). Though explicit revenue earmarking is generally to be discouraged as it creates rigidities in spending priorities (leading to inefficient allocation of resources), in some cases, it can be a useful tool for governments to commit and clearly communicate how the additional revenues will be used. This can contribute to increase trust and defuse opposition to revenue-raising measures. Earmarking of excise fuel taxes revenues is already in place in about half of OECD and G20 countries, mostly towards the maintenance and construction of transport-related infrastructures (Marten and van Dender, 2019[61]).

80. Recycling revenues through fixed (i.e. lump-sum) transfers is efficient (as they do not distort behaviour) in addition to being simple to administer. Switzerland provides an example of such policy, providing a lump-sum transfer to partially compensate for its CO_2 tax on heating fuels (Box 18). However, fixed transfers are seldom used in practice as they can be expensive.

[9] Vona (2021[195]) provides a detailed review of the evidence.

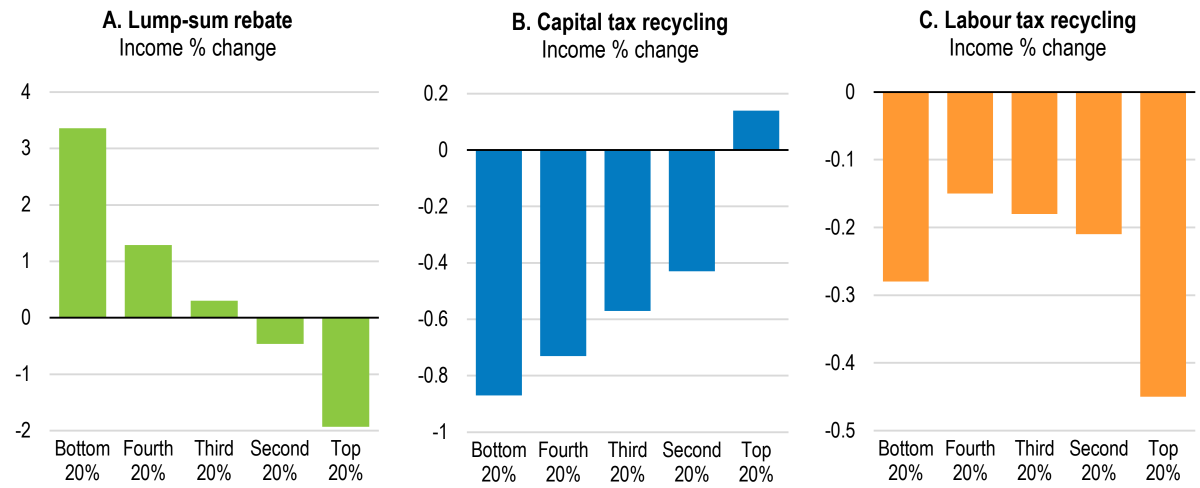
Targeting can be problematic and compensating every household irrespective of income blunts their redistributive power (Zachmann, Fredriksson and Claeys, 2018[136]).

81. Targeted transfers are usually preferred because they tend to be less expensive than fixed (lump-sum) transfers and can be perceived as fairer. Different methods can be used to target the transfers to households (Lavallee et al., 2010[157]). However, targeted transfers may distort incentives to work, can be stigmatising and cause regressive outcomes in countries with significant tax evasion and be administratively complex. In British Columbia (Canada), revenues from a carbon tax are redistributed with a combination of support to firms, cut to income taxes, targeted property tax rebates to rural and northern homeowners, and a targeted financial transfer for lower-income households (Box 20). Because of the volatility and regressivity of oil prices, providing strengthened household support in case of oil price peaks can prove effective, provided that the support is temporary (Bureau, Henriet and Schubert, 2019[158]).

82. Revenues can also allow for tax cuts. Reducing direct taxes (such as corporate and personal income tax) improves the cost-effectiveness of climate policies (lowering both emissions and tax distortions) and fosters job creation (Bovenberg, 1999[159]; Goulder, 1995[160]). However, reducing corporate income and capital taxation is likely to be strongly regressive (Rosenberg, Toder and Lu, 2018[161]). Similarly, personal income tax reductions may be regressive for people with very low income, as they are mostly exempted to pay the personal income tax. Indeed, emission pricing combined with a reduction in employee payroll taxes or social security contributions entails a ‘U-shape’ effect on household income: higher costs for the bottom and top income households than for the middle-income households (Chiroleu-Assouline and Fodha, 2014[162]) (see Figure 21 for recent evidence on the United States).

Figure 21. Distributional effects of a carbon tax under different uses of revenue

% change in income across income quintiles, United States, 2015



Note: The y-axis represents the percentage change in income, omitting the environmental benefit of the carbon tax from reduced GHG and air pollution.
Source: (Williams, Burtraw and Morgenstern, 2015[163]).

83. Investments and social funds can also be used to increase the progressivity of climate policies, by focusing on infrastructures benefitting especially the poor (such as public transportation) or targeting to the poor, such as subsidies for home energy retrofits (Bourgeois,

Giraudet and Quirion, 2021[164]). 'Green' social housing is one such common intervention in several countries, including Ireland, the United States, and Brazil (UN-Habitat/UNEP, 2015[165]).

84. The phasing out of fossil fuel subsidies is a necessary step towards decarbonisation and will reduce the strain on public budgets. The existence of fossil fuel subsidies is justified based on their role in supporting household consumption, especially for poor households. The phasing out of fossil fuel subsidies should be gradual, well communicated, and accompanied by other supporting or compensating measures. For example, Indonesia's reform of electricity subsidies and fuel pricing (Box 16) has been accompanied by increased funding for social assistance programmes as well as infrastructure projects (OECD/IEA, 2021[166]). More than 30 countries, including the United Kingdom, US, Canada and Germany, agreed to end new direct public support for the international unabated fossil fuel energy sector by the end of 2022, during the 2021 COP in Glasgow.

Box 16. Phasing out fossil fuel subsidies: the case of Indonesia

Indonesia is one of the world's largest GHG emitters (OECD, 2021[167]). In 2018, coal, natural gas and oil accounted for 74% of its energy mix (IEA, 2020[168]), supported by decades-long and generous fossil-fuel subsidies. The rationale behind these subsidies is to support fossil fuel production industries and attract related investments, as well as to maintain low and stable energy and fuel prices to alleviate poverty and reduce inequality.[1]

The subsidies have supported the consumption and production of dwindling fossil fuel reserves, increasingly burdening the environment, producing local air pollution, and contributing to climate change. Between 1990 and 2018, rapid economic growth and reliance on fossil fuels resulted in a more than four-fold increase in CO_2 emissions (OECD, 2012[169]; IEA, 2020[168]). Moreover, the social-welfare redistributive rationale of aiding low-income households was only partly met, due to flawed targeting that resulted in middle- and high-income households being the major beneficiaries (Mourougane, 2010[170]). Subsidies have also weighed heavily on the budget, accounting for above 4% of total spending (2017).

To address these issues, the government has enacted several reforms in recent years, promoting energy pricing liberalisation and better targeting of subsidies. This has resulted in a reduction in consumption of subsidised fuels (Republic of Indonesia: Ministry of Finance and Ministry of Energy and Mineral Resources, 2019[171]), as well as substantial budget savings, which the government has reallocated to investments in infrastructure, rural development, welfare, health, education and agricultural subsidies. To cushion the impacts on the poor and increase acceptability, the reforms were complemented by mitigation measures (such as temporary cash transfers and support for health and education), and accompanied by public information campaigns highlighting their rationales and benefits.

In tandem, Indonesia has committed to utilise its renewable energy potential and aims to reach 23% renewables in its energy mix by 2025. However, reaching the Nationally Determined Contribution (NDC) target to reduce GHG emissions (compared with business-as-usual) by 29% (or 41% conditional on receiving international support) by 2030 will require a substantial improvement in energy efficiency and further development of renewable energy sources (OECD, 2021[167]).

[1] Fossil fuel subsidies mentioned here include direct budgetary support; tax code provisions; and support for fossil fuel use or production via government provisions of auxiliary goods or services for no cost or at below-market prices, requiring non-government entities to provide some services to fossil fuel producers at below-market rates or purchase from them services at above-market quantities. For an overview of the support measures for fossil fuels in Indonesia and other G20 or OECD countries, see the OECD Inventory of Support Measures for Fossil Fuels (2021[37]).

Source: (OECD; IEA; World Bank; IISD-GSI; GIZ Indonesia; Members of the Peer Review Team: China, Germany, Italy, Mexico, New Zealand, 2019[172]; Durand-Lasserve et al., 2015[173]).

5.3. Addressing 'source-side' income effects through supporting workers in transition

85. The reallocation of workers from high to low-emission industries can involve large economic and welfare costs. The skills required in brown jobs are only partially transferable to green jobs, especially within the same working categories (ILO (International Labour Organisation), 2011[174]). Recent empirical evidence points to a negative effect of climate policies on manual workers (Marin and Vona, 2019[146]). Some green jobs are highly innovative, suggesting that the skill requirements may be higher and more specific than in comparable occupations elsewhere (OECD, 2012[144]; Consoli et al., 2016[175]). In particular, the green transition could increase the demand for science, technology, engineering and maths (STEM) and managerial skills that are necessary to implement and monitor environmentally related organisational practices (Vona et al., 2018[176]). So far, skill shortages have been small, except in specific areas, such as photovoltaic panels installations (Germany), design engineers for smart grids (the United Kingdom), and installation and maintenance of solar electrical systems (Spain) (OECD, 2011[177]).

86. Ramping up and adapting active labour market programs (ALMPs) will facilitate the reallocation of workers (Botta, 2019[178]). Job-search and training schemes, such as those implemented in Germany (Ruhr region), Canada (Alberta) and the United Kingdom, help workers with brown jobs to find green opportunities with equivalent skills. Job brokerage services, such as the online services used to accompany oil and gas displaced workers in the United Kingdom can help match job seekers with hiring firms (UK Department for Business, Energy & Industrial Strategy, 2016[179]). Policies that encourage business start-ups, such as Sweden's "Support for starting a business", can play an additional role in creating jobs. (OECD/European Union, 2017[180]). Unemployment support and welfare benefits are an important complement to ALMPs to support displaced workers' income during the transition.

87. Boosting training and skill development programs is crucial to address skill mismatches. Skill transferability suggests that most of the training needed for green jobs may take the form of a 'top-up', allowing already qualified workers to adapt their skills and knowledge to suit green jobs' practices and technologies (Jagger, Foxon and Gouldson, 2014[181]). In parallel, it is important to target training to low-skilled displaced workers, with sponsored retraining policies to lower costs for and increase participation of low-income groups (Viebrock and Clasen, 2008[182]).

88. In the short run, public training programmes or subsidies to employers to hire and train workers can help to reduce skill shortages. However, in the medium- to long-run, the education system needs to structurally adapt to the increased demand for green skills. It is important to anticipate these changes as early as possible (ILO, 2015[183]), for example by surveying the energy industry employment needs, as done in the United States Energy & Employment Report (NASEO and EFI, 2020[184]). Vocational education and training programs (including continuing training) need to include the relevant green skills in their curricula. Coordination with the private sector, such as the one taking place in the Flanders region (Belgium) (OECD, 2017[185]), can generate synergies to lower skill shortages. In the long run, countries should also ensure that the skills necessary for the transition, as those involved in running and operating nuclear power plants, are not lost.

89. Regions with heavy reliance on fossil fuels, such as coal mining regions, and energy-intensive industries may demand specific policy measures (Box 17). Jobs in these industries tend to be geographically concentrated (IEA, 2021[20]). In these cases, the green transition requires transforming the industrial specialisation of entire regions and the geographical relocation of a large number of workers. In the past, many countries introduced social transfers

and early retirement schemes to manage the de-industrialisation of some areas, but these measures have proved ineffective at creating new jobs besides being very expensive.

90. A more promising approach combines place-based policies with policies aimed at removing obstacles to geographical mobility. Place-based policies include early-stage re-skilling and up-skilling, public investment programs, and improvements in social conditions through higher quality healthcare and transport policies in the region (Botta, 2019[178]; Causa, Abendschein and Cavalleri, 2021[186]). Examples encompassing both social transfers and industrial restructuring programmes include the Ruhr region (Germany) (Sheldon, Junankar and De Rosa Pontello, 2018[187]), Alberta (Canada) (Hussey and Jackson, 2019[188]), and Germany's coal districts (OECD, 2020[189]). Reviewing poorly-designed land-use regulations that limit housing supply and rental market regulation can increase the supply of affordable housing and foster mobility.

Box 17. Managing the reallocation challenges caused by phasing out coal-fired power plants: an example from Germany

Coal-fired power generation is a major source of greenhouse gas emissions in Germany, amounting to 18% of its energy supply mix (IEA, 2020[190]). In July 2020, the parliament passed legislation to end coal-fired power generation by 2038, potentially bringing the date forward to 2035.

As a whole, the coal exit will have little effect on the German economy, except in poor regions where a sizable share of the population is employed in lignite (coal) mining such as Lausitz and Rhineland. The government approach combines the decarbonisation process with support for regions and workers to achieve a fair transition. The federal government has pledged EUR 40 billion (1.2% of 2019 GDP) in support of affected coal mining regions up until 2038 (focusing on infrastructure, innovation and job markets), as well as financial support of up to EUR 5 billion (0.1% of 2019 GDP) for early retirement (amounting to about EUR 580 000 per affected employee) (Commission on Growth, Structural Change and Employment, 2019[191]). On the other hand, the government has also pledged to pay EUR 4.35 billion (0.1% of 2019 GDP) to lignite-fired power plants' owners; while the aim is to address potential future costs from legal remedies, the practice contrasts the 'polluter pays' principle and increases the fiscal cost of reducing emissions. Distributional impacts of the coal exit are addressed by reducing renewables-generated electricity prices, thus partly offsetting the increase in energy costs that will mostly fall on low-income households (Bach et al., 2020[192]).

Overall, Germany is addressing the distributional challenges associated with the large reallocation of resources caused by the coal exit but at a high fiscal cost. Applying a similar approach more broadly could significantly increase the burden on the public budget of greenhouse gas abatement.

Source: (OECD, 2020[189])

6. Political economy and public support for climate policies

6.1. Reducing information and knowledge gaps are key to building trust and making behaviour more climate-friendly

91. Awareness of climate change and the perception of its threat vary considerably across countries (Figure 22). In most countries, a majority of people think that climate change is a major threat, but there are still persisting pockets of scepticism (Cook, 2019[193]). The OECD is currently developing two survey tools to gauge public perceptions on climate policies: *i) A Project on the public acceptability of climate change mitigation policies*, which is a large-scale

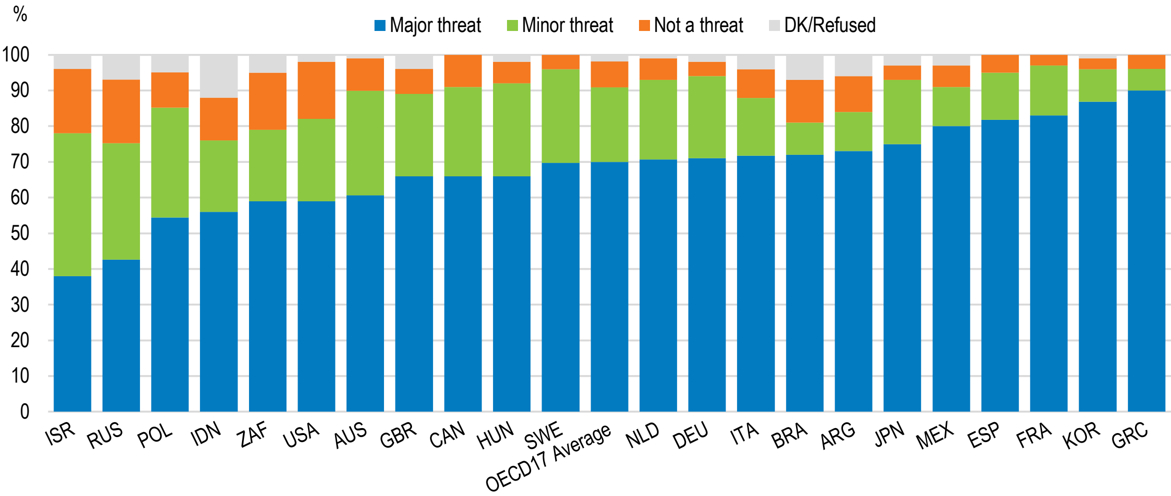
cross country survey covering more than 15 countries to assess and understand people's knowledge, concerns, willingness-to-change behaviour and policy preferences in this context (some preliminary results may be found in the latest OECD Economic Survey of Denmark (2021[194])); and *ii) Compare your Environment*, which aims to gather data for future research on the perceptions of people around the world about their environment and related policy and political economy matters.

92. Imperfect information is salient especially among disadvantaged socio-economic groups (Vona, 2021[195]), and is one of the causes for their low willingness-to-pay (WTP) for a clean environment compared to higher-income households (Greenstone and Jack, 2015[196]). Conversely, widespread knowledge on climate change (emphasising human causation and potentially imminent severe impacts), and related policies' objectives, is key to maintaining an informed debate and garnering public trust and cooperation (Krosnick et al., 2006[197]; Zahran et al., 2006[198]; Dietz, Dan and Shwom, 2007[199]; Harring and Jagers, 2013[200]; Park and Vedlitz, 2013[201]; Sibley and Kurz, 2013[202]).

93. The fragmentation of opinions can lead to resistance to reform (Tompson, 2009[203]) and an environment conducive to the dissemination of false information (bona fide or intended).[10] For instance, some interest groups can exacerbate concerns about job losses and insecurity relating to climate change policies (Morgenstern, Pizer and Shih, 2002[204]; Coglianese, Finkel and Carrigan, 2013[205]). Scepticism towards climate change may also be prevalent in regions relying on energy-intensive industries and mining as they stand to lose from the decarbonisation process (Bontadini and Vona, 2020[206]; Rodríguez-Pose, 2018[207]; Lockwood, 2018[208]; Rosés and Wolf, 2018[209]).

Figure 22. Perception of threat from climate change by country

Share of survey respondents in a country perceiving climate change as a major, minor or no threat, 2018



Note: "OECD17 Average" is the arithmetic average of the participating OECD countries.
Source: Pew Research Center (2018[210]), *Spring 2018 Global Attitudes Survey* (Q22d).

10 In a recent work by the OECD, Matasick, Alfonsi and Bellantoni (2020[218]) distinguish between misinformation (sharing false information bona fide), disinformation (knowingly sharing false information to cause harm), and malinformation (sharing genuine information to cause harm).

94. Disseminating knowledge about climate change and nurturing constructive narratives about climate policies can be achieved through the following measures:

- **Public communication and education campaigns**: *i)* transparently promoting knowledge on climate change and its dangers; *ii)* emphasising the benefits of mitigation policies despite possible short-term transitional costs; and *iii)* informing citizens on how existing energy policies (e.g. fossil fuel subsidies) are significantly more regressive (usually an unpopular outcome) than a carbon tax or an auctioned ETS (Vona, 2021[195]). Communicating these messages by experts representing diverse views can help to reach out to wider audiences (Cohen et al., 2007[211]).

  In addition, effective marketing of policies, such as providing policies with non-aversive names and branding, can allay opposition to climate change policies (Carattini et al., 2017[212]; Kallbekken, Kroll and Cherry, 2011[213]; Klenert et al., 2018[214]). This is especially important given the phenomenon of loss aversion (Kahneman, Knetsch and Thaler, 1991[215]), which suggests that resentment of new taxes is likely to be greater than appreciation for complementary policies offering equal compensation (Harrison, 2013[216]). A recent unsuccessful example is the Swiss "CO_2 Levy", a revision of which was rejected at a referendum in June 2021 (Box 18).
- **Strengthen informed choice mechanisms to complement information campaigns** via nudging individuals towards their informed preference by framing choices in specific manners (e.g. providing the opportunity of opting out from programmes believed to be inconsistent with one's preferences, or highlighting specific information). This can aid in avoiding decision-making errors and myopic behaviour (Beshears et al., 2008[217]).
- **Targeted-combating of dis/misinformation** by creating counter-narratives, requiring higher source transparency from media, regulation of online speech and dissemination of false information as well as media / civic policy responses (e.g. accessible government information, public broadcasters, citizen journalism, promotion of critical media consumption, public funding of climate research) (Matasick, Alfonsi and Bellantoni, 2020[218]).
- **Promoting transparent and accessible political discourse on the design and rationale of climate policies**, thus raising trust and support in the government's intentions and facilitating further dissemination of knowledge (Rafaty, 2018[219]). A central example is green budgeting instruments, e.g. green budget tagging and statements, which can help to increase transparency and accountability of governments' budgetary policies, thus supporting greater public engagement in budgetary decision making (Box 13) (OECD, 2020[111]).
- **Taking into account sound and trusted information and evaluation sources in the design of decarbonisation strategies**, such as RIAs, pilot projects and inputs from climate experts, policy research and civil society bodies (Section 3 and Box 10), and making their inputs accessible and understandable to the wide public.

Box 18. Despite past progress, Switzerland faces carbon-pricing acceptability challenges

Switzerland's carbon intensity is the lowest in OECD due to the low energy intensity of its economy and a large share of energy from hydro and nuclear power. The country implemented strong carbon pricing on heating fuels in 2008 in order to meet its annual carbon target. In 2018, The Federal Council adopted "Switzerland's Long-Term Climate Strategy", establishing strategic climate targets for key sectors and setting the carbon price at CHF 96 per ton of CO_2 (about EUR 88 per ton of CO_2) (OECD, 2019[220]). This policy has raised distributional and competitiveness concerns, which the federal government has attempted to address while maintaining transparent processes and accountability:

- **Grandfathering**: large emitters that are not included in the ETS are exempted from any carbon taxation, if they commit to abate emissions.
- **Redistributive mechanisms and earmarking of revenues to environmental goals**: about two-thirds of the tax revenue were redistributed to households and firms through a lump-sum rebate of social security contributions of around EUR 80 per person and reimbursement of firms proportional to their wage bill. The remaining third of tax revenue is earmarked for retrofitting works and the development of sustainable heating fuels.
- **Carbon pricing increases may be frozen upon early achievement of abatement goals**. The level of the carbon tax depends on the country's climate performance and its success in meeting annual objectives, adding another incentive for emission abatement. Since 2011, the tax rate adjusts to these objectives: it increases following a determined pathway if the objectives are not met, and the increase is postponed to the following year if they are.

It is worth noting, however, that plans to further raise the maximum tax rate (up to CHF 210 (EUR 194)) and to introduce a levy on the purchase of air tickets have been halted as of June 2021, with the rejection of a revised CO_2 Act via a referendum.

Source: (Office fédéral de l'environnement (OFEV), Confédération Suisse, 2020[221]).

6.2. Sound monitoring and sanctioning systems can limit free riding

95. Building international and national ex-ante and ex-post monitoring systems, in conjunction with sanctioning tools, is a first step to reduce free-riding behaviour and ensure wide participation in fighting climate change. At the national level, independent ombudsmen, bodies and officials (e.g. dedicated climate monitoring agencies, statistical offices and central banks) can lead these monitoring systems, to help address the issue of coordination and time inconsistency in political decision making.

96. At the international level, support monitoring bodies such as UNFCCC (United Nations Framework Convention on Climate Change) and multilateral NGOs is crucial, while ensuring the data is transparent, reliable and comparable. Furthermore, establishing so-called 'climate clubs' can be an effective means to deal with the problem of free-riding. These are multilateral binding agreements for undertaking harmonised emission reductions, by setting a target emission price (Nordhaus, 2015[222]) or other policy packages (e.g. as recently suggested by the German Government (2021[223])). A key aspect of the mechanism is that non-participants are sanctioned, e.g. by tariffs on their exports to the club region, thus creating an incentive framework that favours joining the club. An example is the EU's recently published draft of the carbon border adjustment mechanism (CBAM), which puts forward a framework for an import levy depending on the emission intensity of foreign production as of 2026 (European Commission, 2021[224]).

6.3. Stakeholder consultations can build support but also raise risks of policy capture

97. Though the net effects of climate policies will increase overall social welfare, some groups may lose out, especially in the short term. Interest groups may thus arise, varying widely in institutional forms and sizes (Mueller, 2003[225]), some mounting effective opposition, including by influencing public opinion, possibly with dis/misinformation. Governments can rely on different policies to listen to such opposition, mitigate its concerns and garner support from a more diverse spectrum of stakeholders:

- **Stakeholder consultation**. Stakeholders and interest groups may enrich the policymaking process by expressing their opinions, needs and sharing valuable knowledge and policy proposals (UNEP, 2019[81]). Their involvement usually takes place via consultation (initiated by policymakers or lobbying groups), and is likely to boost their support for the final version of the suggested policies (OECD, 2021[80]; Mueller, 2003[225]; OECD, 2012[74]).[11]
- **Gradual and transparent increases in climate change policy stringency**, which lower uncertainty, thus allowing stakeholders and households to plan ahead and change behaviour (Coady, Parry and Shang, 2018[226]; IMF, 2019[227]). A notable example is the annual carbon price increase introduced by the Pan-Canadian Framework (PCF) in 2019, planned to reach full capacity in 2022.
- **Mixing several compensation mechanisms** (as is done for example in New Zealand (Box 19) and Canada (Box 20), simultaneously addressing concerns of different sets of stakeholders (e.g. by reducing business taxes to promote efficiency and targeted acceptability) and promoting equity (e.g. via progressive schemes such as lump-sum rebates). This can help to build a larger political constituency and bridge the common left-right political cleavage (Klenert and Mattauch, 2019[228]; Vona, 2021[195]).
- **Temporary exemptions and grandfathering (long-term exemptions)**. This includes: exempting relevant groups and providing smooth means to transition to the new regulatory framework (e.g. allocation of free pollution permits as an initial stage of an ETS system – see Section 3, Box 2 and Box 4); providing relevant groups with concessions, and involving them in the design of the post-reform framework in a way that would account for their special needs and soften the potential costs (Tompson, 2009[203]). The trade-off, however, is that policies may be less effective as a result, in addition to competitiveness concerns.

98. Transparent and well-regulated lobbying activities are key to diminishing the risk of policy capture by private interests (OECD, 2017[229]; OECD, 2021[80]; Mueller, 2003[225]). For example, Deng, Wu and Xu (2020[230]) find that in China, firms who are better politically connected enjoy regulatory pollution shelters, resulting in flawed enforcement of pollution-control regulations. The following strategies may help to address this issue:

  - **Levelling the playing field when involving stakeholders** by ensuring a more inclusive decision-making process, making it more difficult for specific actors to capture it. This relies on policies that encourage stakeholder engagement, while promoting integrity and transparency in lobbying activities and political finance (OECD, 2017[108]; OECD, 2017[231]).
  - **Promoting accountability and sound oversight over stakeholder involvement** through public bodies and regulators, such as competition authorities, with a strong institutional design to promote independence and resilience in the face of outside

[11] The OECD has recently published a report outlining best practice principles for stakeholder involvement and lobbying (see *Lobbying in the 21st Century – Transparency, Integrity and Access* (2021[267])).

pressure (OECD, 2021[80]). However, due to their centrality and importance, such bodies are at risk of becoming policy capture targets themselves, and hence independent oversight bodies (e.g. supreme audit institutions or an ombudsman), who are independent of the government, can serve as a second layer of defence (Zuegel, Cantera and Bellantoni, 2018[232]).

- **Enforcing the right to know** by providing transparent, reliable and accessible information about the decisions and involved parties in the policymaking process (OECD, 2021[80]). This is especially important for public funding and notably for research programs.[12] In the absence of any regulation, organisations themselves can promote transparent governance structures and provide information about their funding on their websites, annual reports or even in documents related to specific research findings, evidence or data.[13]
- **Organisational integrity policies**, i.e. promotion of a culture of integrity supported by the establishment of an official code of conduct with corresponding internal mechanisms (OECD, 2021[80]).

Box 19. A diverse complementary policy mix can aid in garnering support for climate action: the case of New Zealand

In 2019, New Zealand enacted the Climate Change Response (Zero-carbon) Amendment Act, which develops a framework for reaching zero GHG emissions by 2050. The act rules that an updated carbon budget will be set every five years and an independent Climate Change Commission will provide expert climate budgeting advice to the government and monitor progress (Ministry of Environment, New Zealand Government, 2019[233]). Additionally, the New Zealand government has established a green investment bank (New Zealand Green Investment Finance (NZGIF)), intending to catalyse investments in low-emission initiatives (New Zealand Green Investment Finance, 2021[234]).

A 2018 poll by Horizon Research Limited (2018[235]) has shown that a majority of citizens are supportive of policies aiming to reach net-zero emissions by 2050 (with 52% respondents expressing support, as opposed to only 11% expressing opposition). This may be due to several reasons:

- **Geographical conditions**. As a country composed of islands, New Zealand is exposed to a rise in the sea level and floods resulting in the evacuating of thousands of households (Royal Society, 2016[236]). This issue affects the population directly and contributes to higher awareness of the need for effective climate mitigation policies.
- **Successful communication and education campaigns**. The national effort to increase climate awareness comprises information dissemination via multiple media channels and dedicated programs in schools to nurture environmentally friendly behaviour among the youth (Salmon et al., 2017[237]). It has been widely successful, with 43% of the population seeing climate change as an urgent and immediate problem (Horizon Research Limited, 2019[238]). On top of that, climate policy was at the core of political parties' agenda for the 2020 election (Policy Ltd., 2020[239]).

---

[12] In the OECD, the EU Transparency Register is the only transparency scheme requiring think tanks, research centres and academic institutions to disclose the source of their funding.

[13] For example, the American Economic Association requires that the funding of scholarly work be disclosed before it can be published in its journals (OECD, 2021[267]).

- **Phased policy implementation, grandfathering and support measures for stakeholders**. In the context of the 2019 Act, the government has reformed the emission trading scheme in 2020, implementing several measures to cushion the transition and allow stakeholders to prepare: a five-year transition phase before pricing agricultural emissions; free allocation of 95% of the carbon credits at the farm level; financial incentives for early adopters; increased farm advisory efforts to help the residents decrease their emissions most cost-effectively; and tools for estimating farms' emissions to help them plan ahead (de Klein, Rollo and van der Weerden, 2019[240]; OECD, 2021[80]; Climate Action Tracker, 2020[241]; Ministry of Environment, New Zealand Government, 2019[233]).

Box 20. The political economy of British Columbia's (Canada) carbon tax

In 2008, the Canadian province of British Columbia (BC) introduced a carbon tax on the combustion sources of all fossil fuels. At the time Canada had one of the highest emission levels within the OECD, due to heavy reliance on fossil fuels for both domestic use and export-oriented production. The tax was introduced at a rate of CAD 10 per tonne of CO_2, with a schedule for annual increases of CAD 5 per tonne of CO_2 up to a maximum levy of CAD 30 per tonne of CO_2 in 2012. The sales of petroleum fuels have declined, with high-emission industries most severely affected by the tax. Starting in 2019 as part of the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), the federal government has made carbon pricing mandatory in all Canadian provinces. Each province can design its own pricing system tailored to local needs in case it prefers that over the federal "Backstop" scheme (Environment and natural resources, Canadian Government, 2021[242]).

Initially, the 2008 BC reform enjoyed significant support among the BC public, including local academics, environmental groups, and the business sector. This is mainly thanks to the strong wilderness-oriented environmental movement in the region and the high public awareness for climate change. However, the support was met with a backlash after implementation, fuelled by:

- **Perceptions of unfairness and political alienation**: rural communities argued they would bear more of the cost of the tax, due to living in a colder climate and relying more on private transportation. This is despite the fact that an analysis found that they would pay less compared to their urban counterparts, if their homes are well-insulated and when they are subject to shorter commutes (Peet and Harrison, 2012[243]).
- **Application of the tax in a period of high gas prices**, which increased prices further–surpassing the symbolic CAD 1.50 mark per litre of gasoline at Vancouver gas stations.
- **Concerns of carbon leakage and disadvantages to local energy-intensive trade-exposed industries** (e.g. mining, oil and gas, pulp and paper, cement). In response, the Business Council of British Columbia called for measures that would level the playing field (2012[244]).
- **An effective opposition campaign claiming downsides to the tax**, including misleading claims about tax avoidance among big polluting companies and invoked beliefs of lower returns to the tax paid by the public than reality.

By 2012, despite many still viewing the tax scheme as unfair, expensive and ineffective (Horne, Sauvé and Pedersen, 2012[245]), public support for it significantly strengthened. Some reasons for that may be:

- **Revenue recycling and complementary support measures** to firms, income tax cuts, targeted property tax rebates to rural and northern homeowners and targeted financial transfers for low-income households (Beck et al., 2015[246]).
- **Familiarity to the tax**, with a sharp decline in public discourse and costs of the tax being milder compared to initial concerns.
- **Wider political support for the tax**, with a majority now supporting the reform – including those belonging to the party leading the past opposition.
- **BC provincial government's reliance on the tax revenues**, which would entail a budget gap in case of removal.

Source: (Harrison, 2013[216]; Murray and Rivers, 2015[247])

6.4. Perceptions of distributional fairness can play a significant role

99. Identifying prevalent views among the public and designing framework policies accordingly may boost public support. For example, climate policies' reallocative costs are likely to be large especially for disadvantaged groups such as low-skilled low-wage workers. Many view these outcomes as unfair and may therefore stoke opposition to the source policies even if they are not directly harmed themselves (Douenne and Fabre, 2020[248]) (Box 21).

100. Complementary policies (e.g. tax reductions and provision of targeted support for affected households) can mitigate adverse distributional impacts and raise public acceptability (Coady, Parry and Shang, 2018[226]; Sterner, 2012[249]; Hsu, Walters and Purgas, 2008[250]). Promoting an efficient, transparent and equitable image of the use of carbon revenues can further raise acceptability (Lam, 2015[251]; IMF, 2019[227]).

101. Dedicated bodies responsible for directing efforts of climate change can lead the assessment of public views (e.g. through stakeholder consultations). The responsibility that such bodies assume over climate policy recommendations, even if the government makes the final decision, may potentially alleviate political difficulties when making controversial choices. Examples are the scientific climate councils in the Netherlands and Denmark (Box 11) (Thacher and Rein, 2004[252]; Stewart, 2006[253]; OECD, 2021[80]).

102. High levels of inequality in a country are a significant constraint to public and political support for climate policies (Banzhaf et al. (2019[254]; 2019[255])). Reducing inequality may facilitate a gradual expansion of a country's middle-class, and potentially accelerate the diffusion of pricier green technologies through the creation of a critical mass (e.g. EVs, building on network effects). The middle class is also likely to care more broadly about collective goods such as environmental quality and climate change (Vona and Patriarca, 2011[256]; Drupp et al., 2018[257]).

Box 21. The Yellow Vests movement in France: carbon pricing acceptability hampered by distributional impacts

In 2014, the French government initiated an ambitious carbon tax scheme (Contribution Climat-Énergie or CCE) to reduce the country's GHG emissions, planning to annually increase the carbon price from EUR 7 per ton of CO_2 in 2014 to EUR 86.2 per ton of CO_2 by 2022. In this context, the so-called "Yellow Vests" protests broke out in November 2018, protesting against the planned rise in fuel taxes and the decline in living standards in rural areas. As a result of the protests, the government withdrew the planned increase in fuel taxes and the carbon tax has since then been frozen at EUR 44.6 per ton of CO_2 (Douenne and Fabre, 2020[248]).

The protests broke out despite studies showing high awareness of climate change dangers among the French public, linked to high support for climate policy (Douenne and Fabre, 2020[248]). This can be due to several reasons:

- **General tax aversion** to all types of tax increases (Douenne and Fabre, 2020[258]).
- **Regressive outcomes, perceived as distributionally unfair**: the carbon tax increase was not followed by a proportional increase in compensation mechanisms to the most vulnerable households and rural-zones inhabitants, the latter relying to a large extent on private transportation that would be made significantly more expensive (Guisse and Hoibian, 2017[259]; Vie Publique, 2017[260]; Agence de la transition écologique (ADEME), 2019[261]; Conseil des prélèvements obligatoires (CPO), 2019[262]).
- **A sharp rise in world oil prices in 2018,** which coincided with the pre-planned carbon price increase, would have resulted in a surge in gas prices beyond what the French government had anticipated (Magnenou, 2019[263]; Statista, 2019[264]). This is similar to the sharp rise in energy prices in 2021, fueled by the post-COVID energy demand surge coupled with supply shortages due to insufficient, though rising, investment in green energy and receding investment in brown energy in the preceding decade (IEA, 2021[265]).
- **Inadequate communication efforts**. Lack of information about the new tax scheme combined with the general aversion to new taxes may have further amplified the opposition to it.

References

Acemoglu, D. et al. (2012), "The Environment and Directed Technical Change", *American Economic Review*, Vol. 102/1, pp. 131-166, http://dx.doi.org/10.1257/aer.102.1.131. [51]

Agence de la transition écologique (ADEME) (2019), *La contribution climat-solidarité: une taxe carbone pour la transition écologique et pour plus de solidarité fiscale*. [261]

Aghion, P. et al. (2016), "Carbon Taxes, Path Dependency, and Directed Technical Change: Evidence from the Auto Industry", *Journal of Political Economy*, Vol. 124, 1, pp. 1-51. [52]

Aldy, J. and R. Stavins (2012), "The Promise and Problems of Pricing Carbon", *The Journal of Environment & Development*, Vol. 21/2, pp. 152-180, http://dx.doi.org/10.1177/1070496512442508. [11]

Anderson, B. et al. (2021), "Policies for a climate-neutral industry: Lessons from the Netherlands", *OECD Science, Technology and Industry Policy Papers*, No. 108, OECD Publishing, Paris, https://dx.doi.org/10.1787/a3a1f953-en. [60]

Ang, B. (2004), "Decomposition analysis for policymaking in energy:", *Energy Policy*, Vol. 32/9, pp. 1131-1139, http://dx.doi.org/10.1016/s0301-4215(03)00076-4. [25]

Angelopoulos, K., G. Economides and A. Philippopoulos (2010), *What is the best environmental policy? Taxes, permits and rules under economic and environmental uncertainty*, CESifo Working Paper, No. 2980, Center for Economic Studies and ifo Institute (CESifo). [86]

Annicchiarico, B. and F. Di Dio (2015), "Environmental policy and macroeconomic dynamics in a new Keynesian model", *Journal of Environmental Economics and Management*, Vol. 69, pp. 1-21, http://dx.doi.org/10.1016/j.jeem.2014.10.002. [87]

Australian Government Department of Industry, Science, Energy and Resources (2021), *Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2021*, https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-june-2021. [29]

Bach, S. et al. (2020), *Nachbesserungen beim Klimapaket richtig, aber immer noch unzureichend-CO 2-Preise stärker erhöhen und Klimaprämie einführen*. [192]

Banzhaf, H., L. Ma and C. Timmins (2019), "Environmental Justice: Establishing Causal Relationships", *Annual Review of Resource Economics*, Vol. 11/1, http://dx.doi.org/10.1146/annurev-resource-100518-094131. [255]

Banzhaf, S., L. Ma and C. Timmins (2019), "Environmental Justice: The Economics of Race, Place, and Pollution", *Journal of Economic Perspectives*, Vol. 33/1, http://dx.doi.org/10.1257/jep.33.1.185. [254]

Baritaud, M. (2012), "Securing Power during the Transition: Generation Investment and Operation Issues in Electricity Markets with Low-Carbon Policies", *IEA Energy Papers*, No. 2012/13, OECD Publishing, Paris, https://dx.doi.org/10.1787/5k3wb8fmsz6h-en. [266]

Baumol, W. and W. Oates (1971), "The Use of Standards and Prices for Protection of the Environment", in *The Economics of Environment*, Palgrave Macmillan UK, London, http://dx.doi.org/10.1007/978-1-349-01379-1_4. [9]

Beck, M. et al. (2015), "Carbon tax and revenue recycling: Impacts on households in British Columbia", *Resource and Energy Economics*, Vol. 41, pp. 40-69, http://dx.doi.org/10.1016/j.reseneeco.2015.04.005. [246]

Berck, P. and G. Helfand (2011), *The economics of the environment*, Addison-Wesley. [54]

Berestycki, C. and A. Dechezleprêtre (2020), "Assessing the efficiency of environmental policy design and evaluation: Results from a 2018 cross-country survey", *OECD Economics Department Working Papers*, No. 1611, OECD Publishing, Paris, https://dx.doi.org/10.1787/482f8fbe-en. [55]

Beshears, J. et al. (2008), "How are preferences revealed?", *Journal of Public Economics*, Vol. 92/8-9, pp. 1787-1794, http://dx.doi.org/10.1016/j.jpubeco.2008.04.010. [217]

Bessen, J. and E. Maskin (2009), "Sequential innovation, patents, and imitation", *The RAND Journal of Economics*, Vol. 40/4, pp. 611-635, http://dx.doi.org/10.1111/j.1756-2171.2009.00081.x. [62]

Boffo, R., C. Marshall and R. Patalano (2020), *ESG Investing: Environmental Pillar Scoring and Reporting*, OECD Paris, http://www.oecd.org/finance/esg-investing-environmental-pillar-scoring-and-reporting.pdf. [115]

Böhringer, C. et al. (2016), "Good things do not always come in threes: On the excess cost of overlapping regulation in EU climate policy", *Energy Policy*, Vol. 94, pp. 502-508, http://dx.doi.org/10.1016/j.enpol.2015.12.034. [68]

Bontadini, F. and F. Vona (2020), "Anatomy of Green Specialization: Evidence from EU Production Data, 1995-2015", *OFCE Working Paper 21/2020*. [206]

Boone, L. and A. Elgouacem (2021), *At the cross-roads of a low-carbon transition: what can we learn from the current energy crisis?*, https://oecdecoscope.blog/2021/10/22/at-the-cross-roads-of-a-low-carbon-transition-what-can-we-learn-from-the-current-energy-crisis/ (accessed on 8 November 2021). [14]

Borenstein, S. and L. Davis (2016), "The Distributional Effects of US Clean Energy Tax Credits", *Tax Policy and the Economy*, Vol. 30/1, pp. 191-234, http://dx.doi.org/10.1086/685597. [138]

Botta, E. (2019), "A review of "Transition Management" strategies: Lessons for advancing the green low-carbon transition", *OECD Green Growth Papers*, No. 2019/04, OECD Publishing, Paris, https://dx.doi.org/10.1787/4617a02b-en. [178]

Botta, E. and T. Koźluk (2014), "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach", *OECD Economics Department Working Papers*, No. 1177, OECD Publishing, Paris, https://dx.doi.org/10.1787/5jxrjnc45gvg-en. [40]

Bourgeois, C., L. Giraudet and P. Quirion (2021), “Lump-sum vs. energy-efficiency subsidy recycling of carbon tax revenue in the residential sector: A French assessment”, *Ecological Economics*, Vol. 184, p. 107006, http://dx.doi.org/10.1016/j.ecolecon.2021.107006. [164]

Bovenberg, A. (1999), “Green Tax Reforms and the Double Dividend: an Updated Reader’s Guide”, *International Tax and Public Finance*, Vol. 6/3, pp. 421-443, http://dx.doi.org/10.1023/a:1008715920337. [159]

Bureau, D., F. Henriet and K. Schubert (2019), *A proposal for the climate: Taxing carbon not people*, Notes du conseil danalyse economique. [158]

Business Council of British Columbia (2012), *Submission on the Provincial Carbon Tax*. [244]

Calel, R. and A. Dechezleprêtre (2016), “Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market”, *Review of Economics and Statistics*, Vol. 98/1, pp. 173-191, http://dx.doi.org/10.1162/rest_a_00470. [93]

Carattini, S. et al. (2017), “Green Taxes In A Post-Paris World: Are Millions of Nays Inevitable?”, *Environmental and Resource Economics*, Vol. 68/1, pp. 97-128. [212]

Cattaneo, C. et al. (2019), “Human Migration in the Era of Climate Change”, *Review of Environmental Economics and Policy*, Vol. 13/2, pp. 189-206, http://dx.doi.org/10.1093/reep/rez008. [156]

Causa, O., M. Abendschein and M. Cavalleri (2021), *The laws of attraction: Economic drivers of inter-regional migration, housing costs and the role of policies*, OECD Economics Department Working Papers No. 1678. [186]

Chateau, J., R. Bibas and E. Lanzi (2018), “Impacts of Green Growth Policies on Labour Markets and Wage Income Distribution: A General Equilibrium Application to Climate and Energy Policies”, *OECD Environment Working Papers*, No. 137, OECD Publishing, Paris, https://dx.doi.org/10.1787/ea3696f4-en. [145]

Chay, K. and M. Greenstone (2003), “The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession”, *The Quarterly Journal of Economics*, Vol. 118/3, pp. 1121-1167, http://dx.doi.org/10.1162/00335530360698513. [151]

Chiluwa, I. and S. Samoilenko (eds.) (2019), *Understanding and Countering Misinformation About Climate Change*, Hershey, PA: IGI-Global, http://dx.doi.org/10.4018/978-1-5225-8535-0. [193]

China Energy Portal (2021), *2019 detailed electricity statistics (update of Jan 2021)*, https://chinaenergyportal.org/en/2019-detailed-electricity-statistics-update-of-jan-2021/. [44]

Chiroleu-Assouline, M. and M. Fodha (2014), “From regressive pollution taxes to progressive environmental tax reforms”, *European Economic Review*, Vol. 69, pp. 126-142, http://dx.doi.org/10.1016/j.euroecorev.2013.12.006. [162]

Clean Energy Pipeline (2014), *The European Renewable Energy Investor Landscape*, https://www.yumpu.com/en/document/view/47848751/the-european-renewable-energy-investor-landscape. [116]

Clean Energy Wire (2021), *New regulation aims to prevent carbon leakage due to national CO2 price*, https://www.cleanenergywire.org/news/new-regulation-aims-prevent-carbon-leakage-due-national-co2-price. [43]

Clean Energy Wire (2020), *Germany's carbon pricing system for transport and buildings*, https://www.cleanenergywire.org/factsheets/germanys-planned-carbon-pricing-system-transport-and-buildings. [42]

Climate Action Tracker (2020), *New Zealand*, https://climateactiontracker.org/countries/new-zealand/. [241]

Climate Change Committee (2021), , https://www.theccc.org.uk/about/. [82]

Climate-Related Market Risk Subcommittee (2020), *Managing Climate Risk in the U.S. Financial*. [117]

Coady, D., I. Parry and B. Shang (2018), "Energy Price Reform: Lessons for Policymakers", *Review of Environmental Economics and Policy*, Vol. 12/2, pp. 197-219, http://dx.doi.org/10.1093/reep/rey004. [226]

Coglianese, C., A. Finkel and C. Carrigan (eds.) (2013), *Does Regulation Kill Jobs?*, University of Pennsylvania Press. [205]

Cohen, G. et al. (2007), "Bridging the Partisan Divide: Self-Affirmation Reduces Ideological Closed-Mindedness and Inflexibility in Negotiation", *Journal of Personality and Social Psychology*, Vol. 93/3, pp. 415-430, http://dx.doi.org/10.1037/0022-3514.93.3.415. [211]

Commission on Growth, Structural Change and Employment (2019), *Final Report*, Federal Ministry for Economic Affairs and Energy (BMWi). [191]

Conseil des prélèvements obligatoires (CPO) (2019), *La fiscalité environnementale au défi de l'urgence climatique*. [262]

Consoli, D. et al. (2016), "Do green jobs differ from non-green jobs in terms of skills and human capital?", *Research Policy*, Vol. 45/5, pp. 1046-1060, http://dx.doi.org/10.1016/j.respol.2016.02.007. [175]

Danish Economic Councils (2021), *Danish Economic Councils | De Økonomiske Råd*, https://dors.dk/english. [83]

Davis, L. and C. Knittel (2019), "Are Fuel Economy Standards Regressive?", *Journal of the Association of Environmental and Resource Economists*, Vol. 6/S1, pp. S37-S63, http://dx.doi.org/10.1086/701187. [143]

de Klein, C., M. Rollo and T. van der Weerden (2019), *Assessment of tools for estimating on-farm GHG emissions: Report for the Ministry for Primary Industries*, AgResearch, https://www.mpi.govt.nz/dmsdocument/39092/direct. [240]

de Serres, A., F. Murtin and G. Nicoletti (2010), “A Framework for Assessing Green Growth Policies”, *OECD Economics Department Working Papers*, No. 774, OECD Publishing, Paris, https://dx.doi.org/10.1787/5kmfj2xvcmkf-en. [5]

Dechezleprêtre, A., R. Martin and M. Mohnen (2013), *Knowledge spillovers from clean and dirty technologies: a patent citation analysis*, Centre for Climate Change Economics and Policy No. 151 / Grantham Research Institute on Climate Change and the Environment Working Paper No. 135. [49]

Deng, Y., Y. Wu and H. Xu (2020), “Political Connections and Firm Pollution Behaviour: An Empirical Study”, *Environmental and Resource Economics*, Vol. 75, pp. 867-898, https://doi.org/10.1007/s10640-020-00410-7. [230]

Dietz, T., A. Dan and R. Shwom (2007), “Support for Climate Change Policy: Social Psychological and Social Structural Influences”, *Rural Sociology*, Vol. 72/2, pp. 185-214, https://doi.org/10.1526/003601107781170026. [199]

Dorband, I. et al. (2019), “Poverty and distributional effects of carbon pricing in low- and middle-income countries – A global comparative analysis”, *World Development*, Vol. 115, pp. 246-257, http://dx.doi.org/10.1016/j.worlddev.2018.11.015. [150]

Douenne, T. and A. Fabre (2020), “Yellow Vests, Carbon Tax Aversion, and Biased Beliefs”. [258]

Douenne, T. and A. Fabre (2020), “Yellow Vests, Pessimistic Beliefs, and Carbon Tax Aversion”. [248]

Drupp, M. et al. (2018), “Economic Inequality and the Value of Nature”, *Ecological Economics*, Vol. 150, http://dx.doi.org/10.1016/j.ecolecon.2018.03.029. [257]

Durand-Lasserve, O. et al. (2015), “Modelling of distributional impacts of energy subsidy reforms: an illustration with Indonesia”, *OECD Environment Working Papers*, No. 86, OECD Publishing, Paris, https://dx.doi.org/10.1787/5js4k0scrqq5-en. [173]

Environment and natural resources, Canadian Government (2021), *Carbon pollution pricing systems across Canada*, https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work.html. [242]

Eskeland, G. and S. Yan (2021), “The Norwegian CO2-differentiated motor vehicle registration tax: An extended Cost-Benefit Analysis”, *OECD Environment Working Papers*, No. 178, OECD Publishing, Paris, https://dx.doi.org/10.1787/ee108c96-en. [133]

European Commission (2021), *Carbon Border Adjustment Mechanism*, https://ec.europa.eu/taxation_customs/green-taxation-0/carbon-border-adjustment-mechanism_en. [224]

European Commission (2013), “Review of the EU Air policy”, *Clean Air Programme*, https://ec.europa.eu/environment/air/clean_air/index.htm. [78]

European Environment Agency (2019), *The air implementation pilot project*, https://www.eea.europa.eu/themes/air/activities/the-air-implementation-pilot-project. [76]

Fankhauser, S., C. Hepburn and J. Park (2010), "Combining Multiple Climate Policy Instruments: How Not To Do It", *Climate Change Economics*, Vol. 01/03, pp. 209-225, http://dx.doi.org/10.1142/s2010007810000169. [72]

FAO (2020), "Emissions due to agriculture. Global, regional and country trends 2000-2018", *FAOSTAT Analytical Brief Series*, Vol. 18. [30]

Finon, D. (2013), "The transition of the electricity system towards decarbonization: the need for change in the market regime", *Climate Policy*, Vol. 13/SUPPL.1, pp. 130-145, http://dx.doi.org/10.1080/14693062.2012.741832. [120]

Fischer, C. and R. Newell (2008), "Environmental and technology policies for climate mitigation", *Journal of Environmental Economics and Management*, Vol. 55/2, pp. 142-162, http://dx.doi.org/10.1016/j.jeem.2007.11.001. [66]

Flues, F. et al. (2014), "Designing an EU energy and climate policy portfolio for 2030: Implications of overlapping regulation under different levels of electricity demand", *Energy Policy*, Vol. 75, pp. 91-99, http://dx.doi.org/10.1016/j.enpol.2014.05.012. [69]

Flues, F. and A. Thomas (2015), "The distributional effects of energy taxes", *OECD Taxation Working Papers*, No. 23, OECD Publishing, Paris, https://dx.doi.org/10.1787/5js1qwkqqrbv-en. [137]

Foster, A. and M. Rosenzweig (2010), "Microeconomics of Technology Adoption", *Annual Review of Economics*, Vol. 2/1, http://dx.doi.org/10.1146/annurev.economics.102308.124433. [140]

Fridstrøm, L. (2021), "The Norwegian Vehicle Electrification Policy and Its Implicit Price of Carbon", *Sustainability*, Vol. 13/3, p. 1346, http://dx.doi.org/10.3390/su13031346. [132]

Fullerton, D. (2011), *Six Distributional Effects of Environmental Policy*, National Bureau of Economic Research, Cambridge, MA, http://dx.doi.org/10.3386/w16703. [147]

Gillingham, K. and J. Stock (2018), "The Cost of Reducing Greenhouse Gas Emissions", *Journal of Economic Perspectives*, Vol. 32/4, pp. 53-72, http://dx.doi.org/10.1257/jep.32.4.53. [89]

Goulder, L. (1995), "Environmental taxation and the double dividend: A reader's guide", *International Tax and Public Finance*, Vol. 2/2, http://dx.doi.org/10.1007/BF00877495. [160]

Goulder, L. and I. Parry (2008), "Instrument Choice in Environmental Policy", *Review of Environmental Economics and Policy*, Vol. 2/2, pp. 152-174, http://dx.doi.org/10.1093/reep/ren005. [10]

Graff Zivin, J. and M. Neidell (2013), "Environment, Health, and Human Capital", *Journal of Economic Literature*, Vol. 51/3, pp. 689-730, http://dx.doi.org/10.1257/jel.51.3.689. [152]

Grainger, C. (2012), "The distributional effects of pollution regulations: Do renters fully pay for cleaner air?", *Journal of Public Economics*, Vol. 96/9-10, pp. 840-852, http://dx.doi.org/10.1016/j.jpubeco.2012.06.006. [155]

Greenstone, M. and B. Jack (2015), "Envirodevonomics: A Research Agenda for an Emerging Field", *Journal of Economic Literature*, Vol. 53/1, pp. 5-42, http://dx.doi.org/10.1257/jel.53.1.5. [196]

Guillemette, Y. and D. Turner (2018), "The Long View: Scenarios for the World Economy to 2060", *OECD Economic Policy Papers*, No. 22, OECD Publishing, Paris, https://dx.doi.org/10.1787/b4f4e03e-en. [85]

Guisse, N. and S. Hoibian (2017), *Les Français et leurs territoires: vécus et attentes vis-à-vis des pouvoirs publics*, https://www.credoc.fr/publications/les-francais-et-leurs-territoires-vecus-et-attentes-vis-a-vis-des-pouvoirs-publics-1. [259]

Hanna, R. and P. Oliva (2011), *The Effect of Pollution on Labor Supply: Evidence from a Natural Experiment in Mexico City*, National Bureau of Economic Research, Cambridge, MA, http://dx.doi.org/10.3386/w17302. [153]

Harring, N. and S. Jagers (2013), "Should We Trust in Values? Explaining Public Support for Pro-Environmental Taxes", *Sustainability*, Vol. 5/1, pp. 210-227, http://dx.doi.org/10.3390/su5010210. [200]

Harrison, K. (2013), "The Political Economy of British Columbia's Carbon Tax", *OECD Environment Working Papers*, No. 63, OECD Publishing, Paris, https://dx.doi.org/10.1787/5k3z04gkkhkg-en. [216]

Hepburn, C., J. Pless and D. Popp (2018), "Policy Brief—Encouraging Innovation that Protects Environmental Systems: Five Policy Proposals", *Review of Environmental Economics and Policy*, Vol. 12/1, pp. 154-169, http://dx.doi.org/10.1093/reep/rex024. [97]

Horizon Research Limited (2019), *Public concern over climate change hits new high*, https://www.horizonpoll.co.nz/page/541/public-conc. [238]

Horizon Research Limited (2018), *Majority support all-party action on climate change*, https://www.horizonpoll.co.nz/page/510/majority-support-all-party-action-on-climate-change. [235]

Horne, M., K. Sauvé and T. Pedersen (2012), *British Columbians' Perspectives On Global Warming and the Carbon Tax*. [245]

Hsiang, S. et al. (2017), "Estimating economic damage from climate change in the United States", *Science*, Vol. 356/6345, pp. 1362-1369, http://dx.doi.org/10.1126/science.aal4369. [154]

Hsu, S., J. Walters and A. Purgas (2008), "Pollution Tax Heuristics: An Empirical Study of Willingness to Pay Higher Gasoline Taxes", *Energy Policy*, Vol. 36/9, pp. 3612-3619, http://dx.doi.org/10.1016/j.enpol.2008.06.010. [250]

Hussey, I. and E. Jackson (2019), *Alberta's Coal Phase-Out: A Just Transition?*, Parkland Institute. University of Alberta. [188]

IEA (2021), *CO2 emissions in World Energy Outlook scenarios over time, 2000-2050*, https://www.iea.org/data-and-statistics/charts/co2-emissions-in-world-energy-outlook-scenarios-over-time-2000-2050-and-corresponding-global-temperature-rise-in-2100. [22]

IEA (2021), *Global EV Outlook 2021*, IEA, Paris, https://www.iea.org/reports/global-ev-outlook-2021 (accessed on 2 August 2021). [127]

IEA (2021), *Net Zero by 2050*, IEA. [20]

IEA (2021), *Patents and the Energy Transition*, IEA, https://www.iea.org/reports/patents-and-the-energy-transition. [92]

IEA (2021), *Renewable Energy Law of the People's Republic of China*, https://www.iea.org/policies/3080-renewable-energy-law-of-the-peoples-republic-of-china. [45]

IEA (2021), *Temperature rise in 2100, by scenario*, https://www.iea.org/data-and-statistics/charts/temperature-rise-in-2100-by-scenario. [23]

IEA (2021), *What is behind soaring energy prices and what happens next?*, https://www.iea.org/commentaries/what-is-behind-soaring-energy-prices-and-what-happens-next. [265]

IEA (2021), *World Energy Outlook 2021*, https://www.iea.org/reports/world-energy-outlook-2021. [21]

IEA (2020), *Energy Technology RD&D Budget Database*, https://www.iea.org/subscribe-to-data-services/energy-technology-rdd. [38]

IEA (2020), *IEA Mobility Model*, https://www.iea.org/areas-of-work/programmes-and-partnerships/the-iea-mobility-model. [123]

IEA (2020), *The Netherlands Country Report*, https://www.iea.org/news/the-netherlands-is-well-prepared-to-reduce-co2-emissions-iea-policy-review-says (accessed on 24 June 2021). [59]

IEA (2020), *World Energy Balances - Germany*, https://www.iea.org/data-and-statistics/data-browser/?country=GERMANY&fuel=Energy%20supply&indicator=TPESbySource. [190]

IEA (2020), *World Energy Balances - Indonesia*, https://www.iea.org/data-and-statistics/data-browser?country=INDONESIA&fuel=Energy%20supply&indicator=TPESbySource. [168]

IEA (2020), *World Energy Balances: Overview*, IEA, https://www.iea.org/reports/world-energy-balances-overview. [121]

IEA (2020), *World Energy Investment*, IEA, https://www.iea.org/reports/world-energy-investment-2019. [39]

IEA (2019), *The Future of Hydrogen*, IEA, https://www.iea.org/reports/the-future-of-hydrogen. [104]

IEA (2019), *The Future of Rail*, IEA, Paris, https://www.iea.org/reports/the-future-of-rail (accessed on 30 July 2021). [125]

IEA (2017), *The Future of Trucks*, IEA, Paris, https://www.iea.org/reports/the-future-of-trucks (accessed on 30 July 2021). [124]

ILO (2015), *Anticipating skill needs for green jobs: A practical guide*, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_564692.pdf. [183]

ILO (International Labour Organisation) (2011), *Skills for Green Jobs: A Global View, Synthesis report based on 21 country studies conducted jointly with CEDEFOP (European Centre for the Development of Vocational Training)*. [174]

IMF (2019), *Fiscal Monitor: How to Mitigate Climate Change*. [227]

International Renewable Energy Agency (2021), *Country Rankings*, https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings. [47]

IRENA (2020), *Renewable Power Generation Costs in 2019*, International Renewable Energy Agency. [102]

ITF (2021), *ITF Transport Outlook 2021*, OECD Publishing, Paris, https://dx.doi.org/10.1787/16826a30-en. [122]

Jacob, K. et al. (2011), *Integrating The Environment n Regulatory Impact Assessments*, https://www.oecd.org/gov/regulatory-policy/Integrating%20RIA%20in%20Decision%20Making.pdf. [75]

Jacobsen, M. et al. (2020), "The Use of Regression Statistics to Analyze Imperfect Pricing Policies", *Journal of Political Economy*, Vol. 128/5, pp. 1826-1876, http://dx.doi.org/10.1086/705553. [142]

Jagger, N., T. Foxon and A. Gouldson (2014), "Licensing and certification to increase skills provision and utilisation amongst low-carbon small and medium-sized enterprises in the United Kingdom", in *Greener Skills and Jobs*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264208704-11-en. [181]

Jeudy-Hugo, S., L. Lo Re and C. Falduto (2021), "Understanding countries' net-zero emissions targets", *OECD/IEA Climate Change Expert Group Papers*, No. 2021/03, OECD Publishing, Paris, https://dx.doi.org/10.1787/8d25a20c-en. [1]

Joint Research Centre, European Commission (2014), *Tailoring air quality actions for sustainable cities*, https://ec.europa.eu/jrc/sites/default/files/20141021-certh-jrc-conference-pisoni.pdf. [77]

Kahneman, D., J. Knetsch and R. Thaler (1991), "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias", *Journal of Economic Perspectives*, Vol. 5/1, pp. 193-206, http://dx.doi.org/10.1257/jep.5.1.193. [215]

Kallbekken, S., S. Kroll and T. Cherry (2011), "Do You Not Like Pigou, or Do You Not Understand Him? Tax Aversion and Revenue Recycling in the Lab", *Journal of Environmental Economics and Management*, Vol. 62/1, pp. 53-64. [213]

Katz, M. and C. Shapiro (1994), "Systems Competition and Network Effects", *Journal of Economic Perspectives*, Vol. 8/2, pp. 93-115, http://dx.doi.org/10.1257/jep.8.2.93. [63]

Kaufman, N. (ed.) (2018), *Distributional Implications of a Carbon Tax*, Urban-Brookings Tax Policy Center, Columbia SIPA Center on Global Energy Policy. [161]

Klenert, D. and L. Mattauch (2019), "Carbon Pricing for Inclusive Prosperity: The Role of Public Support", *Economics for Inclusive Prosperity Network*, Vol. Policy Brief 16. [228]

Klenert, D. et al. (2018), "Making Carbon Pricing Work for Citizens", *Nature Climate Change*, Vol. 8, pp. 669-677. [214]

Kolstad, C. (2011), *Intermediate environmental economics: International edition*, OUP Catalogue. [53]

Koźluk, T. (2014), "The Indicators of the Economic Burdens of Environmental Policy Design: Results from the OECD Questionnaire", *OECD Economics Department Working Papers*, No. 1178, OECD Publishing, Paris, https://dx.doi.org/10.1787/5jxrjnbnbm8v-en. [41]

Krosnick, J. et al. (2006), "The Origins and Consequences of Democratic Citizens' Policy Agendas: A Study of Popular Concern About Global Warming", *Climate Change*, Vol. 77, pp. 7-43. [197]

Lam, S. (2015), "Predicting Support of Climate Policies by Using A Protection Motivation Model", *Climate Policy*, Vol. 15/3, pp. 321-338, https://doi.org/10.1080/14693062.2014.916599. [251]

Larson and E. al. (2013), "Land tenure and REDD+: The good, the bad and the ugly", *Global Environmental Change*, Vol. 23/3, pp. 678-689, https://doi.org/10.1016/j.gloenvcha.2013.02.014. [34]

Lavallee, E. et al. (2010), *Poverty alleviation policy targeting: a review of experiences in developing countries*, Université Paris-Dauphine. [157]

Lecuyer, O. and P. Quirion (2013), "Can uncertainty justify overlapping policy instruments to mitigate emissions?", *Ecological Economics*, Vol. 93, pp. 177-191, http://dx.doi.org/10.1016/j.ecolecon.2013.05.009. [67]

Levinson, A. (2019), "Energy Efficiency Standards Are More Regressive Than Energy Taxes: Theory and Evidence", *Journal of the Association of Environmental and Resource Economists*, Vol. 6/S1, pp. S7-S36, http://dx.doi.org/10.1086/701186. [141]

Levinson, A. (2010), "Belts and Suspenders: Interactions Among Climate Policy Regulations", *NBER Working Paper 16109*. [70]

Lockwood, M. (2018), "Right-wing populism and the climate change agenda: exploring the linkages", *Environmental Politics*, Vol. 27/4, http://dx.doi.org/10.1080/09644016.2018.1458411. [208]

Magnenou, F. (2019), *"Gilets jaunes" : les prix du carburant ont-ils augmenté un an après le début du mouvement ?*, https://www.francetvinfo.fr/economie/transports/gilets-jaunes/infographies-gilets-jaunes-les-prix-du-carburant-ont-ils-augmente-un-an-apres-le-debut-du-mouvement_3702561.html. [263]

Marin, G. and F. Vona (2019), "Climate policies and skill-biased employment dynamics: Evidence from EU countries", *Journal of Environmental Economics and Management*, Vol. 98, p. 102253, http://dx.doi.org/10.1016/j.jeem.2019.102253. [146]

Marten, M. and K. van Dender (2019), "The use of revenues from carbon pricing", *OECD Taxation Working Papers*, No. 43, OECD Publishing, Paris, https://dx.doi.org/10.1787/3cb265e4-en. [61]

Masson-Delmotte, V. et al. (eds.) (2021), *Summary for Policymakers*, Cambridge University Press. [16]

Matasick, C., C. Alfonsi and A. Bellantoni (2020), "Governance Responses to Disinformation", *OECD Working Papers on Public Governance*, Vol. 39, https://doi.org/10.1787/19934351. [218]

Mazzucato, M. (2015), "The Entrepreneurial State", in *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, Anthem Press, https://books.google.fr/books?id=L-znCgAAQBAJ. [101]

Mazzucato, M. (2015), "The Green Entrepreneurial State", *SSRN Electronic Journal*, pp. 134-152, http://dx.doi.org/10.2139/ssrn.2744602. [98]

Mazzucato, M. and C. Perez (2014), "Innovation as Growth Policy: The Challenge for Europe", *The Triple Challenge: Europe in a New Age*, No. SWPS 2014-13, SPRU, University of Sussex, http://www.sussex.ac.uk/spru/research/swps' (accessed on 21 July 2021). [105]

Mendelsohn, M. and C. Kreycik (2012), *Federal and State Structures to Support Financing Utility-Scale Solar Projects and the Business Models Designed to Utilize Them*, Technical Report NREL/TP-6A20-48685, National Renewable Energy Laboratory, U.S. Department of Energy, http://www.osti.gov/bridge (accessed on 21 July 2021). [103]

Ministry of Environment, New Zealand Government (2019), *Climate Change Response (Zero Carbon) Amendment Act 2019*, https://www.legislation.govt.nz/act/public/2019/0061/latest/whole.html. [233]

Ministry of Finance, Germany (2021), *Bundesministerium der Finanzen*, https://www.bundesfinanzministerium.de/Content/EN/Downloads/key-issues-paper-international-climate-club.pdf?__blob=publicationFile&v=3. [223]

Morgenstern, R., W. Pizer and J. Shih (2002), "Jobs Versus the Environment: An Industry-Level Perspective", *Journal of Environmental Economics and Management*, Vol. 43/3, pp. 412-436. [204]

Mourougane, A. (2010), "Phasing Out Energy Subsidies in Indonesia", *OECD Economics Department Working Papers*, No. 808, OECD Publishing, Paris, https://dx.doi.org/10.1787/5km5xvc9c46k-en. [170]

Mueller, D. (2003), *Public Choice III*, Cambridge University Press, http://dx.doi.org/10.1017/cbo9780511813771. [225]

Murray, B. and N. Rivers (2015), "British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy", *Energy Policy*, Vol. 86, pp. 674-683, http://dx.doi.org/10.1016/j.enpol.2015.08.011. [247]

NASEO and EFI (2020), *U.S. Energy and Employment Report*, https://www.usenergyjobs.org/. [184]

NDRC (2021), *Main Functions of the NDRC*, https://en.ndrc.gov.cn/aboutndrc/mainfunctions/. [46]

Neaimeh, M. et al. (2017), "Analysing the usage and evidencing the importance of fast chargers for the adoption of battery electric vehicles", *Energy Policy*, Vol. 108, pp. 474-486, http://dx.doi.org/10.1016/J.ENPOL.2017.06.033. [128]

New Zealand Green Investment Finance (2021), *NZ Green Investment Finance*, https://nzgif.co.nz/. [234]

Newell, R. and W. Pizer (2003), "Regulating stock externalities under uncertainty", *Journal of Environmental Economics and Management*, Vol. 45/2, pp. 416-432, http://dx.doi.org/10.1016/s0095-0696(02)00016-5. [57]

Nicholas, M. and D. Hall (2018), *Lessons learned on early electric vehicle fast-charging deployments*, International Council on Clean Transportation. [130]

Nordhaus, W. (2015), "Climate Clubs: Overcoming Free-riding in International Climate Policy", *American Economic Review*, Vol. 105/4, pp. 1339-1370, http://dx.doi.org/10.1257/aer.15000001. [222]

Norwegian Ministry of Climate and Environment (2021), *Oversikt over alle regjeringa vil-punkta i meldinga*, https://www.regjeringen.no/contentassets/202fec60ac844d4ca7d53d65b6b9ac9c/alle-regjeringa-vil-punkt-i-meldinga.pdf. [131]

Novan, K. (2017), "Overlapping Environmental Policies and the Impact on Pollution", *Journal of the Association of Environmental and Resource Economists*, Vol. 4/S1, pp. S153-S199, http://dx.doi.org/10.1086/691994. [71]

OECD (2022), *OECD Economic Surveys: Norway*, OECD Publishing, Paris. [134]

OECD (2021), *Assessing the Economic Impacts of Environmental Policies: Evidence from a Decade of OECD Research*, OECD Publishing, Paris, https://dx.doi.org/10.1787/bf2fb156-en. [84]

OECD (2021), *Climate Finance Provided and Mobilised by Developed Countries: Aggregate Trends Updated with 2019 Data*, Climate Finance and the USD 100 Billion Goal, OECD Publishing, Paris, https://dx.doi.org/10.1787/03590fb7-en. [19]

OECD (2021), *International Programme for Action on Climate (IPAC) – Proposal for a first edition of the indicator dashboard*. [24]

OECD (2021), *Lobbying in the 21st Century: Transparency, Integrity and Access*, OECD Publishing, Paris, https://dx.doi.org/10.1787/c6d8eff8-en. [267]

OECD (2021), *Making Better Policies for Food Systems*, OECD Publishing, https://doi.org/10.1787/ddfba4de-en. [80]

OECD (2021), “OECD Economic Survey of Denmark 2021”, Vol. Chapt. 2 and 3. [194]

OECD (2021), *OECD Economic Surveys: Denmark 2021*, OECD Publishing, Paris, https://dx.doi.org/10.1787/86f7b2d9-en. [26]

OECD (2021), *OECD Economic Surveys: Indonesia 2021*, OECD Publishing, Paris, https://dx.doi.org/10.1787/fd7e6249-en. [167]

OECD (2021), *OECD Environmental Performance Reviews: Ireland 2021*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://dx.doi.org/10.1787/9ef10b4f-en. [27]

OECD (2021), *OECD Inventory of Support Measures for Fossil Fuels: Country Notes*, OECD Publishing, Paris, https://dx.doi.org/10.1787/5a3efe65-en. [37]

OECD (2021), “Policies for a climate-neutral industry”*, OECD Science, Technology and Industry Policy Papers*, Organisation for Economic Co-Operation and Development (OECD), http://dx.doi.org/10.1787/a3a1f953-en. [58]

OECD (2021), “Policy strategies and challenges for climate change mitigation in the Agriculture, Forestry and Other Land Use (AFOLU) sector”, Vol. 149, http://dx.doi.org/10.1787/47b3493b-en. [31]

OECD (2021), *Spurring growth and closing gaps through digitalization in a post-COVID world: Policies to LIFT all boats*, OECD Publishing. [106]

OECD (2021), “Strengthening adaptation-mitigation linkages for a low-carbon, climate-resilient future”*, OECD Environment Policy Papers*, No. 23, OECD Publishing, Paris, https://dx.doi.org/10.1787/6d79ff6a-en. [4]

OECD (2021), *Taxing Energy Use for Sustainable Development. Opportunities for energy tax and subsidy reform in selected developing countries and emerging economies*, OECD. [36]

OECD (2020), *Financing SMEs and Entrepreneurs 2020: An OECD Scoreboard*, OECD Publishing, Paris, https://dx.doi.org/10.1787/061fe03d-en. [107]

OECD (2020), “Green budgeting and tax policy tools to support a green recovery”, *OECD Publishing*. [111]

OECD (2020), *Green Infrastructure in the Decade for Delivery: Assessing Institutional Investment*, Green Finance and Investment, OECD Publishing, Paris, https://dx.doi.org/10.1787/f51f9256-en. [114]

OECD (2020), *OECD Economic Surveys: Germany 2020*, OECD Publishing, Paris, https://dx.doi.org/10.1787/91973c69-en. [189]

OECD (2020), *Policy Instruments for the Environment*, http://www.oecd.org/environment/indicators-modelling-outlooks/policy-instrument-database/. [35]

OECD (2019), "A Global Economic Evaluation of GHG Mitigation Policies for Agriculture", *Joint Working Party on Agriculture and the Environment*. [32]

OECD (2019), "Aligning Development Cooperation and Climate Action: The Only Way Forward". [17]

OECD (2019), *Budgeting and Public Expenditures in OECD Countries 2019*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264307957-en. [110]

OECD (2019), *OECD Economic Surveys: China 2019*, OECD Publishing, Paris, https://dx.doi.org/10.1787/eco_surveys-chn-2019-en. [48]

OECD (2019), *Slovenia Development Strategy 2030: Prospects, challenges and policy options to achieve the main objectives*. [112]

OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action*, OECD Publishing, Paris, https://dx.doi.org/10.1787/058ca239-en. [220]

OECD (2019), "The Impacts of Climate Change Mitigation Policies in Agriculture: Finding the Balance", *Joint Working Party on Agriculture and the Environment*. [33]

OECD (2018), *Developing Robust Project Pipelines for Low-Carbon Infrastructure*, OECD, http://dx.doi.org/10.1787/9789264307827-en. [113]

OECD (2018), *Rethinking Urban Sprawl*, OECD, http://dx.doi.org/10.1787/9789264189881-en. [126]

OECD (2017), *Boosting Skills for Greener Jobs in Flanders, Belgium*, OECD Green Growth Studies, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264265264-en. [185]

OECD (2017), *OECD Best Practice Principles on Stakeholder Engagement in Regulatory (Draft)*, http://www.oecd.org/governance/regulatory-policy/public-consultation-best-practiceprinciples-on-stakeholder-engagement.htm. [108]

OECD (2017), *OECD Environmental Performance Reviews: New Zealand 2017*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264268203-en. [28]

OECD (2017), "Preventing Policy Capture: Integrity in Public Decision Making", *OECD Public Governance Reviews*, https://doi.org/10.1787/9789264065239-en. [229]

OECD (2017), *Recommendation of the Council on Open Government*, https://www.oecd.org/gov/Recommendation-Open-Government-Approved-Council-141217.pdf. [231]

OECD (2017), *Tackling Environmental Problems with the Help of Behavioural Insights*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264273887-en. [90]

OECD (2015), *Aligning Policies for a Low-carbon Economy*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264233294-en. [8]

OECD (2015), "Environmentally related R&D", *Environment at a Glance 2015: OECD Indicator*, https://doi.org/10.1787/9789264235199-21-en. [99]

OECD (2015), “Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists”, *OECD Science, Technology and Industry Policy Papers*, Vol. 21, https://doi.org/10.1787/5js33l1jcpwb-en. [79]

OECD (2012), *OECD Economic Surveys: Indonesia 2012*, OECD Publishing, Paris, https://dx.doi.org/10.1787/eco_surveys-idn-2012-en. [169]

OECD (2012), *Recommendation of the Council on Regulatory Policy and Governance*, https://www.oecd.org/gov/regulatory-policy/49990817.pdf. [74]

OECD (2012), “The Jobs Potential of a Shift Towards a Low-Carbon Economy”, *OECD Green Growth Papers*, No. 2012/1, OECD Publishing, Paris, https://dx.doi.org/10.1787/5k9h3630320v-en. [144]

OECD (2011), *Better Policies to Support Eco-innovation*, OECD Studies on Environmental Innovation, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264096684-en. [100]

OECD (2011), *Fostering Innovation for Green Growth*, OECD Green Growth Studies, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264119925-en. [96]

OECD (2011), *Invention and Transfer of Environmental Technologies*, OECD Studies on Environmental Innovation, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264115620-en. [95]

OECD (2011), *Towards Green Growth*, OECD Green Growth Studies, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264111318-en. [177]

OECD (2008), *Household Behaviour and the Environment: Reviewing the Evidence*, OECD Publishing, Paris. [139]

OECD (2007), *Instrument Mixes for Environmental Policy*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264018419-en. [65]

OECD/European Union (2017), *The Missing Entrepreneurs 2017: Policies for Inclusive Entrepreneurship*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264283602-en. [180]

OECD/IEA (2021), *Update on recent progress in reform of inefficient fossil-fuel subsidies that encourage wasteful consumption*, http://www.oecd.org/fossil-fuels/publicationsandfurtherreading/OECD-IEA-G20-Fossil-Fuel-Subsidies-Reform-Update-2021.pdf. [166]

OECD/NEA (2019), *The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables*, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_15000/the-costs-of-decarbonisation-system-costs-with-high-shares-of-nuclear-and-renewables. [119]

OECD; IEA; World Bank; IISD-GSI; GIZ Indonesia; Members of the Peer Review Team: China, Germany, Italy, Mexico, New Zealand (2019), *Indonesia’s effort to phase out and rationalise its fossil-fuel subsidies - A report on the G20 peer-review of inefficient fossil-fuel subsidies that encourage wasteful consumption in Indonesia*, https://www.oecd.org/fossil-fuels/publication/G20%20peer%20review%20Indonesia_Final-v2.pdf. [172]

Office fédéral de l'environnement (OFEV), Confédération Suisse (2020), *Taxe sur le CO2*, https://www.bafu.admin.ch/bafu/fr/home/themes/climat/info-specialistes/mesures-reduction/taxe-co2.html. [221]

Paris Agreement (2015), *Report*. [15]

Park, H. and A. Vedlitz (2013), "Climate Hazards and Risk Status: Explaining Climate Risk Assessment, Behavior, and Policy Support", *Sociological Spectrum*, Vol. 33/3, pp. 219-239, https://doi.org/10.1080/02732173.2013.732900. [201]

Peet, C. and K. Harrison (2012), "Historical Legacies and Policy Reform: Diverse Regional Reactions to British Columbia's Carbon Tax", *BC Studies*, Vol. 173, pp. 95-120, https://doi.org/10.14288/bcs.v0i173.2431. [243]

Perino, G., R. Ritz and A. van Benthem (2019), *Overlapping Climate Policies*, National Bureau of Economic Research, Cambridge, MA, http://dx.doi.org/10.3386/w25643. [73]

Pew Research Center (2018), *Spring 2018 Global Attitudes Survey*. [210]

Phylipsen, D., A. Anger-Kraavi and C. Mukonza (2020), *CPLC Executive Brief: Distributional Impacts of Carbon Pricing On Households*, https://climatestrategies.org/publication/cplc-distributional-impacts/. [148]

Policy Ltd. (2020), *Compare the parties: Environment — NZ Election 2020*, https://policy.nz/topic/environment#Emissions%20reduction. [239]

Popp, D. (2019), *Environmental Policy and Innovation: A Decade of Research*, National Bureau of Economic Research, Cambridge, MA, http://dx.doi.org/10.3386/w25631. [13]

Popp, D. (2003), "Pollution control innovations and the Clean Air Act of 1990", *Journal of Policy Analysis and Management*, Vol. 22/4, pp. 641-660, http://dx.doi.org/10.1002/pam.10159. [94]

Popp, D., R. Newell and A. Jaffe (2010), "Energy, the Environment, and Technological Change", in *Handbook of the Economics of Innovation, Volume 2, Handbook of the Economics of Innovation*, Elsevier, http://dx.doi.org/10.1016/s0169-7218(10)02005-8. [50]

Rafaty, R. (2018), "Perceptions of Corruption, Political Distrust, and the Weakening of Climate Policy", *SSRN Electronic Journal*, http://dx.doi.org/10.2139/ssrn.3175064. [219]

Reguant, M. (2019), "The Efficiency and Sectoral Distributional Impacts of Large-Scale Renewable Energy Policies", *Journal of the Association of Environmental and Resource Economists*, Vol. 6/S1, pp. S129-S168, http://dx.doi.org/10.1086/701190. [135]

Republic of Indonesia: Ministry of Finance and Ministry of Energy and Mineral Resources (2019), *Indonesia Effort to Phase Out and Rationalise Its Fossil-Fuel Subsidies - A self report on the G-20 peer review of inefficient fossil fuel subsidies that encourage wasteful consumption in Indonesia*. [171]

Risk Control Limited (2020), *Infrastructure Debt Capital Charges for Insurers*, https://www.gihub.org/resources/publications/increasing-infrastructure-investment/ (accessed on June 2021). [118]

Rodríguez-Pose, A. (2018), "The revenge of the places that don't matter (and what to do about it).", *Cambridge journal of regions, economy and society*, Vol. 11/1, pp. 189-209. [207]

Rosés, J. and N. Wolf (2018), *The return of regional inequality: Europe from 1900 to today*, https://voxeu.org/article/return-regional-inequality-europe-1900-today. [209]

Royal Society (2016), *Coastal Change*, https://www.royalsociety.org.nz/what-we-do/our-expert-advice/all-expert-advice-papers/climate-change-implications-for-new-zealand/key-risks/coastal-change/. [236]

Salmon, R. et al. (2017), *Climate Change Communication in New Zealand*, Oxford University Press, http://dx.doi.org/10.1093/acrefore/9780190228620.013.475. [237]

Sheldon, P., R. Junankar and A. De Rosa Pontello (2018), *The Ruhr or Appalachia? deciding the future of Australia's coal power workers and communities*, University of New South Wales, Industrial Relations Research Centre. [187]

Sibley, C. and T. Kurz (2013), "A Model of Climate Belief Profiles: How Much Does It Matter If People Question Human Causation?", *Analyses of Social Issues and Public Policy*, Vol. 13/1, pp. 245-261, http://dx.doi.org/10.1111/asap.12008. [202]

Statista (2019), *Prix annuel moyen du pétrole brut de l'OPEP entre 1960 et 2019*, https://fr.statista.com/statistiques/564926/prix-annuel-du-petrole-de-l-opep-1960/. [264]

Sterner, T. (ed.) (2012), *Fuel Taxes and the Poor: The Distributional Effects of Gasoline Taxation and Their Implications for Climate Policy*, Resources for the Future Press. [249]

Stewart, J. (2006), "Value Conflict and Policy Change", *Review of Policy Research*, Vol. 23/1, pp. 183-195, https://doi.org/10.1111/j.1541-1338.2006.00192.x. [253]

Stiglitz, J. (2019), "Addressing climate change through price and non-price interventions", *European Economic Review*, Vol. 119, pp. 594-612, http://dx.doi.org/10.1016/j.euroecorev.2019.05.007. [7]

Stiglitz, J. et al. (2017), *Report of the high-level commission on carbon prices*. [6]

Thacher, D. and M. Rein (2004), "Managing Value Conflict in Public Policy", *Governance*, Vol. 17/4, pp. 457-486, http://dx.doi.org/10.1111/j.0952-1895.2004.00254.x. [252]

Tikoudis, I. and W. Oueslati (2020), "MOLES: A New Approach to Modeling the Environmental and Economic Impacts of Urban Policies", *Computational Economics*, http://dx.doi.org/10.1007/s10614-019-09962-3. [91]

Tompson, W. (2009), *The Political Economy of Reform: Lessons from Pensions, Product Markets and Labour Markets in Ten OECD Countries*, OECD Publishing, https://dx.doi.org/10.1787/9789264073111-en. [203]

Transport & Environment (2018), *Roll-out of public EV charging infrastructure in the EU*, https://www.transportenvironment.org/publications/roll-out-public-ev-charging-infrastructure-eu (accessed on 2 August 2021). [129]

UK Department for Business, Energy & Industrial Strategy (2016), *Oil and gas workforce plan*, https://www.gov.uk/government/publications/oil-and-gas-workforce-plan. [179]

UNEP (2019), *Collaborative Framework for Food Systems Transformation A multi-stakeholder*, https://www.oneplanetnetwork.org/resource/collaborative-framework-food-systems-transformation-multi-stakeholder-pathway-sustainable. [81]

UNFCCC (2021), *Nationally determined contributions under the Paris Agreement. Synthesis report by the secretariat*. [2]

UNFCCC (2009), *Copenhagen Accord*, https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf. [18]

UN-Habitat/UNEP (2015), *Green Building Interventions For Social Housing*, United Nations Human Settlements Programme (UN-Habitat). [165]

United Nations Environment Programme (2019), *Emissions Gap Report 2019*, UNEP. [3]

Vie Publique (2017), *Loin des métropoles, le sentiment d'être délaissé par les pouvoirs publics*, https://www.vie-publique.fr/en-bref/19769-loin-des-metropoles-sentiment-detre-delaisse-par-les-pouvoirs-publics. [260]

Viebrock, E. and J. Clasen (2008), "Flexicurity and welfare reform: a review", *Socio-Economic Review*, Vol. 7/2, pp. 305-331, http://dx.doi.org/10.1093/ser/mwp001. [182]

Vollebergh, H. and E. van der Werf (2014), "The Role of Standards in Eco-innovation: Lessons for Policymakers", *Review of Environmental Economics and Policy*, Vol. 8/2, pp. 230-248, http://dx.doi.org/10.1093/reep/reu004. [64]

Vona, F. (2021), "Managing the distributional effects of environmental and climate policies: The narrow path for a triple dividend", *OECD Environment Working Papers*, No. 188, OECD Publishing, Paris, https://dx.doi.org/10.1787/361126bd-en. [195]

Vona, F. et al. (2018), "Environmental Regulation and Green Skills: An Empirical Exploration", *Journal of the Association of Environmental and Resource Economists*, Vol. 5/4, pp. 713-753, http://dx.doi.org/10.1086/698859. [176]

Vona, F. and F. Patriarca (2011), "Income inequality and the development of environmental technologies", *Ecological Economics*, Vol. 70/11, pp. 2201-2213, http://dx.doi.org/10.1016/j.ecolecon.2011.06.027. [256]

Walker, W. (2013), "The Transitional Costs of Sectoral Reallocation: Evidence From the Clean Air Act and the Workforce*", *The Quarterly Journal of Economics*, Vol. 128/4, pp. 1787-1835, http://dx.doi.org/10.1093/qje/qjt022. [149]

Weber, E. and E. Johnson (2011), "Psychology And Behavioral Economics Lessons For The Design Of A Green Growth Strategy", Vol. Policy Research Working Paper 6240. [12]

Weitzman, M. (1974), “Prices vs. quantities”, *The review of economic studies*, Vol. 41/4, pp. 477-491. [56]

Williams, R., D. Burtraw and R. Morgenstern (2015), “The Impacts of a US Carbon Tax across Income Groups and States”, *Resources Magazine*, https://www.resources.org/archives/the-impacts-of-a-us-carbon-tax-across-income-groups-and-states/. [163]

Yamano, N. and J. Guilhoto (2020), “CO2 emissions embodied in international trade and domestic final demand: Methodology and results using the OECD Inter-Country Input-Output Database”*, OECD Science, Technology and Industry Working Papers*, No. 2020/11, OECD Publishing, Paris, https://dx.doi.org/10.1787/8f2963b8-en. [88]

Zachmann, G., G. Fredriksson and G. Claeys (2018), *The Distributional Effects of Climate Policies*. [136]

Zahran, S. et al. (2006), “Climate Change Vulnerability and Policy Support”, *Society & Natural Resources*, Vol. 19/9, pp. 771-789, http://dx.doi.org/10.1080/08941920600835528. [198]

Zhou, Y. and S. Li (2018), “Technology Adoption and Critical Mass: The Case of the U.S. Electric Vehicle Market”, *The Journal of Industrial Economics*, Vol. 66/2, pp. 423-480, http://dx.doi.org/10.1111/joie.12176. [109]

Zuegel, K., E. Cantera and A. Bellantoni (2018), “The Role of Ombudsman Institutions in Open Government”, *OECD Working Papers on Public Governance*, Vol. 29, https://doi.org/10.1787/7353965f-en. [232]