

WG III contribution to the Sixth Assessment Report

List of corrigenda to be implemented

The corrigenda listed below will be implemented in the Chapter during copy-editing.

CHAPTER 13

Document (Chapter, Annex, Supp. Material)	Page (Based on the final pdf FGD version)	Line	Detailed information on correction to make
Chapter 13	27	43	Delete 'Clemens 1997' from the list of in-text citations
Chapter 13	99	34-35	Delete 'Clemens, E. S., 1997: The People's Lobby: Organizational Innovation and the Rise of Interest Group Politics in the United States 1890-1925. The University of Chicago Press, Chicago and London, 467 pp.'
Chapter 13	28	4	Delete 'Meyer and Tarrow 1997' from the list of in-text citations
Chapter 13	132	30-31	Delete 'Meyer, D. S., and S. Tarrow, eds., 1997: The Social Movement Society: Contentious Politics for a New Century. Rowman & Littlefield Publishers, Washington D.C, 292 pp.'
Chapter 13	27	33	Delete 'Salt and Layzell 1985' from the list of in-text citations

Chapter 13	143	45-46	Delete 'Salt, C., and J. Layzell, 1985: Here We Go!: Women's Memories of the 1984/85 Miners Strike. London Political Committee Co-operative Retail Services Limited, 88 pp.'
Chapter 13	24	22-32	<p>Replace:</p> <p>Evidence shows that CO2 emissions increase with corruption, either through the direct negative effect of corruption on law enforcement, including in the forestry sector (Sundström 2016), or through the negative effect of corruption on countries' income (Welsch 2004).</p> <p>With</p> <p>Evidence shows that CO2 emission levels can be affected by corruption, either through the direct negative effect of corruption on law enforcement, including in the forestry sector (Sundström 2016), or through the negative effect of corruption on countries' income (Welsch 2004).</p>
Chapter 13	30	8-13	<p>Overall, courts have also played a more active role for climate governance in democratic political systems (Peel and Osofsky 2015; Eskander et al. 2021), but recently legal reforms have also developed in other countries, such as the environmental public interest law in China that allows individuals and groups to initiate environmental litigation (Xie and Xu 2021; Zhao et al. 2019). Whether and to what extent differing law traditions and political systems influence the role and importance of climate litigation has, however, not been examined enough scientifically (Peel and Osofsky 2020; Setzer and Vanhala 2019).</p> <p>With :</p> <p>Overall, courts have also played a more active role for climate governance in democratic political systems (Peel and Osofsky 2015; Eskander et al. 2021). Whether and to what extent differing law traditions and political systems influence the role and importance of climate litigation has, however, not been examined enough scientifically (Peel and Osofsky 2020; Setzer and Vanhala 2019).</p>
Chapter 13	53	34-35	<p>A paper cites Taiwan's green public procurement law, which has contributed to reduced emissions intensity (Tsai 2017). In practice, awareness and knowledge of 'green' public procurement techniques and procedures is decisive for climate-friendly procurement (Testa et al. 2016).</p> <p>With</p> <p>A paper cites Taiwan (province of China) green public procurement law, which has contributed to reduced emissions intensity (Tsai 2017). In practice, awareness and knowledge of 'green' public procurement techniques and procedures is decisive for climate-friendly procurement (Testa et al. 2016).</p>

Chapter 13: National and Sub-national Policies and Institutions

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Executive Summary

Long-term deep emission reductions, including the reduction of emissions to net zero, is best achieved through institutions and governance that nurture new mitigation policies, while at the same time reconsidering existing policies that support continued Greenhouse Gas (GHG) emissions (*robust evidence, high agreement*). To do so effectively, the scope of climate governance should include both direct efforts to target GHG emissions and indirect opportunities to tackle GHG emissions that result from efforts directed towards other policy objectives). {13.2, 13.5, 13.6, 13.7, 13.9}

Institutions and governance underpin mitigation by providing the legal basis for action. This includes setting up implementing organisations and the frameworks through which diverse actors interact (*medium evidence, high agreement*). Institutions can create mitigation and sectoral policy instruments; policy packages for low-carbon system transition; and economy wide measures for systemic restructuring. {13.2, 13.7, 13.9}

Policies have had a discernible impact on mitigation for specific countries, sectors, and technologies (*robust evidence, high agreement*), **avoiding emissions of several GtCO₂-eq yr⁻¹** (*medium evidence, medium agreement*). Both market-based and regulatory policies have distinct, but complementary roles. The share of global GHG emissions subject to mitigation policy has increased rapidly in recent years, but big gaps remain in policy coverage, and the stringency of many policies falls short of what is needed to achieve strong mitigation outcomes (*robust evidence, high agreement*). {13.6, Cross-chapter box 10 in Chapter 14}

Climate laws enable mitigation action by signalling the direction of travel, setting targets, mainstreaming mitigation into sector policies, enhancing regulatory certainty, creating law-backed agencies, creating focal points for social mobilization, and attracting international finance (*medium evidence, high agreement*). By 2020, ‘direct’ climate laws primarily focused on GHG reductions were present in 56 countries covering 53% of global emissions, while more than 690 laws, including ‘indirect’ laws, may also have an effect on mitigation. Among direct laws, ‘framework’ laws set an overarching legal basis for mitigation either by pursuing a target and implementation approach, or by seeking to mainstream climate objectives through sectoral plans and integrative institutions. {13.2}

Institutions can enable improved governance by coordinating across sectors, scales and actors, building consensus for action, and setting strategies (*medium evidence, high agreement*). Institutions are more stable and effective when they are congruous with national context, leading to mitigation-focused institutions in some countries and the pursuit of multiple objectives in others. Sub-national institutions play a complementary role to national institutions by developing locally-relevant visions and plans, addressing policy gaps or limits in national institutions, building local administrative structures and convening actors for place-based decarbonisation. {13.2}

Sub-national actors are important for mitigation because municipalities and regional governments have jurisdiction over climate-relevant sectors such as land-use, waste and urban policy; are able to experiment with climate solutions; and can forge partnerships with the private sector and internationally to leverage enhanced climate action (*robust evidence, high agreement*). More than 10,500 cities and nearly 250 regions representing more than 2 billion people have pledged largely voluntary action to reduce emissions. Indirect gains include innovation, establishing norms and developing capacity. However, sub-national actors often lack national support, funding, and capacity to mobilize finance and human resources, and create new institutional competences. {13.5}

Climate governance is constrained and enabled by domestic structural factors, but it is still possible for actors to make substantial changes (*medium evidence, high agreement*). Key structural factors are domestic material endowments (such as fossil fuels and land-based resources); domestic political systems; and prevalent ideas, values and belief systems. Developing countries face additional material constraints in climate governance due to development challenges and scarce economic or natural resources. A broad group

of actors influence how climate governance develop over time, including a range of civic organizations, encompassing both pro-and anti-climate action groups. {13.3, 13.4}

Mitigation strategies, instruments and policies that fit with dominant ideas, values and belief systems within a country or within a sector are more easily adopted and implemented (*medium evidence, medium agreement*). Ideas, values and beliefs may change over time. Policies that bring perceived direct benefits, such as subsidies, usually receive greater support. The awareness of co-benefits for the public increases support of climate policies (*robust evidence, high agreement*). {13.2, 13.3, 13.4}

Climate litigation is growing and can affect the outcome and ambition of climate governance (*medium evidence, high agreement*). Since 2015, at least 37 systemic cases have been initiated against states that challenge the overall effort of a state to mitigate or adapt to climate change. If successful, such cases can lead to an increase in a country's overall ambition to tackle climate change. Climate litigation has also successfully challenged governments' authorizations of high-emitting projects setting precedents in favour of climate action. Climate litigation against private sector and financial institutions is also on the rise. {13.4}

The media shapes the public discourse about climate mitigation. This can usefully build public support to accelerate mitigation action, but may also be used to impede decarbonisation (*medium evidence, high agreement*). Global media coverage (across a study of 59 countries) has been growing, from about 47,000 stories in 2016-17 to about 87,000 in 2020-21. Generally the media representation of climate science has increased and become more accurate over time. On occasion, the propagation of scientifically misleading information by organized counter-movements has fuelled polarization, with negative implications for climate policy. {13.4}

Explicit attention to equity and justice is salient to both social acceptance and fair and effective policymaking for mitigation (*robust evidence, high agreement*). Distributional implications of alternative climate policy choices can be usefully evaluated at city, local and national scales as an input to policymaking. Institutions and governance frameworks that enable consideration of justice and just transitions are likely to build broader support for climate policymaking. {13.2, 13.6, 13.8, 13.9}

Carbon pricing is effective in promoting implementation of low-cost emissions reductions (*robust evidence, high agreement*). While the coverage of emissions trading and carbon taxes has risen to over 20 percent of global CO₂ emissions, both coverage and price are lower than is needed for deep reductions. The design of market mechanisms should be effective as well as efficient, balance distributional goals and find social acceptance. Practical experience has driven progress in market mechanism design, especially of emissions trading schemes (*robust evidence, high agreement*). Carbon pricing is limited in its effect on adoption of higher-cost mitigation options, and where decisions are often not sensitive to price incentives such as in energy efficiency, urban planning, and infrastructure (*robust evidence, medium agreement*). Subsidies have been used to improve energy efficiency, encourage the uptake of renewable energy and other sector-specific emissions saving options (*robust evidence, high agreement*) {13.6}

Regulatory instruments play an important role in achieving specific mitigation outcomes in sectoral applications (*robust evidence, high agreement*). Regulation is effective in particular applications and often enjoys greater political support, but tends to be more economically costly, than pricing instruments (*robust evidence, medium agreement*). Flexible forms of regulation (e.g., performance standards) have achieved aggregate goals for renewable energy generation, vehicle efficiency and fuel standards, and energy efficiency in buildings and industry (*robust evidence, high agreement*). Infrastructure investment decisions are significant for mitigation because they lock in high- or low- emissions trajectories over long periods. Information and voluntary programs can contribute to overall mitigation outcomes (*medium evidence, high agreement*). Designing for overlap and interactions among mitigation policies enhances their effectiveness (*robust evidence, high agreement*). {13.6}

Removing fossil fuel subsidies could reduce emissions by 1-10% by 2030 while improving public revenue and macroeconomic performance (*robust evidence, medium agreement*). {13.6}

National mitigation policies interact internationally with effects that both support and hinder mitigation action (*medium evidence, high agreement*). Reductions in demand for fossil fuels tend to negatively affect fossil fuel exporting countries (*medium evidence, high agreement*). Creation of markets for emission reduction credits tends to benefit countries able to supply credits. Policies to support technology development and diffusion tend to have positive spillover effects (*medium evidence, high agreement*). There is no consistent evidence of significant emissions leakage or competitiveness effects between countries, including for emissions-intensive trade-exposed industries covered by emission trading systems (*medium evidence, medium agreement*). {13.6}

Policy packages are better able to support socio-technical transitions and shifts in development pathways toward low carbon futures than are individual policies (*robust evidence, high agreement*). For best effect, they need to be harnessed to a clear vision for change and designed with attention to local governance context. Comprehensiveness in coverage, coherence to ensure complementarity, and consistency of policies with the overarching vision and its objectives are important design criteria. Integration across objectives occurs when a policy package is informed by a clear problem framing and identification of the full range relevant policy sub-systems. {13.7}

The co-benefits and trade-offs of integrating adaptation and mitigation are most usefully identified and assessed prior to policy making rather than being accidentally discovered (*robust evidence, high agreement*). This requires strengthening relevant national institutions to reduce silos and overlaps, increasing knowledge exchange at the country and regional levels, and supporting engagement with bilateral and multilateral funding partners. Local governments are well placed to develop policies that generate social and environmental co-benefits but to do so require legal backing and adequate capacity and resources. {13.8}

Climate change mitigation is accelerated when attention is given to integrated policy and economy wide approaches, and when enabling conditions (governance, institutions, behaviour, innovation, policy, and finance), are present (*robust evidence, medium agreement*). Accelerating climate mitigation includes simultaneously weakening high carbon systems and encouraging low carbon systems; ensuring interaction between adjacent systems (e.g. energy and agriculture); overcoming resistance to policies (e.g., from incumbents in high carbon emitting industries), including by providing transitional support to the vulnerable and negatively affected by distributional impacts; inducing changes in consumer practices and routines; providing transition support; and addressing coordination challenges in policy and governance. {13.7, 13.9}

Economy wide packages, including economic stimulus packages, can contribute to shifting sustainable development pathways and achieving net zero outcomes whilst meeting short term economic goals (*medium evidence, high agreement*). The 2008-9 Global Recession showed that policies for sustained economic recovery go beyond short-term fiscal stimulus to include long-term commitments of public spending on the low carbon economy; pricing reform; addressing affordability; and minimising distributional impacts. COVID-19 spurred stimulus packages and multi-objective recovery policies that may have the potential to meet short-term economic goals while enabling longer-term sustainability goals. {13.9}

13.1 Introduction

This chapter assesses national and sub-national policies and institutions. Given the scale and scope of the climate challenge, an immediate challenge for this assessment is defining its scope. Because a very wide range of institutions and policies at multiple scales carry implications for climate change, the approach followed here is to embrace a broad approach. Consequently, institutions and policies discussed include dedicated climate laws and organisations (Section 13.2) and direct mitigation policies such as carbon taxes (Section 13.6), but also those, such as sectoral ministries and their policies (Sections 13.6 and 13.7) and sub-national entities such as regional bodies, cities, and their policies (Section 13.5), the implications of which are salient to mitigation outcomes. This approach recognises that there are important linkages with international climate governance (Chapter 14), notably the role of internationally mandated Nationally Determined Contributions' in stimulating domestic policy development (Section 13.2), transnational networks in spurring sub-national action (Section 13.5), and international effects of domestic policies (Section 13.6).

This encompassing approach to climate governance is also built on a recognition that climate policymaking is routinely formulated in the context of multiple policy objectives such as energy security, energy access, urban development, and mitigation-adaptation linkages. This informs policymaking based on an understanding that to fully maximise direct and indirect climate mitigation potential, maximising co-benefits and minimising trade-offs should be explicitly sought rather than accidentally discovered and policies designed accordingly. This understanding also informs the design of institutions (Section 13.2) and policies (Sections 13.6 and 13.7) as well as the linkage between mitigation and adaptation (Section 13.8).

The chapter also engages with several new developments and an expansion of the literature since AR5.

A growing literature assesses how national policymaking on climate mitigation is dependent on national politics around, and building consensus on, climate action. This, in turn, is shaped by both nationally specific structural features (Section 13.3) and the role of different actors in the policy making process (Section 13.4). Important new avenues through which climate policy making is shaped, such as climate litigation (Section 13.4.2), and channels for public opinion formation, such as the media (Section 13.4.3) are also assessed. The chapter weaves discussions of the role of justice, understood through a discussion of procedural justice (Section 13.2), distributional justice (Section 13.6) and vulnerability (Section 13.8), and its role in creating public support for climate action (Section 13.9).

A significant new theme is the focus on the dynamic elements of policymaking, that is, how policy can be designed to accelerate mitigation. This includes through technological transitions, socio-technical transitions, shifts in development pathways and economy wide measures. This literature emphasizes the importance of examining not just individual policies, but packages of policies (Section 13.7) and how these are enabled by the alignment of policy, institutions, finance, behaviour and innovation. (Section 13.9). Also new is attention to the opportunities for economy-wide system change presented by consideration of post-COVID recovery packages, and wider efforts at sustainable economic restructuring (Section 13.9). Consistent with the discussion in Chapter 4, these larger approaches offer opportunities to undertake systemic restructuring and shift development pathways.

Finally, the chapter addresses core themes from earlier assessment reports, but seeks to do so in an enhanced manner. The discussion of climate institutions assesses a growing literature on climate law, as well as both purpose-built climate organisations and the layering of climate responsibilities on existing organisations at national and sub-national scales (Section 13.2). The discussion of policies focuses on an ex post assessment of policies, as well as the interaction among them, and learnings on how they can be combined in packages (Sections 13.6 and 13.7). It also lays out a framework for their assessment that encompasses environmental effectiveness, economic effectiveness, distributional outcomes, co-benefits, institutional requirements, as well as a new criterion of transformational potential (Section 13.6).

The aim of this chapter is to assess the full range of the multi-stranded and diverse literature on climate institutions and policy, reflecting the richness of real-world climate governance.

13.2 National and sub-national institutions and governance

Institutions and governance arrangements can help address ‘policy gaps’ and ‘implementation gaps’ (Cross-Chapter Box 4 in Chapter 4) that hinder climate mitigation. While the need for institutions and governance is universal, individual country approaches vary, based on national approaches and circumstances, as discussed in this section.

Since AR5, the understanding of climate governance has become more encompassing and complex, involving multiple actors, decision-making arenas, levels of decision-making and a variety of political goals. Climate governance sometime directly targets GHG emissions; at other times mitigation results from measures that primarily aim to solve other issues, for instance relating to food production, forest management, energy markets, air pollution, transport systems or technology development, but with mitigation or adaptation effects (Karlsson et al. 2020).

Consistent with usage in this assessment, institutions are rules, norms and conventions that guide, constrain or enable behaviours and practices, including the organisations through which they operate, while governance is the structure, processes and actions that public and private actors use to address societal goals (See Glossary for complete definitions). Multiple terms are used in the literature to discuss climate governance, often varying across countries. Climate laws, or legislation, is passed by legislatures, and often sets the overarching governance context, but the term is also used to refer to legislation that is salient to climate outcomes even if not centrally focused on climate change. National strategies, often referred to as plans, most often operate through executive action by government, set guidance for action and often are not legally binding, although strategies may also be enshrined in law. Both laws and strategies may elaborate targets, or goals, for emissions outcomes, although these are not necessary components of laws and strategies. While laws typically operate at the national level (states may also make laws in federal nations), strategies, plans and targets may also operate at the sub-national level.

This section begins with a discussion of national laws for climate action (Section 13.2.1), followed by a discussion of national strategies (Section 13.2.2). The third section examines institutions (Section 13.2.3), including organisations that are established to govern climate actions, and the final section explores sub-national institutions and their challenges in influencing climate mitigation (Section 13.2.4).

13.2.1 Climate laws

National laws that govern climate action often set the legal basis for climate action (Averchenkova et al. 2021). This legal basis can serve several functions: establish a platform for transparent target setting and implementation (Bennett 2018); provide a signal to actors by indicating intent to harness state authority behind climate action (Scotford and Minas 2019); promise enhanced regulatory certainty (Scotford et al. 2017); create law-backed agencies for coordination, compliance and accountability (Scotford and Minas 2019); provide a basis for mainstreaming mitigation into sector action, and create focal points for social mobilisation (Dubash et al. 2013) (*medium evidence, high agreement*). For lower/middle income countries, in particular, the existence of a law may also attract international finance by serving as a signal of credibility (Fisher et al. 2017). The realisation of these potential governance gains depends on local context, legal design, successful implementation, and complementary action at different scales.

There are both narrow and broad definitions of what counts as ‘climate laws’. The literature distinguishes direct climate laws that explicitly considers climate change causes or impacts -- for example through mention of greenhouse gas reductions in its objectives or title (Dubash et al. 2013) -- from indirect laws that have ‘the

capacity to affect mitigation or adaptation' through the subjects they regulate, for example, through promotion of co-benefits, or creation of reporting protocols (Scotford and Minas 2019). Closely related is a 'sectoral approach' based on the layering of climate considerations into existing laws in the absence of an overarching framework law (Rumble 2019). Many countries also adopt executive climate strategies (discussed in Section 13.2), which may either coexist with or substitute for climate laws, and that may also be related to a country's NDC process under the Paris Agreement.

The prevalence of both direct and indirect climate laws has increased considerably since 2007, although definitional differences across studies complicate a clear assessment of their relative importance (Nachmany and Setzer 2018; Iacobuta et al. 2018) (*medium evidence, high agreement*). Direct climate laws – with greenhouse gas limitation as a direct objective -- had been passed in 56 countries (of 194 studied) covering 53% of emissions in 2020, with most of that rise happening between 2010 and 2015 (see Figure 13.1). Both direct and indirect laws - those that have an effect on mitigation even if this is not the primary outcome – is most closely captured by the "Climate Change Laws of the World" database, which illustrates the same trend of growing prevalence, documenting 694 mitigation-related laws by 2020 versus 558 in 2015 and 342 in 2010 (Nachmany and Setzer 2018; LSE Grantham Research Institute on Climate Change and the Environment 2021).¹ Among these, the majority are accounted for by sectoral indirect laws. For example, a study of Commonwealth countries finds that a majority of these countries have not taken the route of a single overarching law, but rather have an array of laws across different areas, for example, Indian laws on energy efficiency and Ghana's laws on renewable energy promotion (Scotford et al. 2017).

Some direct climate laws may serve as 'framework' laws (Averchenkova et al. 2017; Rumble 2019) that set an overarching legal context within which other legislation and policies operate. Framework laws are intended to provide a coherent legal basis for action, to integrate past legislation in related areas, set clear directions for future policy, and create necessary processes and institutions (Townshend et al. 2013; Fankhauser et al. 2018; Averchenkova et al. 2017; Rumble 2019; Averchenkova et al. 2021) (*medium evidence, medium agreement*). There are a variety of approaches to framework laws. Reviews of climate legislation, many of which draw particularly from the long-standing UK Climate Change Act, suggest the need for statutory targets with a long-term direction, shorter term instruments such as carbon budgets to induce action toward targets, a clear assignment of duties and responsibilities including identification of policies and responsibility for their implementation, annual reporting to Parliament; an independent body to support evidence-based decision making and rules to govern information collection and provision (Barton and Campion 2018; Fankhauser et al. 2018; Averchenkova et al. 2021; Abraham-Dukuma et al. 2020).

However, country examples also suggest other, different approaches to framework laws. Korea's Framework Act on Low Carbon, Green Growth seeks to shift business and society toward green growth through a process of strategy setting and action plans (Jang et al. 2010). Kenya's framework Climate Change Act creates an institutional structure to mainstream climate considerations into sectoral decisions, one of several examples across Africa of efforts to create framework legislation to promote mainstreaming (Rumble 2019). Mexico's General Law on Climate Change includes sectoral emission targets, along with the creation of coordinating institutions across ministries and sub-national authorities (Averchenkova and Guzman Luna 2018). Consequently, different countries have placed emphasis on different aspects of framework laws, although the most widely prevalent approach is that exemplified by the UK.

Climate laws spread through multiple mechanisms, including the impetus provided by international negotiation events, diffusion by example across countries, and domestic factors such as business cycles (*medium evidence, medium agreement*). Major landmark events under the UNFCCC have been associated with increases in national legislation (Iacobuta et al. 2018), with a stronger effect in countries where international commitments are binding (Fankhauser et al. 2016). Diffusion through example of legislation

FOOTNOTE ¹ Data from climate-laws.org, search for mitigation focused legislation for different time frames. Accessed Oct 31, 2021.

from other countries has been documented (Fleig et al. 2017; Torney 2017; Inderberg 2019; Torney 2019; Fankhauser et al. 2016). For example, the UK Climate Change Act was an important influence in pursuing similar acts in Finland and Ireland (Torney 2019) and was also considered in the formulation of Mexico's General Law on Climate Change (Averchenkova and Guzman Luna 2018). The presence of a framework law is positively associated with creation of additional supportive legislation (Fankhauser et al. 2015). Domestic contextual factors can also affect the likelihood of legislation such as a weak business cycle that can impact the political willingness to pass legislation (Fankhauser et al. 2015). In some cases, civil society groups play a role as advocates for legislation, as occurred in the UK (Lockwood 2013; Lorenzoni and Benson 2014; Carter and Childs 2018; Devaney et al. 2020) and in Germany in the build up to passage of their respective Climate Change Act (Flachsland and Levi 2021).

The performance of framework laws suggests a mixed picture. While the structure of the UK Act successfully sets a direction of travel and has resulted in a credible independent body, it performs less well in fostering integration across sectoral areas and providing an enforcement mechanism (Averchenkova et al. 2021). A review of seven European climate change acts concludes that overall targets may not be entirely aligned with planning, reporting and evaluation mechanisms, and that sanction mechanisms are lacking across the board (Nash and Steurer 2019), which limit the scope for legislation to perform its integrative task. These observations suggest the need for careful attention to the design of framework laws.

There is extremely limited evidence on the aggregate effects of climate laws on climate outcomes, although there is a broader literature assessing climate policies (see Section 13.6 in this Chapter and Cross-Chapter Box 10 in Chapter 14). A single assessment of direct and indirect climate laws as well as relevant executive action across a global database finds a measurable and positive effect: global annual emissions have reduced by about 5.9GtCO₂ compared to an estimation of what they otherwise would have been (Eskander and Fankhauser 2020). Climate laws require further research, including on the quantification of impact, framework versus sectoral approaches, and the various mechanisms through which laws act - target setting, creating institutional structures, mainstreaming and ensuring compliance.

National climate change mitigation legislation

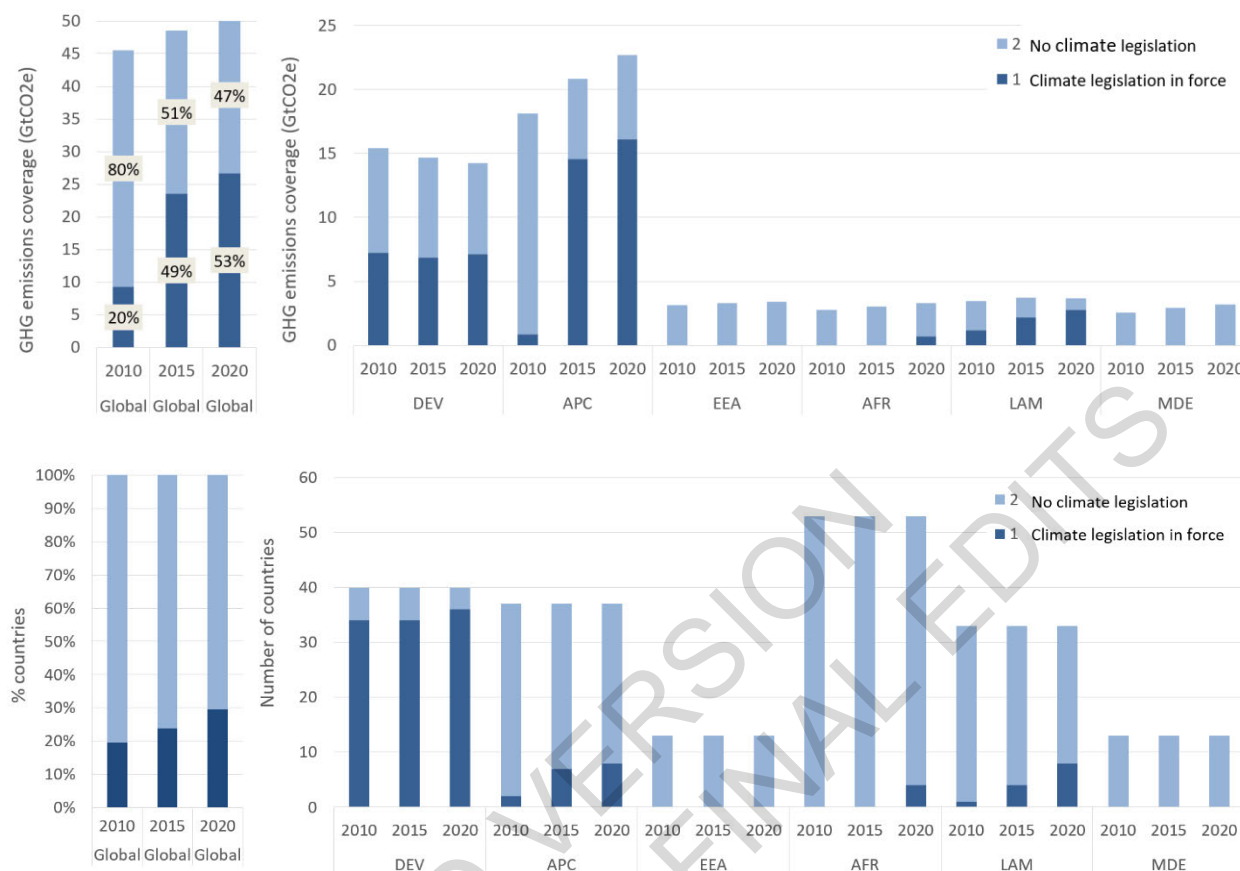


Figure 13.1 Prevalence of legislation by emissions and number of countries across regions

Top: Shares of global GHG emissions under national climate change legislations – in 2010, 2015 and 2020. Emissions data used are for 2019, since emissions shares across regions deviated from past patterns in 2020 due to COVID.

Bottom: Number of countries with national climate legislation - in 2010, 2015, and 2020

Climate legislation is defined as an act passed by a parliament that includes in its title or objectives reductions in GHGs.

AR6 regions: DEV = Developed countries; APC = Asia and developing Pacific; EEA = Eastern Europe and West-Central Asia; AFR = Africa; LAM = Latin America and the Caribbean; MDE = Middle East.

Source: Updated and adapted from (Iacobuta et al. 2018) to reflect AR6 regional aggregation and recent data.

13.2.2 National strategies and Nationally Determined Contributions

National climate strategies, which are often formulated through executive action, contribute to climate governance in several ways. Strategies enable discussion of low-emissions pathways while accounting for uncertainty, national circumstances and socio-economic objectives (Falduto and Rocha 2020).

They frequently set out long term emission goals and possible trajectories over time, with analysis of technological and economic factors (Levin et al. 2018; WRI 2020). This can include quantitative modelling of low-emissions transitions and their economic effects to inform policymakers and stakeholders of potential outcomes (Waisman et al. 2019; Weitzel et al. 2019). Scenario analysis can be used to explore how to make strategies more robust in the face of uncertainty (Sato and Altamirano 2019). Strategies and their regular

1 revision can support long-term structural change by stimulating deliberation and learning (Voß et al. 2009),
2 and to make the link between mitigation and adaptation objectives and actions (Watkiss and Klein 2019;
3 Hans et al. 2020). As part of the Paris Agreement process, several countries have prepared and submitted
4 long-term low-emissions development strategies (Levin et al. 2018), while others have different forms of
5 national climate change strategies independently of the UNFCCC process. Strategies set over time by the
6 European Union are discussed in Box 13.1.

7 Nationally Determined Contributions (NDCs) prepared under the Paris Agreement may be informed by
8 national strategies (Rocha and Falduto 2019). But the process of preparing NDCs can itself raise political
9 awareness, encourage institutional innovation and coordination, and engage stakeholders (Röser et al. 2020).
10 Nationally determined contributions (NDCs) illustrate a diversity of approaches: direct mitigation targets,
11 strategies, plans and actions for low GHG emission development, or the pursuit of mitigation co-benefits
12 resulting from economic diversification plans and/or adaptation actions (UNFCCC Secretariat 2021). Figure
13 13.2 shows that the prevalence of emission targets increased across all regions between 2010 and 2020, the
14 period during which the Paris Agreement was reached.

15 The NDCs vary in their scope, content and time frame, reflecting different national circumstances, and are
16 widely heterogeneous in both stringency and coverage of mitigation efforts (Pauw et al. 2018; Campagnolo
17 and Davide 2019; Pauw et al. 2019; UNFCCC Secretariat 2016, 2021). The mitigation targets in the new or
18 updated NDCs range from economy-wide absolute emission reduction targets to strategies, plans and actions
19 for low-emission development, with specific timeframes or implementation periods specified. Less than 10%
20 of parties' NDCs specify when their emissions are expected to peak and some of these parties express their
21 target as a carbon budget (UNFCCC Secretariat 2021). Many long term strategies submitted by Parties to the
22 UNFCCC refer to net zero emissions or climate neutrality, carbon neutrality, or GHG neutrality with
23 reference to 2050, 2060 or mid-century targets (UNFCCC Secretariat 2021). The growing prevalence and
24 coverage of emission targets is documented in Figure 13.2.

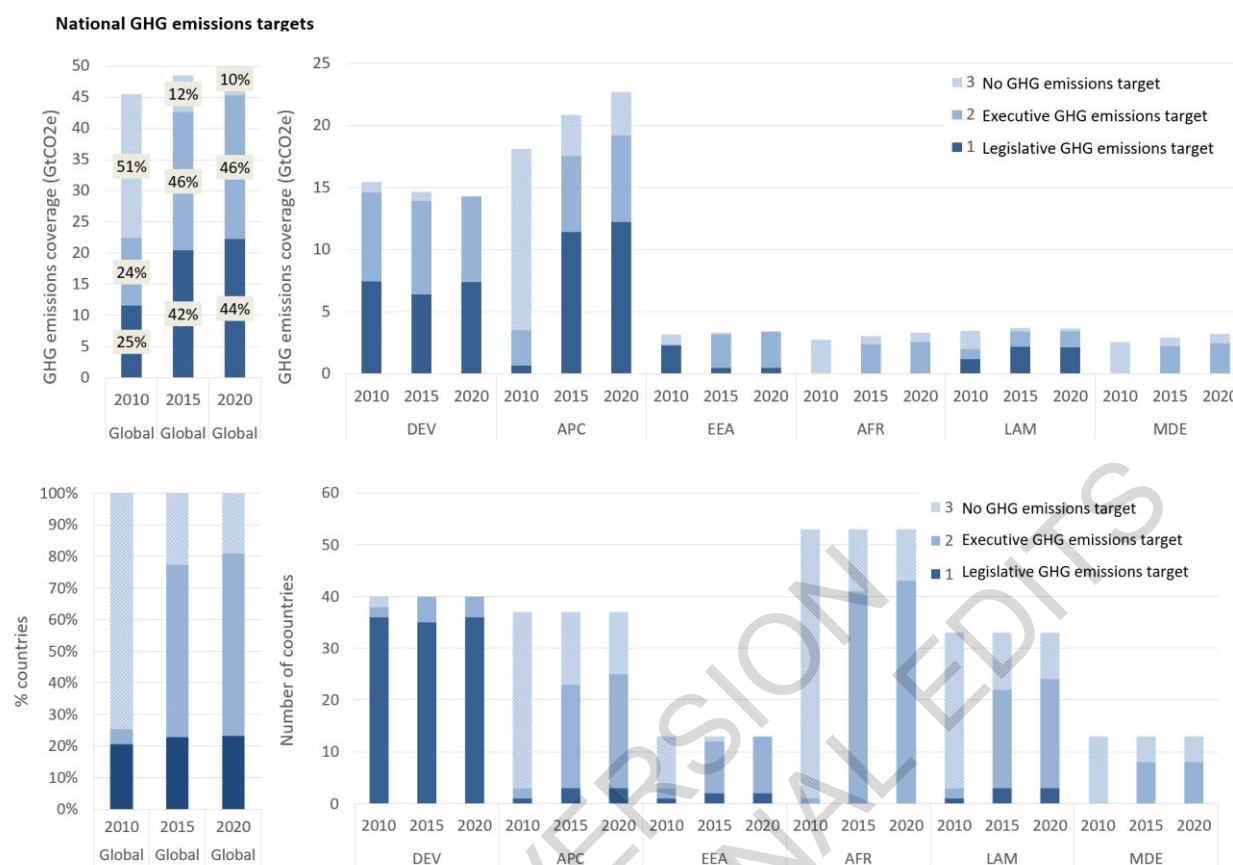


Figure 13.2 Prevalence of targets by emissions and number of countries across region

Top: Shares of global GHG emissions under national climate emission targets – in 2010, 2015 and 2020. Emissions data used are for 2019, since emissions shares across regions deviated from past patterns in 2020 due to COVID.

Bottom: Number of countries with national climate emission targets - in 2010, 2015, and 2020

Emissions reductions targets were taken into account as a legislative target when they were defined in a law or as part of a country's submission under the Kyoto Protocol, or as an executive target when they were included in a national policy or official submissions under the UNFCCC. Targets were included if they were economy wide or included at least the energy sector. The proportion of national emissions covered are scaled to reflect coverage and whether targets are in GHG or CO₂ terms.

AR6 regions: DEV = Developed countries; APC = Asia and developing Pacific; EEA = Eastern Europe and West-Central Asia; AFR = Africa; LAM = Latin America and the Caribbean; MDE = Middle East.

Source: Updated and adapted from (Iacobuta et al. 2018) to reflect AR6 regional aggregation and recent data.

Almost all Parties outlined domestic mitigation measures as key instruments for achieving mitigation targets in specific priority areas such as energy supply (89%), transport (80%), buildings (72%), industry (39%), agriculture (67%), LULUCF (75%) and waste (68%). Renewable energy generation was the most frequently indicated mitigation option (84%), followed by improving energy efficiency of buildings (63%) and multisector energy efficiency improvement (48%); afforestation, reforestation and revegetation (48%); and improving energy efficiency of transport (45%) (UNFCCC Secretariat 2021). Parties often communicated mitigation options related to the circular economy, including reducing waste (29%) and recycling waste (30%) and promoting circular economy (25%). Many Parties highlighted policy coherence and synergies between their mitigation measures and development priorities, which included long-term low-emission

development strategy(ies) (LT-LEDS), the sustainable development goals (SDGs) and, for some, green recovery from the COVID-19 pandemic.

Some countries approach NDCs as an opportunity to integrate mitigation objectives and broader economic shifts or sectoral transformations (*medium evidence, medium agreement*). For example, Brazil's 2016 NDC focussed on emissions from land use change, including agricultural intensification, to align mitigation with a national development strategy of halting deforestation in the Amazon, and increasing livestock production (De Oliveira Silva et al. 2018). While the forest sector accounts for the bulk of Madagascar's mitigation potential, its NDC promotes GHG mitigation in both AFOLU and energy sectors to maximize co-benefits, and achieve a higher number of sustainable development goals (SDGs) (Nogueira et al. 2020).

START BOX 13.1 HERE

Box 13.1 EU climate policy portfolio and the European Green Deal

The European Union (EU)² has developed an encompassing climate governance framework (Kulovesi and Oberthür 2020), having ratified the Kyoto Protocol in 2002. In 2003 the EU adopted an Emissions Trading System for sectors with large GHG emitters, which started in 2005. From 2007 to 2009, the EU revised its climate policies, including for vehicle emissions, renewable energy and energy efficiency, and adopted targets for 2020 for GHG emissions reductions, renewable energy shares and energy efficiency improvements. It also adopted in 2009 an Effort Sharing Decision for Member States' emissions reductions for the period 2013 - 2020 in sectors not covered by the ETS (Boasson and Wettestad 2013; Bertoldi 2018). The ETS has been improved multiple times, including through a 2015 Market Stability Reserve to reduce the surplus of emission allowances (Wettestad and Jevnaker 2019; Chaton et al. 2018). In 2010, the European Commission created a directorate-general (equal to a ministry at the domestic level) for Climate Action. Between 2014 and 2018, the EU agreed on emission reduction targets for 2030 of 30% GHG emission reductions compared to 1990, and again revised its climate policy portfolio including new targets for renewable energies and energy efficiency and a new Effort Sharing Regulation (Fitch-Roy et al. 2019a; Oberthür 2019).

From 2018, climate planning and reporting has been regulated by the EU Governance Regulation (Regulation (EU) 2018/1999), requiring member states to develop detailed and strategic National Energy and Climate Plans (Knodt et al. 2020). In 2019, the European Commission, backed by the European Council (heads of states and government in the EU) and the European Parliament, launched a new broad climate and environment initiative; the 'European Green Deal', implying the revision of many EU policies and introducing the Climate Pact (European Commission 2019a). This roadmap develops a 'new growth strategy for the EU' aimed at reaching climate neutrality by 2050 and spans multiple sectors. In 2020, the European Commission introduced a new climate law establishing the framework for achieving the climate neutrality by 2050 principle, and upgraded its 2030 GHG emission reduction target to at least net 55% reduction, which was adopted in June 2021 (European Commission 2020a). In June 2021, the new policy package "Fit for 55" was adopted by the Commission; the packages included a proposal for the revision of the ETS, including its extension to shipping and a separate emission trading system for road transport and buildings, a revision of the effort sharing regulation, an amendment of the regulation setting CO₂ emission standards for cars and vans, a revision of the energy tax directive, a new carbon border adjustment mechanism, a revision of renewable energy and energy efficiency targets and directives, and a new social climate funds to make the transition to climate neutrality fair.

FOOTNOTE ² The European Union is an international organization that is discussed here because it plays a large role in shaping climate obligations and policies of its Member States.

END BOX 13.1 HERE**13.2.3 Approaches to national institutions and governance****13.2.3.1 The forms of climate institutions**

Universal ‘best-practice’ formulations of organisations may not be applicable across country contexts, but institutions that are suited to national context can be ratcheted up over time in their scope and effectiveness (*medium evidence, medium agreement*). National climate institutions take diverse forms because they emerge out of country specific interactions between national climate politics and existing institutional structures. Certain institutional forms tend to be common across countries, such as expert climate change commissions; a review finds eleven such institutions in existence as of mid-2020. Although this institutional form may be common, these commissions vary in terms of expertise, independence and focus (Abraham-Dukuma et al. 2020), reinforcing the important shaping role of national context.

A review of institutions in eight countries suggests three broad processes through which institutions emerge: ‘purpose-built’ dedicated institutions focused explicitly on mitigation; ‘layering’ of mitigation objectives on existing institutions; and ‘latent’ institutions created for other purposes that nonetheless have implications for mitigation outcomes (Dubash 2021). In relatively few countries do new, purpose-built, legally-mandated bodies created specifically for climate mitigation exist although this number is growing; examples include the UK (Averchenkova et al. 2018), China (Teng and Wang 2021), Australia (Keenan et al. 2012) and New Zealand (Timperley 2020). These cases indicate that dedicated and lasting institutions with a strategic long-term focus on mitigation emerge only under conditions of broad national political agreement around climate mitigation as a national priority (Dubash 2021). However, the specific forms of those institutions differ, as illustrated by the case of the UK’s Climate Change Committee established as an independent agency (see Box 13.2) and China, which is built around a top-down planning structure (See Box 13.3).

START BOX 13.2 HERE**Box 13.2 Climate change institutions in the UK**

The central institutional arrangements of climate governance in the UK were established by the 2008 Climate Change Act (CCA): statutory five-year carbon budgets; an independent advisory body, the Committee on Climate Change (CCC); mandatory progress monitoring and reporting to Parliament; and continuous adaptive planning following a five-yearly cycle. The CCC is noteworthy as an innovative institution that has also been emulated by other countries.

The design of the CCC was influenced by the concept of independent central banking (Helm et al. 2003). It has established a reputation for independent high quality analysis and information dissemination, is frequently referred to in Parliament and widely used by other actors in policy debates, all of which suggest a high degree of legitimacy (Averchenkova et al. 2018). However, since the CCC only recommends rather than sets budgets (McGregor et al. 2012), accountability for meeting the carbon budgets works primarily through reputational and political effects rather than legal enforcement.

END BOX 13.2 HERE**START BOX 13.3 HERE****Box 13.3 China’s climate change institutions**

Climate governance in China features a combination of top-down planning and vertical accountability (Sims Gallagher and Xuan 2019; Teng and Wang 2021). An overarching coordination role is performed by the Leading Group on Carbon Peaking and Carbon Neutrality, appointed by and reporting to the Central Committee of the Chinese Communist Party, and the National Leading Group on Climate Change Response, Energy Conservation, and Emissions Reduction (NLGCCR), headed by the Premier and consisting of more than 30 ministers (Wang et al. 2018a). The Department of Climate Change (DCC) under the Ministry of Ecology and Environment (MEE) is the primary agency in charge of climate issues, with a corresponding local Bureau of Ecology and Environment in each province or city. While MEE is the leading agency for climate policy, the National Development and Reform Commission (NDRC) is the leading agency for setting overall and industry-specific targets in five-year plans, and thus has a key role in coordinating carbon emissions targets with energy and industrial development targets (Wang et al. 2019; Yu 2021). Involvements of ministries related to foreign affairs, public finance, science and technology, as well as sector ministries such as transportation, construction, and manufacturing industries are also needed to push forward sector-specific climate initiatives. At subsidiary levels of government carbon intensity targets are enforced through a “targets and responsibilities” system that is directly linked to the evaluation of governments’ performances (Lin 2012a; Li et al. 2016).

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Where economy-wide institutions do not exist, new institutions may still address sub-sets of the challenge. In Australia, while political conditions resulted in the repeal of an overarching Clean Energy Act in 2014, although a Climate Change Authority continued, other institutions primarily focused on the energy sector such as the Clean Energy Regulator, the Clean Energy Finance Corporation, and the Australia Renewable Agency continued to shape energy outcomes (MacNeil 2021).

Where new dedicated organisations have not emerged, countries may layer climate responsibilities on existing institutions; the addition of mitigation to the responsibilities of the US Environmental Protection Agency is an example (Mildenberger 2021). Layering is also a common approach when climate change is embedded within consideration of multiple objectives of policy. In these cases, climate institutions tend to be layered on sectoral institutions for the pursuit of co-benefits or broader development concerns. Examples include India, where energy security was an important objective of renewable energy promotion policy (Pillai and Dubash 2021), Brazil’s mitigation approach focused on sectoral forest policy (Hochstetler 2021) and South Africa’s emphasis on job creation as a necessary factor in mitigation policy (Chandrashekeran et al. 2017; Rennkamp 2019). Prior to this process of layering, sectoral institutions, such as in forest and energy sectors, may play an important latent role in shaping climate outcomes, before climate considerations are part of their formal mandate.

New rules and organisations are not only created, they are also dismantled or allowed to wither away. Cases of institutional dismantling or neglect include the Australian Clean Energy Act (Crowley 2017; MacNeil 2021), the Indian Prime Minister’s Council on Climate Change, which, while formally functional, effectively does not meet (Pillai and Dubash 2021), and the weakening of climate units inside sectoral ministries in Brazil (Hochstetler 2021). While there is limited literature on the robustness of climate institutions, case studies suggest institutions are more likely to emerge, persist and be effective when institutions map to a framing of climate change that has broad political support (*medium evidence, medium agreement*). Thus while mitigation focused framings and institutions may win political support in some countries, in other cases sectorally focused or multiple objectives oriented institutions may be most useful and resilient (Dubash 2021).

13.2.3.2 Addressing climate governance challenges

Climate governance challenges include ensuring coordination, building consensus by mediating conflict, and setting strategy (*medium evidence, high agreement*). Coordination is important because climate change is an

all-of-economy and society problem that requires cross-sectoral and cross-scale action; building consensus is needed because large scale transformations can unsettle established interests; and strategy setting is required due to the transformative and time-bound nature of climate mitigation (Dubash et al. 2021). Yet, climate institutions have a mixed record in addressing these challenges.

Institutions that provide coordination, integration across policy areas and mainstreaming are particularly important given the scope and scale of climate change (See Section 13.7) (Candel and Biesbroek 2016; Tosun and Lang 2017). Ministries of environment are often appointed as *de facto* agents of coordination, but have been hampered by their limited regulative authority and ability to engage in intra-governmental bargaining with ministries with larger budgets and political heft (Aamodt 2018).

Creation of a high-level coordinating body to coordinate across departments and mainstream climate into sectoral actions is another common approach (Oulu 2015). For example, Kenya has created a National Climate Change Council, which operates through a climate change directorate in the environment ministry to mainstream climate change at the county level (Guey and Bilich 2019). Zhou and Mori (2011) suggest that well-functioning inter-agency coordination mechanisms require support from heads of government, involvement by industry and environment agencies; and engagement by multiple sectoral agencies. However, coordination mechanisms without a clear authority and basis for setting directions run the risk of ‘negative coordination’, a process through which ministries comment on each other’s proposals, removing any ideas that run counter to the interests of their own ministry, leading to even weaker decisions (Flachsland and Levi 2021). Countries with dedicated, new climate institutions tend to have a more explicit and authorised body for climate coordination, such as China’s National Leading Group’ (See Box 13.3).

Without explicit coordination with finance ministries, there is a risk of parallel and non-complementary approaches. For example, the South African Treasury pursued a carbon tax without clear indication of how it interfaced with a quantitative sectoral budget approach espoused by the environment ministry (Tyler and Hochstetler 2021). Skovgaard (2012) suggests that there is an important distinction between finance ministries that bring a limiting ‘budget frame’ to climate action, versus a ‘market failure frame’ that encourages broader engagement by relevant ministries.

Coordination within federal systems poses additional complexities, such as overlapping authority across jurisdictions, multiple norms in place, and approaches to coordination across scales (Brown 2012). Multilevel governance systems such as the EU can influence the design and functioning of climate policies and institutions in member states, such as Germany (Skjærseth 2017; Jänicke and Wurzel 2019; Flachsland and Levi 2021) and the UK (Lockwood 2021a). In some cases, this can result in distinct European modes of governance as has been suggested occurred in the case of wind energy (Fitch-Roy 2016).

Within countries, institutional platforms allow federal and subnational governments to negotiate and agree on policy trajectories (Gordon 2015). In Germany, cooperation is channelled through periodic meetings of environment ministers and centre-state working groups (Weidner and Mez 2008; Brown 2012), and in Canada through bilateral negotiations and side-payments between scales of government (Rabe 2007; Gordon 2015). Federal systems might allow for sub-national climate action despite constraints at the federal level, as has occurred in Australia (Gordon 2015; MacNeil 2021) and the United States (Rabe 2011; Jordaan et al. 2019; Bromley-Trujillo and Holman 2020; Thompson et al. 2020). Where agenda-setting rests with the central government, coordination may operate through targets, as with China (Qi and Wu 2013), or frameworks for policy action, as in India (Vihma 2011; Jogesh and Dubash 2015).

Because transition to a low-carbon future is likely to create winners and losers over different time scales; institutions are needed to mediate these interests and build consensus on future pathways (Kuzemko et al. 2016; Lockwood et al. 2017; Finnegan 2019; Mildenerberger 2020). Institutions that provide credible knowledge can help support ambition. For example, analysis by the UK Climate Change committee has been harnessed, including by non-state actors, to prevent backsliding on decisions (Lockwood 2021a). Institutions can also help create positive feedback by providing spaces in decision making for low carbon interests

(Aklin and Urpelainen 2013; Roberts et al. 2018; Lockwood et al. 2017; Finnegan 2019). For example, a renewable energy policy community emerged in China through key agenda setting meetings (Shen 2017), and in India, a National Solar Mission provided a platform for the renewable energy industry (Pillai and Dubash 2021). Conversely, institutions can also exert a drag on change through ‘regulatory inertia,’ as in the case of the UK energy regulator Ofgem, which has exercised veto powers in ways that may limit a low carbon transition (Lockwood et al. 2017).

Institutions can also create spaces to accommodate concerns of other actors (Upadhyaya et al. 2021). Deliberative bodies, such as Germany’s Enquete Commission (Weidner and Mez 2008; Flachslund and Levi 2021) or the Brazilian Forum on Climate Change (Tyler and Hochstetler 2021) provide a space for reconciling competing visions and approaches to climate change. Many countries are creating deliberative bodies to forge ‘Just Transition’ strategies (Section 13.9). A recent innovation is the creation of Citizens’ Assemblies that bring together representative samples of citizens to deliberate on policy questions with the intent of informing them (Sandover et al. 2021; Devaney et al. 2020). The ability of institutions to forge agreement also rests on attention to procedural justice (See Box 13.4).

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Box 13.4 Procedural justice

Decision making consistent with energy and climate justice requires attention to procedural justice (McCauley and Heffron 2018), which includes how decisions are made, and who is involved and has influence on decisions (Sovacool and Dworkin 2015). Procedural justice emphasizes the importance of equitable access to decision-making processes and non-discriminatory engagement with all stakeholders (Jenkins et al. 2016), attention to the capability, particularly of marginalised groups, to shape decisions (Holland 2017) and recognition of their specific vulnerabilities in collective political processes (Schlosberg 2012). Consensus-building institutions should avoid reducing normative questions to technical ones, recognising that values, interests and behaviours are all shaped by ongoing climate governance (Schwanen 2021; Ryder 2018). Additionally, communities affected by low-carbon transition may face challenges in articulating their understandings and experiences, which needs to be addressed in the design of climate institutions (Schwanen 2021; Ryder 2018).

Spatially localized alternative discourses of justice are often more recognised socially than national and universal framings of climate justice (Bailey 2017). Participatory forms of governance such as climate assemblies and citizen juries (Ney and Verweij 2015) can help enhance the legitimacy of institutional decisions, even while empirical assessments suggest that these approaches continue to face practical challenges (Sandover et al. 2021; Creasy et al. 2021; Devaney et al. 2020).

END BOX 13.4 HERE

Since addressing climate change requires transformative intent and shifting development pathways (Section 13.9 in this Chapter, Section 1.6 in Chapter 1, Section 3.6 in Chapter 3, Sections 4.3 and 4.4 in Chapter 4, Section 17.3.2 in Chapter 17, and Cross-Chapter Box 5 in Chapter 4), institutions that can devise strategies and set trajectories are useful enablers of transformation. Strategy setting often requires an overarching framework such as through framework laws that set targets (Averchenkova et al. 2017), or identify key sectors and opportunities for low-carbon transition (Hochstetler and Kostka 2015) and innovation (UNEP 2018). Few countries have built deliberate and lasting institutions that provide strategic intent, and those that have, have pursued different approaches. The UK’s approach rests on five-yearly targets (Box 13.2); Germany requires sectoral budgets enforced through the Bundestag (Flachslund and Levi 2021); and China uses an apex decision-body to set targets (Box 13.3) (Teng and Wang 2021).

Addressing all of these governance concerns – coordination, mediating interests, and strategy setting – require attention to institutional capacity. These include the capacity to address ‘upstream’ policy issues of agenda setting, framing, analysis and policy design; pursue goals even while mediating interests (Upadhyaya et al. 2021); identify and manage synergies and trade-offs across climate and development objectives (Ürge-Vorsatz et al. 2014; von Stechow et al. 2015; McCollum et al. 2018); identify and choose amongst possible policy options (Howlett and Oliphant 2010); identify areas for transformation and the means to induce innovation (Patt 2017; UNEP 2018); and developing the ability to monitor and evaluate outcomes (Upadhyaya et al. 2021) (See Box 13.5). Domorenok et al. (2021) highlight different aspects of the capacity challenge particularly necessary for integrated policy making including: the capacity for horizontal and vertical coordination; implementation capacity including the independence of the state from interests; and administrative capacity required to address compound problems. At a basic level, questions of governmental capacity – the numbers and training of personnel – can shape the choices available for climate institutions and their ability to be strategic (Richerzhagen and Scholz 2008; Harrison and Kostka 2014; Kim 2016). Box 13.5 describes South Africa’s approach to building monitoring and evaluation capacity.

The perceived need for attention to institutional capacity is highlighted by the fact that the NDCs of 113 developing countries out of 169 countries studied list capacity building as a condition of NDC implementation (Pauw et al. 2020). While international support for capacity is widely articulated as essential for many countries (Khan et al. 2020), ensuring the form of capacity is appropriate, effective and led domestically remains a challenge (Nago and Krott 2020; Sokona 2021).

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Box 13.5 South Africa’s monitoring and evaluation system

South Africa’s national monitoring and evaluation system provides high-level guidance on information requirements and assessment methodologies (DEA 2015). The country is developing a comprehensive, integrated National Climate Change Information System, to enable tracking, analysis and enhancement of South Africa’s progress towards the country’s transition to a low-carbon economy and climate-resilient society (DFFE Republic of South Africa 2021). It includes information on GHG emission reductions achieved, observed and projected climate change, impacts and vulnerabilities, the impact of adaptation and mitigation actions, financial flows and technology transfer activities. South Africa’s approach is premised upon continuous learning and improvement through a phased implementation approach (DEA 2019).

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13.2.4 Institution building at the sub-national level

Jurisdiction over significant mitigation-related arenas like planning, housing and community development reside at the subnational level. To address linkages between mitigation and local concerns, subnational actors engage in institution building within a broader socio-economic and political context, with actors and institutions at a multitude of scales shaping the effectiveness of subnational-scale interventions (Romero-Lankao et al. 2018a). Mitigation policies may demand coordination between sectoral and jurisdictional units that historically have not collaborated; they may require subnational actors to confront politically sensitive issues such as carbon taxes or increases in utility rates; and they may demand a redistribution of resources to protect endangered ecosystems or vulnerable populations (Hughes and Romero-Lankao 2014).

Subnational actors have built climate institutions by creating new visions and narratives, by setting new entities or committing existing offices, providing them with funds, staff and legal authority, or by experimenting with innovative solutions that could be transferred to other local governments or scaled nationally (Hoffmann 2011; Hoornweg et al. 2011; Aylett 2015; Hughes 2019b; Hughes and Romero-Lankao

2014; Romero-Lankao et al. 2015). These actors have also created task forces, referendums, coordination of financial and human resources, technical assistance, awareness campaigns and funding (Castán Broto 2017; Romero-Lankao et al. 2018a; Hughes 2019b). National governments can play a key role supporting planning for climate change at the regional and national level, for example, through the articulation of climate change action in national urban politics (Cobbinah et al. 2019; Van Den Berg et al. 2018).

13.2.4.1 Significance of subnational networks

Multi-jurisdictional and multi-sectoral sub-national networks in dozens of countries globally have helped build climate institutions. They have also facilitated social and institutional learning, and addressed gaps in national policy (Holden and Larsen 2015; Jordan et al. 2015; Setzer 2015; Haarstad 2016; Hermwille 2018; Kammerer and Namhata 2018; Rashidi and Patt 2018; Westman and Castan Broto 2018; Lee 2019; Schwartz 2019; Lee and Jung 2018).

Transnational networks have opened opportunities for subnational actors to play a crucial mitigation role in political stalemates (Jones 2014; Schwartz 2019). The C40, the Global Covenant of Mayors for Climate and Energy, and ICLEI have disseminated information on best practices and promoted knowledge sharing between subnational governments (Lee 2013; Hakelberg 2014; Heidrich et al. 2016; Kona et al. 2016; Di Gregorio et al. 2020) (see Section 14.5.5 in Chapter 14). Organizations such as the US Carbon Cycle Working Group of the United States Global Change Research Program, the Australian Climate Action Network, and the Mexican Metropolitan Environmental Commission have helped facilitate coordination and learning across multiple jurisdictions and sectors, and connected ambiguous spaces between public, private and civil society actors (Horne and Moloney 2019; Romero-Lankao et al. 2015; Hughes 2019b).

Transnational networks have limited influence on climate policies where national governments exert top-down control (e.g., in the city of Rizhao, China) (Westman et al. 2019); where subnational actors face political fragmentation, lack regulations, and financial and human resources; or where vertically-integrated governance exists, as in State of São Paulo, Santiago de Chile, and Mexico City (Setzer 2017; Romero-Lankao et al. 2015).

Public support for sub-national climate institutions increases when climate policies are linked to local issues such as travel congestion alleviation or air pollution control (Puppim de Oliveira 2013; Romero-Lankao et al. 2013; Simon Rosenthal et al. 2015; Romero-Lankao et al. 2015; Ryan 2015), or when embedded in development priorities that receive support from the national government or citizens (Jørgensen et al. 2015b; Floater et al. 2016; Dubash et al. 2018). For example, Indian cities have engaged in international climate cooperation seeking innovative solutions to address energy, water and infrastructure problems (Beermann et al. 2016).

13.2.4.2 Factors influencing institution building at the subnational level

Availability of federal funding is a fundamental pillar of city actors' capacity to develop mitigation policies. Administrative structures, such as the presence of a professional city manager and staff assigned specifically to climate efforts (Simon Rosenthal et al. 2015). Cooperation between administrative departments, and the creation of knowledge and data on energy use and emissions are also essential for mitigation planning (Hughes and Romero-Lankao 2014; Ryan 2015). For example, the high technical competency of Tokyo's bureaucracy combined with availability of historical and current data enabled the city's unique cap-and-trade system on large building facilities (Roppongi et al. 2017).

Visions and narratives about the future benefits or risks of climate change are often effectively advanced at the subnational level, drawing on local governmental abilities to bring together actors involved in place-based decarbonisation across sectors. (Hodson and Marvin 2009; Bush et al. 2016; Huang et al. 2018; Prendeville et al. 2018; Levenda et al. 2019). For example, in the plans of 43 C40 Cities, climate action is framed as part of a vision for vibrant, economically prosperous, and socially just cities, that are habitable,

secure, resource-efficient, socially and economically inclusive, and competitive internationally (Romero-Lankao and Gnatz 2019).

However, institution building is often constrained by a lack of national support, funding, human resources, coalitions, coordination across old and new organizations, and the ability to create new institutional competences (Valenzuela 2014; Jörgensen et al. 2015a; Anderton and Setzer 2018; Cointe 2019; Di Gregorio et al. 2019; Jaccard et al. 2019; Ryan 2015; Dubash et al. 2018; Romero-Lankao et al. 2018a; Hughes 2019b). Climate mitigation can also be limited by cultural norms and values of policy actors with varying levels of power, and shifting alliances (Lachapelle et al. 2012; Damsø et al. 2016; Giampieri et al. 2019; Romero-Lankao et al. 2018a).

Institution building is constrained by inequities; resources, legal remit, knowledge, and political clout vary widely within and among subnational governments globally (Genus and Theobald 2016; Joffe and Smith 2016; Klinsky 2018; Markkanen and Anger-Kraavi 2019; Jörgensen et al. 2015b; Reckien et al. 2018). Dominant discourses tend to prioritize scientific and technical expertise and, thus, they focus on infrastructural and economic concerns over the concerns and needs of disadvantaged populations (Heikkinen et al. 2019; Romero-Lankao and Gnatz 2019).

In addition, expert driven, technical solutions such as infrastructural interventions can undermine the knowledge of lower income countries, communities or indigenous knowledge holders, yet are often used by subnational governments (Ford et al. 2016; Brattland and Mustonen 2018; Nagorny-Koring 2019; Whyte 2017, 2020). Technical solutions, such as electric vehicles or smart grids rarely address the needs and capabilities of disadvantaged communities that may not be able to afford these technologies (Mistry 2014; Romero-Lankao and Nobler 2021). However, mitigation strategies in sectors such as transport and buildings have often focused on technical and market outcomes, the benefits of which are limited to some, while others experience negative externalities or face health risks (Carley and Konisky 2020; Markard 2018; Williams and Doyon 2019). Delivering climate justice requires community-driven approaches to understanding the problem addressing structural inequities and fostering justice, while reducing carbon emissions (Romero-Lankao et al. 2018b; Carley and Konisky 2020; Lewis et al. 2020).

To address this situation requires procedural justice that involves all communities, particularly disadvantaged, in climate mitigation decisions and policies (Box 13.4). Also essential is recognition justice, that addresses past inequities through tools such as subsidies, tariffs, rebates, and other policies (Agyeman 2013; Rydin 2013; UN Habitat 2016). Both tenets are key to ensure the fair distribution of benefits or negative impacts from mitigation policies (distributional justice) (McCauley and Heffron 2018; Lewis et al. 2020). However, the benefits of inclusive approaches are often overlooked in favour of growth oriented mitigation and planning (Rydin 2013; Altenburg 2011; Smith 2019; Lennon 2020). Box 13.6 discusses how the city of Durban has internalized climate change with attention to considerations of justice.

Moreover, deep mitigation requires moving beyond existing technological responses (Mulugetta and Castán Broto 2018) to policies that correspond to the realities of developing countries (Bouteligier 2013). However, best practice approaches tend to be fragmented due to the requirements of different contexts, and often executed as pilot projects that rarely lead to structural change (Nagorny-Koring 2019). Instead, context-specific approaches that include consideration of values, cultures and governance better enable successful translation of best practices (Affolderbach and Schulz 2016; Urpelainen 2018).

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Box 13.6 Institutionalising climate change within Durban's local government

Durban has effectively linked climate change agendas with ongoing sustainability actions and goals. To do so, adaptation has been broadened to include a just transition to a low carbon future to address development, energy security and GHG reduction (Roberts et al. 2016).

Durban has mainstreamed climate and justice concerns within local government through strong local leadership by key individuals and departments; included climate concerns within various municipal short-term and long-term planning processes; mobilised civil society; enhanced local and international networking; explored funding opportunities; and restructured institutions (Roberts et al. 2016).

Durban shows that embedding responses to climate change within local government activities requires that climate change is made relevant locally and framed within a broader environmental justice framework (Roberts 2010). Civil society has been key in balancing the influence of the private sector on Durban's dynamic political process (Aylett 2013).

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13.3 Structural factors that shape condition climate governance

A growing literature suggests that ambitious climate policy emerges out of strong domestic political support (Colgan et al. 2021; Aklin and Mildenberger 2020; Lamb and Minx 2020) (*medium evidence, medium agreement*). Such support is the outcome of political interest constellations and struggles that vary from country to country. Structural factors (such as economic wealth and natural resources, the character of the national political system, and the dominant ideas, values and beliefs) shape how climate change is governed (Hochstetler 2020; Boasson 2015) (*medium evidence, high agreement*). This section assesses the ways these structural factors affect political dynamics and decision making, and ultimately constrain, sustain or enable development of domestic climate governance.

While these structural factors are crucial, they do not determine the outlook of given countries' climate governance, as civic, corporate and/or political groups or individuals can be mobilized and seek to counteract these structural effects, as indicated in the following Section 13.4 that examines the role of various actors and agencies in shaping governance processes. Taken together, Sections 13.3 and 13.4 show that domestic climate governance is not fully constrained by structural factors, but rather that diverse actors can and do achieve substantial changes.

13.3.1 Material endowments

Material endowments are natural and economic resources, such as fossil fuels and renewable energy, forests and land, and economic or financial resources, which tend to shape developments of domestic climate governance (Friedrichs and Inderwildi 2013; Lachapelle and Paterson 2013; Bang et al. 2015; Lamb and Minx 2020) (*medium evidence, high agreement*). Most countries' social and economic systems are largely developed on the basis of their material endowment, and thus they contribute to shape the distribution of political power in that country (Hall and Soskice 2001). Material endowments are by no means the only influencing factor, and actors may succeed to either circumvent or exploit material endowments to impact climate governance (Boasson 2015; Green and Hale 2017; Aklin and Mildenberger 2020) (*limited evidence, medium agreement*).

Since countries are not bound by their material endowment, countries with similar material endowments may differ in climate governance, whereas those with notable differences in material endowments may have similar policies. For instance, countries with rich fossil fuel endowments are found either adopting rather ambitious emission reduction targets and measures, or remaining weak in developing domestic climate policies (Eckersley 2013; Farstad 2019). Further, countries with radically different electricity systems and

energy resource potentials are found developing rather similar renewables support schemes such as feed-in-tariff subsidies and competitive tendering programmes (Vanegas Cantarero 2020; Dobrotkova et al. 2018; Boasson et al. 2021). Some policy instruments are widely applied in both developed and developing countries with similar or different material endowment. For example, renewable energy auctions have been experimented by over 100 countries by the end of 2018 (IRENA 2019).

Rich carbon-intensive resources and well developed infrastructure can make low-carbon activities relatively less economically profitable, and negatively influence some perceptions of climate mitigation potential (Bertram et al. 2015a; Erickson et al. 2015). If effective climate policies are introduced despite this, they can alter the importance of country's material endowments in a way that underpin more forceful climate governance over time. For instance, policy interventions to limit fossil fuel exploitation or support renewable energy deployment may change the value of these energy resources over time (Schmitz et al. 2015; Ürges-Vorsatz et al. 2018; Chailleux 2020; Colgan et al. 2021).

Developing countries face additional material constraints in climate governance due to challenges associated with underdevelopment and scarce economic or natural resources (*medium evidence, high agreement*). Hence, many developing countries design domestic climate mitigation policies in combination with policy goals that address various developmental challenges (von Stechow et al. 2016; Deng et al. 2017; Thornton and Comberti 2017; Campagnolo and Davide 2019), such as air quality, urban transportation, energy access, and poverty alleviation (Geall et al. 2018; Klausbrückner et al. 2016; Li et al. 2016; Melamed et al. 2016; Slovic et al. 2016; Xie et al. 2018; Khreis et al. 2017). Combining climate and developmental policies for beneficial synergies should not overlook potential trade-offs and challenges (Dagnachew et al. 2018; Ellis and Tschakert 2019; Peñasco et al. 2021) (see Section 13.7.2 for wider discussion).

13.3.2 Political systems

The effectiveness of domestic climate governance will significantly rely on how well it fits with the features of the countries' specific political systems (Schmitz 2017; Lamb and Minx 2020) (*limited evidence, high agreement*). Political systems have developed over generations and constitute a set of formal institutions, such as laws and regulations, bureaucratic structures, political executives, legislative assemblies and political parties (Pierson 2004; Egeberg 1999). Different political systems create differing conditions for climate governance to emerge and evolve, but because political systems are so politically and historically entrenched they are not likely to change quickly even though this could facilitate domestic climate mitigation efforts (Duit and Galaz 2008; Boasson et al. 2021) (*medium evidence, high agreement*). In addition, variations in governance capacities also affect climate policy making and implementation (Meckling and Nahm 2018).

Broader public participation and more open contestation spaces tend to nurture more encompassing climate policies, facilitate stronger commitments to international agreements (Bättig and Bernauer 2009; Böhmelt et al. 2016), achieve more success in decoupling economic growth from CO₂ emissions (Lægreid and Povitkina 2018), reduce more CO₂ emissions (Clulow 2019; von Stein 2020), and maintain lower deforestation rates (Buitenzorgy and Mol 2011) (*medium evidence, medium agreement*). States with less public participation and contestation space can also develop ambitious climate emission reduction targets and institutions (Eckersley 2016; Zimmer et al. 2015; Han 2017; Engels 2018), but the drivers and effects of climate policies within less open and liberal political contexts has not yet been sufficiently investigated.

Election systems based on proportional representation tend to have lower emissions, higher energy efficiency, higher renewable energy deployment, and more climate friendly investment than systems where leadership candidates have to secure a majority of the votes to be elected (Fredriksson and Millimet 2004; Finnegan 2019; Lachapelle and Paterson 2013) (*medium evidence, high agreement*). Such systems better enable voters supporting ambitious climate positions to influence policymaking (Harrison and Sundstrom 2010; Willis 2018), place less political risks on legislators from additional costs incurred from climate actions on voters (Finnegan 2018, 2019), and strengthen credible commitments to climate policy (Lockwood

2021b). Similarly, rules that govern the relationship between governments and civic societies in decision-making have also been shown to matter in climate governance. Corporatist societies, where economic groups are formally involved in public policy making, have better climate-related outcomes (lower CO₂ emissions and higher low-carbon investments) than liberal-pluralist countries, where a larger array of non-governmental organizations compete for informal influence, often through lobbying (Jahn 2016; Liefferink et al. 2009; Finnegan 2018) (*medium evidence, medium agreement*).

Political parties with similar ideological roots in different countries (for instance social democratic or conservative parties) may have different positions on climate governance across countries (Boasson et al. 2021). Nevertheless, on average, a higher share of green parties in a parliament is associated with lower greenhouse gas emissions (Neumayer 2003; Jensen and Spoon 2011; Mourao 2019), and left-wing parties tend to adopt more pro-climate policy positions (Carter 2013; Tobin 2017; Farstad 2018; Ladrech and Little 2019) (*medium evidence, high agreement*). There is also evidence, however, that conservative parties in some countries support climate measures (Båtstrand 2015) and consensus can be achieved on climate actions across the political spectrum (Thonig et al. 2021). At the same time, it seems harder to get support for new climate governance initiatives in systems where many political groups can block decision due to many veto points, for instance in systems with bicameralism (the legislature is divided into two separate assemblies) and/or in federalist governments (where regions have national political representation, e.g. US and Brazil) (Madden 2014; von Stein 2020) (*medium evidence, high agreement*) although federal systems hold out the possibility of sub-national action when federal agreement is limited (Section 13.2). There remains a limited literature on the role of green parties and veto points in developing countries (Haynes 1999; Kernecker and Wagner 2019).

In any political system, climate policy adoption and implementation may be obstructed by corrupt practices (Rafaty 2018; Fredriksson and Neumayer 2016) that entail an abuse of entrusted power for private gain (Treisman 2000) (*medium evidence, high agreement*). Evidence shows that CO₂ emissions increase with corruption, either through the direct negative effect of corruption on law enforcement, including in the forestry sector (Sundström 2016), or through the negative effect of corruption on countries' income (Welsch 2004). These early findings are reinforced by studies of a global sample of countries (Cole 2007) and from across the developing world (Bae et al. 2017; Wang et al. 2018b; Sahli and Rejeb 2015; Habib et al. 2020; Ridzuan et al. 2019). Corruption also disrupts public support of climate policies by affecting the levels of trust (Harring 2013; Davidovic and Harring 2020; Fairbrother et al. 2019) (*medium evidence, high agreement*), which then impact on the compliance of climate policies. More research is required to further understand the causal mechanisms between corrupt practices and emissions.

13.3.3 Ideas, values and belief systems

Ideas, values and beliefs affect climate governance by shaping people's perceptions, attitude, and preferences on specific policy and governance issues (Schifeling and Hoffman 2019; McCright et al. 2016b; Boasson 2015; Boasson et al. 2021; Leipold et al. 2019) (*medium evidence, high agreement*). While these are often entrenched, they can also change, for instance when facing growing exposures to climate risks, stronger scientific evidence, and dominant public or political discourse (Mayer et al. 2017; Diehl et al. 2021). While change tend to be incremental, the pace of change may vary substantially across countries and specific climate issue areas.

However, new norms sometimes only influence political discussion and not actual governance. For instance, more ambitious climate emission reduction targets may not lead to more effective mitigation actions or policy instruments. Put another way, words do not replace actions (Geden 2016).

Different sets of beliefs can shape climate related policies, targets, and instruments (Boasson et al. 2021; Boasson and Wettstad 2013; Boasson 2015). First, beliefs link climate governance with social justice concerns; policies, targets and instruments may therefore reflect justice issues (Fuller and McCauley 2016;

Reckien et al. 2017; McCauley and Heffron 2018; Routledge et al. 2018; Bäckstrand and Lövbrand 2006, 2019). Second, climate mitigation may be seen as primarily a market correction issue and mitigation compatible with economic growth, as exemplified by ecological modernization (Bäckstrand and Lövbrand 2006, 2019; Mol et al. 2009), climate capitalism (Newell and Paterson 2010), market logics (Boasson et al. 2021; Boasson 2015) or a global commons approach (Bernstein and Hoffmann 2019). Third, climate governance may be understood relative to policies on technological innovation and progress, often conceptualised as social-technical transformations (Geels et al. 2017a).

Significant variation in ideas, values and beliefs related to climate governance are detected across and within regions, countries, societies, organisations, and individuals (Shwom et al. 2015; Boasson et al. 2021; Knox-Hayes 2016; Wettestad and Gulbrandsen 2018) (*medium evidence, medium agreement*). These factors provide the context for climate policymaking and include differences in countries' histories (Aamodt 2018; Aamodt and Boasson 2020); the political culture and regulatory traditions in governing environmental and energy issues (Tosun 2018; Aamodt 2018; Boasson et al. 2021); and even bureaucrats' educational background (Rickards et al. 2014). Structural factors in a country, such as deeply held value systems, are not changed rapidly, just as political systems or natural endowments, are not changed rapidly. Consequently climate policy and governance is more effective if it takes into account these deep-rooted values and beliefs.

Differences in dominant individual preferences may also be important. The factors that shape individual ideas, values and beliefs about climate governance include trust in politicians, the state and other people in general (Drews and van den Bergh 2016; Harring et al. 2019; Huber et al. 2020), fairness beliefs, variation in political orientation (left leaning more concerned), and class (Schmitz et al. 2018; Inglehart and Norris 2017) (*medium evidence, medium agreement*).

Levels of climate change concern on the individual level have increased in most countries (Shwom et al. 2015), and vary with gender (females are more concerned), and place of residence (urban residents are more concerned) (McCright et al. 2016a; Shwom et al. 2015; Ziegler 2017). The higher educated in developing countries tend to be more concerned (Lee et al. 2015) while individuals working in polluting industries tend to oppose forceful climate governance (Bechtel et al. 2019; Mildenberger 2020).

Shifts in mainstream ideas, values and beliefs can underpin changes in climate policy choices and policy outcomes (Mildenberger and Tingley 2019; Schleich et al. 2018) (*limited evidence, medium agreement*). For example, emission trading schemes are welcomed as a new regulatory instrument in China in the context of its market-oriented reforms and ideological shift in the past decades (Lo 2013). Based on the study of 167 nation-states and 95 subnational jurisdictions with carbon pricing, researchers find that that high public belief in climate science underpin adoption of systems that produce a rather high carbon price (Levi et al. 2020). These public opinions need to be identified and leveraged in supporting specific policy choices or changes (Mildenberger and Tingley 2019). Policy support tends to be greater if people believe effective measures are being taken by other actors, including other households (Bostrom et al. 2018; Marlon et al. 2019), and other countries and at the international level (Schleich et al. 2018).

On the other hand, anti-climate ideas or beliefs may arise due to the introduction of more constraining or ambitious climate policies, for example protests in reaction to toll roads in Norway, which increase the cost of driving, or protests in France against increasing carbon taxes (Grossman 2019; Wanvik and Haarstad 2021). The policy implication is that vulnerable or effected groups should be considered when introducing policy change, and that participation, transparency, and good communication all helps to reduce climate related discontent.

Survey based studies of public perceptions on hypothetical policy instruments or activities, such as carbon taxes or energy infrastructure, suggest that linking climate policy to other economic and social reforms can increase public support for climate governance (Carattini et al. 2019; Bergquist et al. 2020). People and politicians tend to underestimate other peoples' and politicians' willingness to support mitigation policies (Mildenberger and Tingley 2019; Hurlstone et al. 2014), but if actors are informed about other actors actual

perceptions and behaviours this may reduce the tendency to underestimate climate governance support (Mildenberger and Tingley 2019).

13.4 Actors shaping climate governance

While Section 13.3 shows that structural factors condition climate governance, their ultimate importance also depends on whether and how various actors are mobilised (Hochstetler 2020; Boasson 2015). A wide range of regional and local governments as well as non-governmental actors have become increasingly engaged in climate governance, for instance through public-private partnerships and transnational networks (Jordan et al. 2018b; Dorsch and Flachsland 2017; Jordan et al. 2015) and through the media and litigation, as discussed here.

Climate governance processes result from both slow-moving incremental changes to policy and more rapid bursts of change due to, for example, responses to dramatic weather-events, general elections or global climate summits (Aamodt and Stensdal 2017; Jordan and Moore 2020; Boasson et al. 2021) (*medium evidence, high agreement*). While Section 13.3 assessed how entrenched structural factors conditions climate governance developments, this section examines how actors are able to alter climate governance by engaging the climate policy process, undertaking litigation and interacting with media.

13.4.1 Actors and agency in the public process

A broad array of actors are engaged in shaping mitigation policy processes, including politicians and political parties, corporate actors, citizen groups, indigenous peoples organizations, labour unions and international organizations. Actors aiming to influence the climate-related policymaking process are studied together to understand climate policy dynamics and outcomes (Bulkeley 2000; Fisher 2004; Fisher and Leifeld 2019; Jasny et al. 2015; Jasny and Fisher 2019; Jost and Jacob 2004) and collaboration and influence within climate policy networks (Ingold and Fischer 2014; Kammerer et al. 2021; McAllister et al. 2014; Wagner and Ylä-Anttila 2018). Most research, however, focuses on one particular type of actor.

Political actors are decision-makers, and also influence whether climate governance is perceived as urgent and appropriate (Okereke et al. 2019; Ferrante and Fearnside 2019; Boasson et al. 2021). They include political parties, legislative assemblies and committees, governmental executives and the political leaders of governmental ministries (Boasson 2015). They are more likely to pay attention to climate issues when polling indicates high political salience with the public (Carter 2006, 2014), or when it becomes a contested issue among differing political parties (Boasson et al. 2021). Fluctuations in the public's interest and attention may underpin a disjointed approach in politicians' engagement (Willis 2017, 2018). Policy implementation can be hampered if political actors propose frequent policy changes (Boasson et al. 2021).

Corporate actors often influence policies and their adoption (Pulver and Benney 2013; Mildenberger 2020; Goldberg et al. 2020). Corporate actors acting individually or through industry associations, have worked to sway climate policy in different countries (Meckling 2011; Falkner 2008; Bernhagen 2008; Newell and Paterson 2010; Mildenberger 2020). Their ability varies by country and issue (Skjærseth and Skodvin 2010; Boasson and Wettstad 2013; Boasson 2015; Boasson et al. 2021) (*medium evidence, medium agreement*) and depends on material endowments (Moe Singh 2012), access to the political system (Dillon et al. 2018; Mildenberger 2020), and the ability to shape ideas, values and belief systems (Boasson 2015). Corporate actors tend to change their climate policy preferences over time, as indicated by longitudinal studies of some European countries (Boasson and Wettstad 2013; Boasson 2015; Boasson et al. 2021).

Corporate actors are crucial to policy implementation because they are prominent emitters of the greenhouse gases and owners of carbon-intensive technologies and potential providers of solutions as developers, owners and adopters of low emission practices and technologies (Perrow and Pulver 2015; Falkner 2008). Many

climate policies and measures rely on businesses' willingness to exploit newly created economic opportunities, such as support schemes for renewable energy and energy efficiency sector or carbon pricing (Shen 2015; Olsen 2007; Newell and Paterson 2010; World Bank 2019). Some corporate actors provide climate solutions, such as renewable energy deployment, and have successfully influenced climate policy development related to feed-in tariffs, taxations, quotas, or emission trading schemes, in the EU (Boasson 2019), Germany (Leiren and Reimer 2018), the US (Stokes and Breetz 2018), the Nordic countries (Kooij et al. 2018), China (Shen 2017) and Japan (Li et al. 2019).

Fossil fuel industries have been important agenda-setters in many countries, including the USA (Dunlap and McCright 2015; Supran and Oreskes 2017; Downie 2018), the EU (Skjærseth and Skodvin 2010; Boasson and Wettstad 2013), Australia (Ayling 2017), China (Shen and Xie 2018; Tan et al. 2021), India (Blondeel and Van de Graaf 2018; Shen 2017; Schmitz 2017), and Mexico (Pulver 2007), with differing positions and impacts across countries (Kim et al. 2016; Nasiritousi 2017). In the US, the oil industry has underpinned emergence of climate scepticism (Farrell 2016a; Dunlap and McCright 2015; Supran and Oreskes 2017), and its spread abroad (Dunlap and Jacques 2013; Engels et al. 2013; Painter and Gavin 2016). Corporate opposition to climate policies is often facilitated by a broad coalition of firms (Cory et al. 2021).

Conservative foundations, sometimes financed by business revenues, have funded a diversity of types of groups, including think-tanks, philanthropic foundations, or activist networks to oppose climate policy (Brulle 2014, 2019). However, there is limited knowledge about the conditions under which actors opposed to climate action succeed in shaping climate governance (Kinniburgh 2019; Martin and Islar 2021).

Some labour unions have developed positions and programmes on climate change (Snell and Fairbrother 2010; Stevins 2013; Räthzel et al. 2018), formed alliances with other actors in the field of climate policy (Stavis 2018) and participated in domestic policy networks on climate change (Jost and Jacob 2004), but we know little about their relative importance or success. In countries with significant fossil fuel resources such as Australia, Norway, and the United States, labour unions, particularly industrial unions, tend to contribute to reducing the ambition of domestic climate policies mainly due to the concern of job losses (Mildenberger 2020). Other studies find that the role of labour unions varies across countries (Glynn et al. 2017).

Civil society actors can involve citizens working collectively to change individual behaviours that have climate implications. For example, environmental movements that involve various forms of collective efforts encourage their members to make personal lifestyle changes that reduce their individual carbon footprints (Ergas 2010; Middlemiss 2011; Haenfler et al. 2012; Cronin et al. 2014; Saunders et al. 2014; Büchs et al. 2015; Wynes et al. 2018). These efforts seek to change individual members' consumer behaviours by reducing car-use and flying, shifting to non-fossil fuel sources for individual sources of electricity, and eating less dairy or meat (Cherry 2006; Salt and Layzell 1985; Stuart et al. 2013; Thøgersen et al. 2021; Wynes and Nicholas 2017; Büchs et al. 2015; Cronin et al. 2014; Ergas 2010; Haenfler et al. 2012; Middlemiss 2011; Saunders et al. 2014; Wynes et al. 2018). Consumer/citizen engagement is sometimes encouraged through governmental directives, such as the "renewable energy communities" granted by the EU renewable energy directive 2018/2001 (The European Parliament and the Council of the European Union 2018). To date, there are only a limited number of case studies that measure the direct effect of participation in these types of movements as it relates to climate outcomes (Vestergren et al. 2018, 2019; Saunders et al. 2014).

Citizens with less access to resources and power also participate by challenging nodes of power—policymakers, regulators, and businesses—to change their behaviours and/or accelerate their efforts. Tactics include lobbying, legal challenges, shareholder activism, coop board stewardship, and voting (Bratton and McCahery 2015; Clemens 1997; Gillan and Starks 2007; Olzak et al. 2016; Schlozman et al. 2012; Viardot 2013; Yildiz et al. 2015). Citizens provide the labour and political will needed to pressure political and economic actors to enact emission-reducing policies, as well as providing resistance to them (McAdam 2017; Oreskes and Conway 2012; Fox and Brown 1998; Boli and Thomas 1999).

Other citizen engagement involves a range of more confrontational tactics, such as boycotting, striking, protesting, and direct action targeting politicians, policymakers, and businesses (Chamorel 2019; Cock 2019; Eilstrup-Sangiovanni and Bondaroff 2014; Fisher 2010, 2019b; Fisher et al. 2005; Hadden 2014, 2015; Hadden and Jasny 2019; Meyer and Tarrow 1997; O'Brien et al. 2018; Saunders et al. 2012; Swim et al. 2019; Tarrow 2005; Wahlström et al. 2013; Walgrave et al. 2012). Climate strikes and other more confrontational forms of climate activism have become increasingly common (Boulianne et al. 2020; de Moor et al. 2021; Evensen 2019; Fisher and Nasrin 2021a; Martiskainen et al. 2020; Fisher 2019b; O'Brien et al. 2018). Very few studies look specifically at the effect of these tactics on actual climate-related outcomes and more research is needed to understand the climate effects of citizen engagement and activism (Fisher and Nasrin 2021b).

Citizen engagement has also become common among indigenous groups who tend to have limited structural power but often aim to shape the formation and effects of projects that have implications to climate change. These include opposing extraction and transportation of fossil fuels on their traditional lands (especially in the Americas) (Bebbington and Bury 2013; Hindery 2013; Coryat 2015; Claeys and Delgado Pugley 2017; Wood and Rossiter 2017); large-scale climate mitigation projects that may affect traditional rights (Brannstrom et al. 2017; Moreira et al. 2019; Zárate-Toledo et al. 2019); supporting deployment of small-scale renewable energy initiatives (Thornton and Comberti 2017); seeking to influence the development of REDD+ policies through opposition (Reed 2011); and participation in consultation processes and multi-stakeholder bodies (Bushley 2014; Gebara et al. 2014; Astuti and McGregor 2015; Kashwan 2015; Jodoin 2017). Indigenous groups have been reported to have had some influence on some climate discussions, particularly forest management and siting of renewable energy (Claeys and Delgado Pugley 2017; Jodoin 2017; Thornton and Comberti 2017). Further, more scientific assessments are required on the role of indigenous groups in climate activism and policy (Jodoin 2017; Claeys and Delgado Pugley 2017; Thornton and Comberti 2017).

Activism, including litigation, as well as the tactics of protest and strikes, have played a substantial role in pressuring governments to create environmental laws and environmental agencies tasked with enforcing environmental laws that aimed to maintain clean air and water in countries around the world (McCloskey 1991; Schreurs 1997; Rucht 1999; Brulle 2000; Steinhardt and Wu 2016; Wong 2018; Longhofer et al. 2016) (*medium evidence, high agreement*). Several studies find environmental NGOs have a positive effect on reductions in carbon emissions, whether through effects that operate across countries or (Schofer and Hironaka 2005; Jorgenson et al. 2011; Longhofer and Jorgenson 2017; Grant et al. 2018; Frank et al. 2000; Baxter et al. 2013) through impact of NGOs within nations (Dietz et al. 2015; Grant and Vasi 2017; Shwom 2011).

At the same time, other research has documented various forms of backlash against climate policies, both in terms of voting behaviour, as well as other collective efforts (Boudet et al. 2016; Fast et al. 2016; Hill et al. 2010; Krause et al. 2016; Lyon 2016; Mayer 2016; McAdam and Boudet 2012; Muradian and Pascual 2020; Stokes 2016; Stokes and Warshaw 2017; Stokes 2020; Walker et al. 2014; Williamson et al. 2011; Wright and Boudet 2012). In a systematic analysis that includes movements against fossil fuel investments along with those against low-carbon emitting projects around the world, research finds that a quarter of all projects (no matter their targets) were cancelled after facing resistance (Temper et al. 2020).

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Box 13.7 Civic engagement: The school strike movement

On Friday August 20th 2018, Greta Thunberg participated in the first climate school strike. Since then, Fridays for Future—the name of the group coordinating this tactic of skipping school on Fridays to protest inaction on climate change—has spread around the world.

In March 2019, the first *global* climate strike took place, turning out more than 1 million people around the world (Carrington 2019). Six months later in September 2019, young people and adults responded to a call to participate in climate strikes as part of the ‘Global Week for Future’ surrounding the UN Climate Action Summit (Thunberg 2019), and the number of participants globally jumped to an estimated 6 million people (Taylor et al. 2019). Although a handful of studies have reported on who was involved in these strikes, how they were connected, and their messaging (Marris 2019; Wahlström et al. 2019; Bevan et al. 2020; Han and Ahn 2020; Holmberg and Alvinus 2020; Jung et al. 2020; Martiskainen et al. 2020; de Moor et al. 2021; Thackeray et al. 2020; Trihartono et al. 2020; Evensen 2019; Fisher 2019a; Boulianne et al. 2020; Fisher and Nasrin 2021b), its consequences in terms of political outcomes and emissions reductions have yet to be fully understood (Fisher and Nasrin 2021b).

Although digital activism makes it easier to connect globally, it is unclear how digital technology will affect the youth climate movement, and its effects on carbon emissions. Research suggests that online activism is likely to involve a more limited range of participants and perspectives (Bennett 2013; Elliott and Earl 2018). Digital tactics could also mean that groups are less embedded in communities and less successful at creating durable social ties, factors that have been found to lead to longer term engagement (Rohlinger and Bunnage 2018; Tufekci 2017; Shirky 2010).

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A range of international organizations can be important, particularly in developing countries, for instance by assisting in framing of national climate governance and supporting the design of climate policies through technical assistance projects (Talaei et al. 2014; Ortega Díaz and Gutiérrez 2018; Bhamidipati et al. 2019; Charlery and Trærup 2019; Kukkonen et al. 2018). Yet for these climate aid initiatives to work effectively requires improved institutional architecture, better appreciation of local contexts, and more inclusive and transparent governance, based on evidence from many multilateral mechanisms like REDD+, CDM, GEF and GCF (Gomez 2013; Arndt and Tarp 2017), and bilateral programmes on energy, agriculture and land use sectors (Rogner and Leung 2018; Moss and Bazilian 2018; Arndt and Tarp 2017).

13.4.2. Shaping climate governance through litigation

Outside the formal climate policy processes, climate litigation is another important arena for various actors to confront and interact over how climate change should be governed (Calzadilla 2019; Peel and Osofsky 2015, 2018; Setzer and Vanhala 2019; Paiement 2020; Wegener 2020; Wilensky 2015; Bouwer 2018; Setzer and Byrnes 2019) (*robust evidence, high agreement*). Climate litigation is an attempt to control, order or influence the behaviour of others in relation to climate governance, and it has been used by a wide variety of litigants (governments, private actors, civil society and individuals) at multiple scales (local, regional, national and international) (Osofsky 2007; Lin 2012b; Keele 2017; McCormick et al. 2018; Peel and Osofsky 2018; Setzer and Vanhala 2019). Climate litigation has become increasingly common (United Nations Environment Programme 2020), but its prevalence varies across countries (Peel and Osofsky 2015; Wilensky 2015; Bouwer 2018; Setzer and Higham 2021; Lin and Kysar 2020) (*medium evidence, high agreement*). This is not surprising, given that courts play differing roles across varying political systems and law traditions (La Porta et al. 1998).

This sub-section focuses on relevant climate litigation for policies and institutions. Climate litigation is further discussed in Sections 14.5.1.2 (linkages between mitigation and human rights) and 14.5.3 (cross-country implications and international courts/tribunals).

The vast majority of climate cases have emerged in United States, Australia and Europe, and more recently in developing countries (Humby 2018; Kotze and du Plessis 2019; Peel and Lin 2019; Setzer and Benjamin 2019; Zhao et al. 2019; Rodríguez-Garavito 2020). As of 31 May 2021, 1,841 cases of climate change litigation from around the world had been identified. Of these, 1,387 were filed before courts in the United

States, while the remaining 454 were filed in 39 other countries and 13 international or regional courts and tribunals (including the courts of the European Union). Outside the US, Australia (115), the UK (73) and the EU (58) remain the jurisdictions with the highest volume of cases. The majority of cases, 1,006, have been filed since 2015 (Setzer and Higham 2021). The number of climate litigation cases in developing countries is also growing. There are at least 58 cases in 18 Global South jurisdictions (Setzer and Higham 2021; Humby 2018; Kotze and du Plessis 2019; Peel and Lin 2019; Setzer and Benjamin 2019; Zhao et al. 2019; Rodríguez-Garavito 2020) (*robust evidence, high agreement*).

Overall, courts have also played a more active role for climate governance in democratic political systems (Peel and Osofsky 2015; Eskander et al. 2021), but recently legal reforms have also developed in other countries, such as the environmental public interest law in China that allows individuals and groups to initiate environmental litigation (Xie and Xu 2021; Zhao et al. 2019). Whether and to what extent differing law traditions and political systems influence the role and importance of climate litigation has, however, not been examined enough scientifically (Peel and Osofsky 2020; Setzer and Vanhala 2019).

The majority of climate change litigation cases are brought against governments, by civic and non-governmental organisations and corporations (Eisenstat 2011; Markell and Ruhl 2012; Fisher et al. 2017; Wilensky 2015; Setzer and Higham 2021). Many, although not all of these cases, seek to ensure that governmental action on climate change is more ambitious, and better aligned with the need to avert or respond to climate impacts identified and predicted by the scientific community (Setzer and Higham 2021; Markell and Ruhl 2012). Climate aligned cases against governments can be divided into two distinct categories: claims challenging the overall effort of a State or its organs to mitigate or adapt to climate change (sometimes referred to as ‘systemic climate litigation’) (Jackson 2020) and claims regarding authorisation of third-party activity (Bouwer 2018; Gerrard 2021; Ghaleigh 2021).

Systemic climate litigation that seeks an increase in a country’s ambition to tackle climate change has been a growing trend since the first court victories in the Urgenda case in the Netherlands (see Box 13.8 below) and the Leghari case in Pakistan in 2015. These cases motivated a wave of similar climate change litigation across the world (Sindico et al. 2021; Roy and Woerdman 2016; Mayer 2019; Ferreira 2016; Peeters 2016; Paiement 2020; Barritt 2020). Between 2015 and 2021, individuals and communities initiated at least 37 cases (including Urgenda and Leghari) against states (Setzer and Higham 2021), challenging the effectiveness of legislation and policy goals (Setzer and Higham 2021; Jackson 2020). Some cases also seek to shape new legal concepts such as ‘rights of nature’ recognized in the Future Generations case in Colombia (Savaresi and Auz 2019; Rodríguez-Garavito 2020) and ‘ecological damage’ in the case of Notre Affaire à Tous and others v. France (Torre-Schaub 2021).

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Box 13.8 An example of systemic climate litigation: Urgenda v State of the Netherlands

The judgment in *Urgenda v. State of the Netherlands* established the linkage between a state’s international duty, domestic actions, and human rights commitments as to the recommendations of IPCC’s AR5 (Burgers and Staal 2019; Antonopoulos 2020). It was the first to impose a specific emissions reduction target on a state (de Graaf and Jans 2015; Cox 2016; Loth 2016). The District Court of The Hague ordered the Dutch Government to reduce emissions by at least 25% by the end of 2020. Following the decision of the district court of The Hague in 2015 the Dutch government announced that it would adopt additional measures to achieve the 25% emissions reduction target by 2020 (Mayer 2019). The decision was upheld by the Court of Appeal in 2018 and the Supreme Court in 2019. Since the first judgment in 2015 significant changes in the climate policy environment have been reported, the results of which have included the introduction of a Climate Act and the decision to close all remaining coal fired power plants by 2030 (Verschuuren 2019; Wonneberger and Vliegthart 2021).

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Moreover, there are a number of regulatory challenges to state authorisation of high-emitting projects, which differs from systemic cases against states (Bouwer 2018; Hughes 2019a). For instance, the High Court in Pretoria, South Africa, concluded that climate change is a relevant consideration for approving coal-fired power plants (Humby 2018). Similarly, the Federal Court of Australia concluded that the Minister for the Environment owed a duty of care to Australian children in respect to climate impacts when exercising a statutory power to decide whether to authorise a major extension to an existing coal mine (Peel and Markey-Towler 2021)

Climate change litigation has also been brought against corporations by regional or local governments and non-governmental organisations (Ganguly et al. 2018; Wilensky 2015; Foerster 2019). One type of private climate change litigation alleges climate change-related damage and seeks compensation from major carbon polluters (Ganguly et al. 2018; Wewerinke-Singh and Salili 2020). The litigators claim that major oil producers are historically responsible for a significant portion of global greenhouse gas emissions (Heede 2014; Frumhoff et al. 2015; Ekwurzel et al. 2017; Stuart-Smith et al. 2021). These cases rely on advancements in climate science, specifically climate attribution (Marjanac et al. 2017; Marjanac and Patton 2018; McCormick et al. 2018; Minnerop and Otto 2020; Burger et al. 2020b; Stuart-Smith et al. 2021). It is alleged that major carbon emitters had knowledge and awareness of climate change and yet took actions to confound or mislead the public about climate science (Supran and Oreskes 2017). Strategic climate change litigation has also been used to hold corporations to specific human rights responsibilities (Savaresi and Auz 2019; Savaresi and Setzer 2021) (see further Box 13.8).

In addition to direct cases targeting high emitters, litigation is also now being used to argue against financial investments in the fossil fuel industry (Franta 2017; Colombo 2021). In May 2021, the Hague District Court of the Netherlands issued a ground-breaking judgment holding energy company Royal Dutch Shell (RDS) legally responsible for greenhouse gas emissions from its entire value chain (Macchi and Zeven 2021). Claims have also been brought against banks, pension funds and investment funds for failing to incorporate climate risk into their decision-making, and to disclose climate risk to their beneficiaries (Solana 2020; Wasim 2019; Bowman and Wiseman 2020). These litigation cases also impact on the financial market without directly involving specific financial institutions into the case (Solana 2020) but somehow aim to change their risk perceptions and attitude on high carbon activities (Griffin 2020).

The outcomes of climate litigation can affect the stringency and ambitiousness of climate governance (McCormick et al. 2018; Eskander et al. 2021). In the United States, pro-regulation litigants more commonly win in relation to renewable energy and energy efficiency cases, and more frequently lose in relations to coal-fired power plant cases (McCormick et al. 2018). Outside the US, more than half (58%) of litigation have outcomes that are aligned with climate action (Setzer and Higham 2021). But these cases can also have impacts outside of the legal proceedings before, during and after the case has been brought and decided (Setzer and Vanhala 2019). These impacts include changes in the behaviour of the parties (Peel and Osofsky 2015; Pals 2021), public opinion (Hilson 2019; Burgers 2020), financial and reputational consequences for involved actors (Solana 2020), and impact on further litigation (Barritt 2020). Individual cases have also attracted considerable media attention, which in turn can influence how climate policy is perceived (Nosek 2018; Barritt and Sediti 2019; Paiement 2020; Hilson 2019). While there is evidence to show the influence of some key cases on climate agenda-setting (Wonneberger and Vliegenthart 2021), it is still unclear the extent to which climate litigation actually results in new climate rules and policies (Peel and Osofsky 2018; Setzer and Vanhala 2019; Peel and Osofsky 2020) and to what degree this holds true for all cases (Jodoin et al. 2020). However, there is now increasing academic agreement that climate litigation has become a powerful force in climate governance (Bouwer 2018; Peel and Osofsky 2020; United Nations Environment Programme 2020; Burgers 2020). In general, litigations can be applied to constrain both public and private

entities, and to shape structural factors mentioned in Section 13.3, such as the beliefs and institutions around climate governance.

13.4.3 Media as communicative platforms for shaping climate governance

Media is another platform for various actors to present, interpret and shape debates around climate change and its governance (Tindall et al. 2018). The media coverage of climate change has grown steadily since 1980's (O'Neill et al. 2015; Boykoff et al. 2019), but the level and type of coverage differs over time and from country to country (Boykoff 2011; Schmidt et al. 2013; Schäfer and Schlichting 2014) (*robust evidence, high agreement*). Media can be a useful conduit to build public support to accelerate mitigation action, but may also be utilized to impede decarbonisation endeavours (Farrell 2016b; Carmichael et al. 2017; Carmichael and Brulle 2018; Boykoff 2011; O'Neill et al. 2015). Different media systems in different regions and countries and with unique cultural and political traditions also affect how climate change is communicated (Eskjær 2013).

A broad variety of media platforms cover climate change issues, including traditional news media, such as newspapers and broadcasting, digital social media (Walter et al. 2018), creative narratives such as climate fiction and films (Svoboda 2016); humour and entertainment media (Brewer and McKnight 2015; Skurka et al. 2018; Boykoff and Osnes 2019); and strategic communications campaigns (Hansen and Machin 2008; Hoewe and Ahern 2017). Media coverage can have far-reaching consequences on policy processes, but we know less about its relative importance compared to other policy shaping factors (Liu et al. 2011; Hmielowski et al. 2014; Boykoff 2011) (*medium evidence, medium agreement*).

Popular culture images, science fictions and films of ecological catastrophe can dramatically and emotively convey the dangers of climate change (Bulfin 2017). The overall accuracy of the media coverage on climate change has improved from 2005 to 2019 in the United Kingdom (UK), Australia, New Zealand, Canada, and the US (McAllister et al. 2021). Moreover, coverage of climate science is increasing. One study (MeCCO) has tracked media coverage of climate change from over 127 sources from 59 countries in North and Latin America, Europe, Middle East, Africa, Asia and Oceania (Boykoff et al. 2021). It shows the number of media science stories in those sources grew steadily from 47376 per annum to 86587 per annum between 2017 and 2021 across print, broadcast, digital media and entertainment (Boykoff et al. 2021).

However, increasing media coverage does not always lead to more accurate coverage of climate change mitigation, as it can also spur diffusion of misinformation (Boykoff and Yulsman 2013; van der Linden et al. 2015; Whitmarsh and Corner 2017; Fahy 2018; Painter 2019). In addition, media professionals have at times drawn on the norm of representing both sides of a controversy, bearing the risk of the disproportionate representation of scepticism of anthropogenic climate change despite the convergent agreement in climate science that humans contribute to climate change, (Freudenburg and Muselli 2010; Boykoff 2013; McAllister et al. 2021; Tindall et al. 2018; Painter and Gavin 2016) (*robust evidence, high agreement*). This occurs despite increasing consensus among journalists regarding the basic scientific understanding of climate change (Brüggemann and Engesser 2017).

Accurate transference of the climate science has been undermined significantly by climate change counter-movements, particularly in the US (McCright and Dunlap 2000, 2003; Jacques et al. 2008; Brulle et al. 2012; Boussalis and Coan 2016; Boykoff and Farrell 2019; Farrell 2016a; Carmichael et al. 2017; Carmichael and Brulle 2018; Almiron and Xifra 2019) in both legacy and new/social media environments through misinformation (van der Linden et al. 2017) (*robust evidence, high agreement*), including about the causes and consequences of climate change (Brulle 2014; Farrell 2016b; Supran and Oreskes 2017; Farrell 2016a). Misinformation can rapidly spread through social media (Walter et al. 2018). Together with the proliferation of suspicions of 'fake news' and 'post-truth', some traditional and social media contents have fuelled polarization and partisan divides on climate change in many countries (Feldman et al. 2017; Hornsey et al. 2018), which can further deter development of new and ambitious climate policy (Tindall et al. 2018).

Further, the ideological stance of media also influences the intensity and content of media coverage, in developed and developing countries alike (Dotson et al. 2012; Stoddart and Tindall 2015).

Who dominates the debate on media, and how open the debate can be varies significantly across countries (Takahashi 2011; Poberezhskaya 2015) based on participants' material and technological power. Fossil fuel industries have unique access to mainstream media (Geels 2014) via advertisements, shaping narratives of media reports, and exerting political influence in countries like Australia and the US (Holmes and Star 2018; Karceski et al. 2020). For social media, novel technical tools, such as automated bots, are emerging to shape climate change discussion on major online platforms such as Twitter (Marlow et al. 2021). Open debates can underpin the adoption of more ambitious climate policy (Lyytimäki 2011). Media coverage on energy saving, patriotism, and social justice in the countries like US and the UK have helped connect mitigation of climate change with other concerns, thereby raising support to climate action (Leiserowitz 2006; Trope et al. 2007; Doyle 2016; Corner and Clarke 2017; Markowitz and Guckian 2018; Whitmarsh and Corner 2017). Further, media coverage of climate change mitigation has influenced public opinions through discussions on political, economic, scientific and cultural themes about climate change (Irwin and Wynne 1996; Smith 2000; Boykoff 2011; O'Neill et al. 2015) (*medium evidence, high agreement*).

Common challenges in reporting climate change exist around the world (Schäfer and Painter 2021; Schmidt et al. 2013), but particularly so in the developing countries, due to lower capacities, lack of journalists' training in complex climate subjects, and lack of access to clear, timely and understandable climate-related resources and images in newsrooms (Harbinson 2006; Shanahan 2009; Broadbent et al. 2016; Lück et al. 2018) (*robust evidence, high agreement*). Ugandan journalist Patrick Luganda has said, "Those most at risk from the impacts of climate change typically have had access to the least information about it through mass media." (Boykoff, 2011), indicating that information availability and capacity is a manifestation of global climate (in)justice.

13.5 Subnational actors, networks, and partnerships

In many countries, subnational actors and networks are a crucial component of climate mitigation as they have remit over land use planning, waste management, infrastructure, housing and community development, and their jurisdictions are often where the impacts of climate change are felt (*robust evidence, high agreement*). Depending on the legal framework and other institutional constraints, subnational actors play crucial roles in developing, delivering and contesting decarbonisation visions and pathways (Schroeder et al. 2013; Ryan 2015; Amundsen et al. 2018; Fuhr et al. 2018; Bäckstrand et al. 2017; Abbott et al. 2016) (Section 13.3.3).

Sub-national actors include organizations, jurisdictions, and networks (e.g., a coalition of cities or state authorities). These are either formal or informal, profit or non-profit and public or private (Avelino and Wittmayer 2016). For example, corporations are formal, private, and for-profit, the state and labour organizations are formal, public, and non-profit, and communities are private, informal, and non-profit. An intermediary sector, crossing the boundaries between private and public, for profit and non-profit, includes energy cooperatives, not-for-profit energy enterprises, and the scientific community (Avelino and Wittmayer 2016).

To address the challenge of climate mitigation, a range of actors across sectors and jurisdictions have created coalitions for climate governance, operating as actor-networks. For example, mitigation policies are particularly effective when they are integrated with co-benefits such as health, biodiversity, and poverty reduction (Romero-Lankao et al. 2018a). Transnational business and public-private partnerships and initiatives, as well as international co-operation at the sub-national and city levels are discussed in Chapter 14.

13.5.1 Actor-networks, and policies

The decision adopting the Paris Agreement welcomed contributions of subnational actors to mobilizing and scaling up ambitious climate action (see also Chapter 14). They engage in climate relevant mechanisms, such as the Sustainable Development Goals and the New Urban Agenda. Subnational actors fill a gap in national policies, participate in transnational and subnational climate governance networks and facilitate learning and exchange among governmental, community, and private organizations at multiple levels, gathering knowledge and best practices such as emission inventories and risk management tools that can be applied in multiple contexts (Kona et al. 2016; Sharifi and Yamagata 2016; Michaelowa and Michaelowa 2017; Warbroek and Hoppe 2017; Bai et al. 2018; Busch et al. 2018; Hsu et al. 2018; Lee and Jung 2018; Marvin et al. 2018; Romero-Lankao et al. 2018b; Ürge-Vorsatz and Seto 2018; Heikkinen et al. 2019; Amundsen et al. 2018; Hultman et al. 2020).

Subnational climate change policies exist in more than 142 countries and exemplify the increasing significance of mitigation policy at the subnational level (Hsu et al. 2018). However, estimations of the number of subnational actors pledging voluntary climate action are challenging and underreporting is a concern (Chan and Morrow 2019; Hsu et al. 2018). As can be seen in Figure 13.3 more than 10,500 cities and nearly 250 regions representing more than 2 billion people, factoring for overlaps in population between these jurisdictions, have pledged climate action as of December 2020 (Hsu et al. 2020a). More jurisdictions in Europe and North America have pledged action, but in terms of population almost all regions are substantially engaged in subnational action.

Many of these efforts are organised around transnational or regional networks. For example, a coalition of 130 subnational (i.e., state, and regional) governments, representing 21% of the global economy and 672 million people, has pledged about 9% emissions reduction compared to a base year (CDP 2020). More than 10,000 cities, representing more than 10 percent of the global population, participate in the Global Covenant of Mayors, C40 Cities (Global Covenant of Mayors for Climate and Energy 2018), and ICLEI's - Local Governments for Sustainability carbon registry (Hsu et al. 2018). In Europe alone, more than 6,000 cities have adopted their own climate action plans (Palermo et al. 2020a) and nearly 300 U.S. subnational actors – cities and states - were committed to maintaining momentum for climate action as part of 'We Are Still In coalition' (We Are Still In coalition 2020) in the absence of national U.S. climate legislation. Further, as of October 2020, more than 826 cities and 103 regional governments had made specific pledges to decarbonize, whether in a specific sector (e.g., buildings, electricity, or transport) or through their entire economies, pledging to reduce their overall emissions by at least 80 percent or greater (NewClimate Institute and Data Driven EnviroLab 2020). Cities such as Barcelona, Spain and Seattle, Washington have adopted net zero goals for 2050 in policy legislation, while many more cities throughout the world, including the Global South such as Addis Ababa in Ethiopia, have net zero targets under consideration (Energy & Climate Intelligence Unit 2019, 2021).

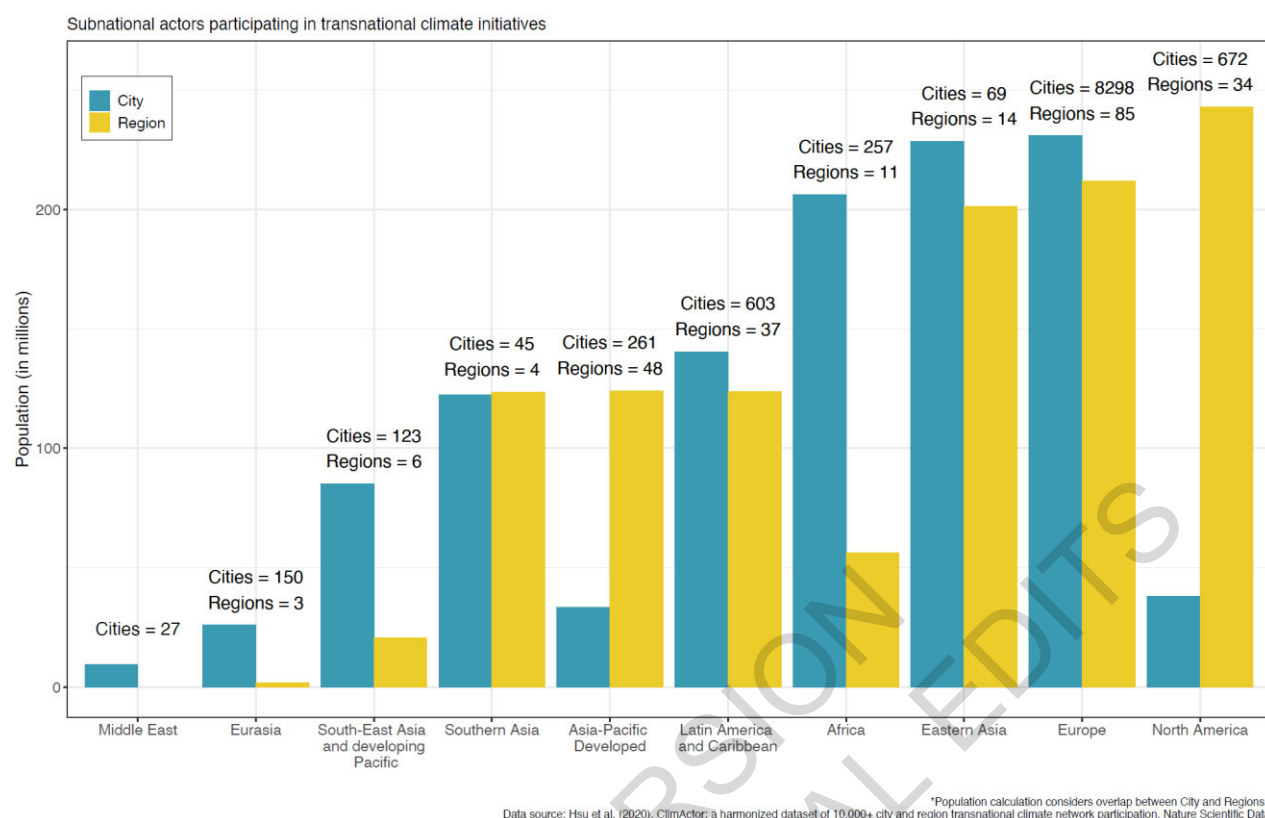


Figure 13.3 Sub-national GHG mitigation commitments: Total population by IPCC region

Population of subnational actors (cities and regions) recording climate action commitments as captured in the ClimActor dataset. Population calculation considers overlap between City and Regions by only accounting for population once for Cities and Regions that are nested jurisdictions

Source: Adapted from (Hsu et al. 2020a) to reflect IPCC AR6 aggregation. Compiled in 2020 from multiple sources based on most recent year of data available.

Sub-national mitigation policies are highlighted below, based on the taxonomy of policies in 13.6.1:

- a) Economic instruments: As of 2020, there were carbon pricing initiatives (ETS, carbon tax or both) in 24 subnational jurisdictions (World Bank 2021a). Examples include emission trading systems within the U.S. the Regional Greenhouse Gas Initiative (RGGI) and Western Climate Initiative, tax rebates for the purchase of EVs, a carbon tax in British Columbia, and a cap-and-trade scheme in Metropolitan Tokyo (Houle et al. 2015; Murray and Rivers 2015; Hibbard et al. 2018; Bernard and Kichian 2019; Raymond 2019; Xiang and Lawley 2019; Chan and Morrow 2019).
- b) Regulatory instruments: Policies such as land use and transportation planning, performance standards for buildings, utilities, transport electrification, and energy use by public utilities, buildings and fleets are widely prevalent (Bulkeley 2013; Jones 2013; C40 and ARUP 2015; Martinez et al. 2015; Hewitt and Coakley 2019; Palermo et al. 2020b). Policies such as regulatory restrictions, low emission zones, parking controls, delivery planning and freight routes, focus on traffic management and reduction of local air pollution but also have a mitigation impact (Slovic et al. 2016; Khreis et al. 2017; Letnik et al. 2018). For instance, in coordination with national governments, subnational actors in China, Europe and US have introduced access to priority lanes, free parking and other strategies fostering the roll-out of EVs (Creutzig 2016; Zhang and Bai 2017; Teske et al. 2018; Zhang and Qin 2018; Romero-Lankao et al. 2021).

- c) Land-use planning addresses building form, density, energy, and transport, which are relevant for decarbonisation (Creutzig et al. 2015; Torabi Moghadam et al. 2017; Teske et al. 2018). Its effectiveness is limited by absent or fragmented jurisdiction, financial resources and powers, competition between authorities and policy domains, and national policies that restrict local governments' ability to enact more ambitious policies (Fudge et al. 2016; Gouldson et al. 2016; Petersen 2016). Most rapidly growing smaller cities in Latin America, Asia and Africa lack capacity for urban planning and enforcement (Romero-Lankao et al. 2015; Creutzig 2016).
- d) Other policies: These include information and capacity building, such as carbon labelling aimed at providing carbon footprint information to consumers (Liu et al. 2016); disclosure and benchmarking policies in buildings to increase awareness of energy issues and track mitigation progress (Hsu et al. 2017; Papadopoulos et al. 2018); and procurement guidelines developed by associations (Sustainable Purchasing Leadership Council 2021). For instance, a building retrofit program was initiated in New York and Melbourne to foster energy efficiency improvements through knowledge provision, training, and consultation (Trencher et al. 2016; Trencher and van der Heijden 2019). Also significant is government provision of public good, services, and infrastructure (Romero Lankao et al. 2019), which includes provision of electric buses or buses on renewable fuels for public transportation (Kamiya and Teter 2019) and zero emission urban freight transport (Quak et al. 2019), sustainable food procurement for public organizations in cities (Smith et al. 2016), decentralized energy resources (Marquardt 2014; Hirt et al. 2021; Kahsar 2021), and green electricity purchase via community choice aggregation programs and franchise agreements (Armstrong 2019).

13.5.2 Partnerships and experiments

Partnerships, such as those among private and public, or transnational and subnational entities, have been found to enable better mitigation results in areas outside direct government control such as residential energy use, emissions from local businesses, or private vehicles (Fenwick et al. 2012; Castán Broto and Bulkeley 2013; Aylett 2014; Hamilton et al. 2014; Bulkeley et al. 2016; Wakabayashi and Arimura 2016; Grandin et al. 2018). Partnerships take advantage of investments that match available grants or enable a local energy project, or enhance the scope or impact of mitigation (Burch et al. 2013).

Subnational actors have also been associated with experiments and laboratories, which promise to achieve the deep change required to address the climate mitigation gap (Smeds and Acuto 2018; Marvin et al. 2018). Experiments span smart technologies (e.g., in Malmö, Sweden (Parks 2019), Eco-Art, Transformation-Labs and other approaches that question the cultural basis of current energy regimes and seek reimagined or reinvented futures (Guy et al. 2015; Voytenko et al. 2016; Hodson et al. 2018; Peng and Bai 2018; Culwick et al. 2019; Pereira et al. 2019; Sengers et al. 2019; Castán Broto and Bulkeley 2013; Smeds and Acuto 2018). They may include governance experiments, from formally defined policy experiments to informal initiatives that mobilise new governance concepts (Kivimaa et al. 2017a; Turnheim et al. 2018), and co-design initiatives and grassroots innovations (Martiskainen 2017; Sheikh and Bhaduri 2021). These initiatives often expand the scope for citizen participation. For example, Urban Living Labs foster innovation, coproducing responses to existing problems of energy use, energy poverty and mobility that integrate scientific and expert knowledge with local knowledge and common values (Voytenko et al. 2016; Marvin et al. 2018). The European Network of Living Labs- with a global outreach- has established a model of open and citizen-centric innovation for policy making. The proliferation of Climate Assemblies at the national and sub-national level further emphasises the increasing role that citizens can play in both innovating and planning for carbon mitigation (Sandover et al. 2021).

State and local authorities are often central to initiating and implementing experiments and use an incremental, 'learning by doing' governing approach (Bai et al. 2010; Nevens et al. 2013; McGuirk et al. 2015; Nagorny-Koring and Nocht 2018; Castán Broto and Bulkeley 2013; Hodson et al. 2018; Peng and

Bai 2018; Smeds and Acuto 2018; Culwick et al. 2019; Sengers et al. 2019). Experiments relate to technological learning and changes in policies, practices, services, user behaviour, business models, institutions, and governance (Wieczorek et al. 2015; Kivimaa et al. 2017a; Laurent and Pontille 2018; Torrens et al. 2019; Castán Broto and Bulkeley 2013).

Experimentation has contributed to learning, changes in outcomes when implemented, and shifts in the political landscape (Turnheim et al. 2018). Experiments, however, are often isolated and do not always result in longer-term, more widespread changes. The transformative potential (understood as changes in the fundamental attributes of natural and human systems, see Glossary) of experiments is constrained by uncertainty about locally relevant climate change solutions and effects; a lack of comprehensive, and sectorally inclusive national policy frameworks for decarbonisation; budgetary and staffing limitations; and a lack of institutional and political capacity to deliver integrated and planned approaches (Evans and Karvonen 2014; Wittmayer et al. 2016; Webb et al. 2017; Hölscher et al. 2018; McGuirk et al. 2015; Bulkeley et al. 2016; Grandin et al. 2018; Nagorny-Koring 2019; Sengers et al. 2019; Voytenko et al. 2016).

13.5.3 Performance and global mitigation impact

The performance of subnational actors' mitigation policies have been measured using criteria such as existence of mitigation targets, incentives for mitigation, definition of a baseline, and existence of a monitoring, reporting, and verification procedure (Hsu et al. 2019). Existing evaluations range from small-scale studies assessing the mitigation potential of commitments by subnational regions, cities and companies in the U.S. or in ten high-emitting economies (Roelfsema 2017; Hsu et al. 2019), to larger studies finding that over 9,149 cities worldwide could mitigate 1,400 MtCO₂-eq in 2030 (Global Covenant of Mayors for Climate and Energy 2018; Hsu et al. 2018, 2019). These subnational mitigation potential estimates vary since a range of approaches exists for accounting for overlaps between subnational governments and their nested jurisdictions (e.g., states, provinces, and national governments) (Roelfsema et al. 2018; Hsu et al. 2019). One analysis found that the cities of New York, Berlin, London, Greater Toronto, Boston, and Seattle have achieved on average a 0.27 tCO₂-eq per capita per year reduction (Kennedy et al. 2012). Hsu et al. (Hsu et al. 2020c) found that 60 percent of more than 1,000 European cities, representing 6 percent of the EU's total emissions, are on track to achieving their targets, reducing more than 51 million tons MtCO₂-eq. While evidence is limited, there are concerns that implementation challenges persist with city level plans, particularly tied to management of initiatives and engagement of the population (Messori et al. 2020).

Whether participation in transnational climate initiatives impacts subnational governments' achievement on climate mitigation goals is uncertain. Some find that higher ambition in climate mitigation commitments did not translate into greater mitigation (Kona et al. 2016; Hsu et al. 2019). Other studies associate participation in networks with increased solar PV investment (Khan and Sovacool 2016; Steffen et al. 2019), and with potential to achieve carbon emissions reductions per capita in line with a global 2 °C scenario (Kona et al. 2016).

Reporting networks may attract high-performing actors, suggesting an artificially high level of cities interested in taking climate action or piloting solutions (self-selection bias) that may not be effective elsewhere (van der Heijden 2018). Many studies present a conservative view of potential mitigation impact because they draw upon publicly reported mitigation actions and exclude subnational actions that are not reported (Kuramochi et al. 2020).

In addition to direct mitigation contributions, climate action partnerships may deliver indirect effects that, while difficult to quantify, ensure long-term change (Chan et al. 2015). Experimentation and policy innovation helps to establish best practices (Hoffmann 2011); set new norms for ambitious climate action that help build coalitions (Bernstein and Hoffmann 2018; Chan et al. 2015); and translate into knowledge sharing or capacity building (Lee and Koski 2012; Purdon 2015; Acuto and Rayner 2016; Hakelberg 2014).

Emergent research explores whether, in addition to realising outcomes, mitigation initiatives also provide the resources, skills and networks that governments and other stakeholders currently use to target other development goals (Shaw et al. 2014; Wolfram 2016; Wiedenhofer et al. 2018; Amundsen et al. 2018; Heikkinen et al. 2019).

13.6 Policy instruments and evaluation

Institutions and governance processes described in previous section result in specific policies, that governments then implement and that shape actions of many stakeholders. This section assesses the empirical experience with the range of policy instruments available to governments with which to shape mitigation outcomes. Section 13.7 that follows deals with how these instruments are combined into packages, and Section 13.9 addresses economy-wide measures and issues.

Many different policy instruments for GHG reduction are in use. They fall into a few major categories that share key characteristics. This section provides one possible taxonomy of these major types of policy instruments, presents a set of criteria for policy evaluation, and synthesizes the literature on the most common mitigation policies. The emphasis is on recent empirical evidence on the performance of different policy instruments and lessons that can be drawn from these experiences. This builds on and enhances the AR5 Chapter 15, which provided a more theoretical treatment of policy instruments for mitigation.

13.6.1 Taxonomy and overview of mitigation policies

13.6.1.1 Taxonomy of mitigation policies

A large number of policies and policy instruments can affect GHG emissions and/or sequestration, whether their primary purpose is climate change mitigation or not. Consequently, consistent with the approach in this chapter, this section adopts a broad interpretation to what is considered mitigation policy. Also, the section recognizes the multiplicity of policies that overlap and interact.

Environmental policy instruments, including for climate change mitigation, have long been grouped into three main categories – (1) economic instruments, (2) regulatory instruments, and (3) other instruments – although the specific terms differ across disciplines and additional categories are common (Kneese and Schultze 1975; Jaffe and Stavins 1995; Nordhaus 2013; Wurzel et al. 2013). Examples of common policies in each category are shown in Table 13.1, but this is not a comprehensive list. Principles of and empirical experience with the various instruments are synthesized in Sections 13.6.3 to 13.6.5, international interactions are covered in 13.6.6.

Table 13.1 Classification of mitigation policies

Category	Examples of common types of mitigation policy instruments
Economic instruments	Carbon taxes, GHG emissions trading, fossil fuel taxes, tax credits, grants, renewable energy subsidies, fossil fuel subsidy reductions, offsets, R&D subsidies, loan guarantees
Regulatory instruments	Energy efficiency standards, renewable portfolio standards, vehicle emission standards, ban on SF ₆ uses, biofuel content mandates, emission performance standards, methane regulations, land-use controls
Other instruments	Information programs, voluntary agreements, infrastructure, government technology procurement policies, corporate carbon reporting

13.6.1.2 Coverage of mitigation policies

An increasing share of global emissions sources is subject to mitigation policies, though coverage is still incomplete (Nascimento et al. 2021; Eskander and Fankhauser 2020).

While consistent information on global prevalence of policies is not available, in G20 countries the use of various policy instruments has increased steadily over the past two decades (Nascimento et al. 2021). The share of countries that had mitigation policy instruments in place rose across all sectoral categories, albeit to different extents in different sectors and for different policy instruments (Figure 13.4). Among G-20 countries the electricity and heat generation has the greatest number of policies in place, and the agriculture and forestry sector the fewest (Nascimento et al. 2021).

The mix of policies has shifted towards more regulatory instruments and carbon pricing relative to information policies and voluntary action (Schmidt and Fleig 2018; Eskander and Fankhauser 2020).

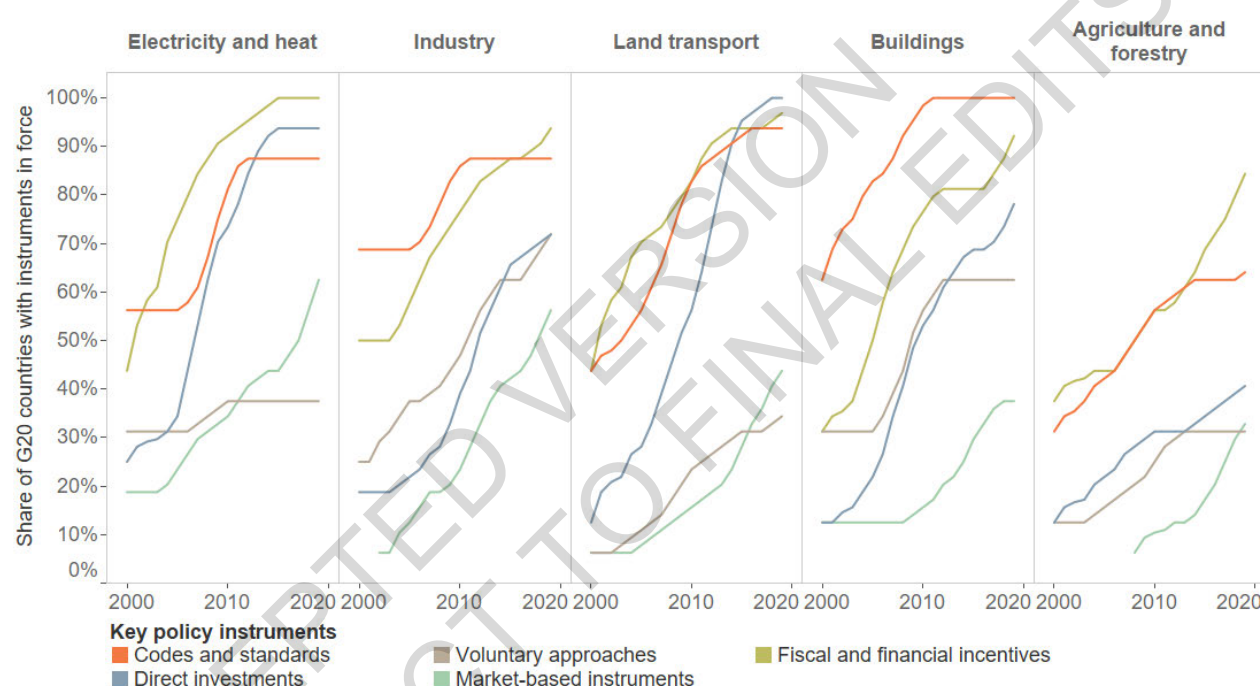


Figure 13.4 Share of countries that adopted different policy instruments in different sectors, 2000-2020 (three year moving average).

Source: Reproduced from (Nascimento et al. 2021).

The IEA database, which tracks renewable energy and energy efficiency policies at the national and sub-national levels for about 160 countries, indicates an average of about 225 new renewable energy and energy efficiency policies annually from 2010 through 2019 with a peak in the number of new renewable energy policies in 2011 (IEA 2021).

While an increasing share of CO₂ emissions from fossil fuel combustion is subject to mitigation policies, there remain many countries and sectors where no dedicated mitigation policies apply to fuel combustion. Fossil fuel use is subject to energy taxes in the majority but not all jurisdictions, and in some instances, it is subsidised.

The main gaps in current mitigation policy coverage are non-CO₂ emissions and CO₂ emissions associated with production of industrial materials and chemical feedstocks, which are connected to broader questions of shifting to cleaner production systems (Bataille et al. 2018a; Davis et al. 2018). Sequestration policies

focus mainly on forestry and CCS with limited support for other carbon dioxide removal and use options (Geden et al. 2019; Vonhedemann et al. 2020).

13.6.1.3 Stringency and overall effectiveness of mitigation policies

The stringency of mitigation policies varies greatly by country, sector and policy (see Box 13.9). Stringency can be increased through sequential changes to policies (Pahle et al. 2018).

Estimates of the effective carbon price (as an estimate of overall stringency across policy instruments) differ greatly between countries and sectors (World Bank 2021a). Countries with higher overall effective carbon prices tend to have lower carbon intensity of energy supply and lower emissions intensity of the economy, as shown in an analysis of 42 G20 and OECD countries (OECD 2018). The carbon price that prevails under a carbon tax or ETS is not directly a measure of policy stringency across an economy, as the carbon prices typically only cover a share of total emissions, and rebates or free allowance allocations can limit effectiveness (OECD 2018). At low emissions prices, mitigation incentives are small; as of April 2021, seventeen jurisdictions with a carbon pricing policy had a tax rate or allowance price less than USD5 per tCO₂ (World Bank 2021a).

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Box 13.9 Comparing the stringency of mitigation policies

Comparing the stringency of policies over time or across jurisdictions is very challenging and there is no single widely accepted metric or methodology (Tosun and Schnepf 2020; Fekete et al. 2021; Compston and Bailey 2016; Burck et al. 2019). Policies are also assessed for their estimated effect on emissions, however this requires estimation of a counterfactual baseline and isolation of other effects (see Cross-Chapter Box 10 in Chapter 14). Economic instruments can be compared on the basis of their price or cost per tCO₂-eq. Even that is fraught with complexity in the context of different definitions and estimations for fossil fuel taxes and subsidies. For non-price policies an implicit or equivalent carbon price can be estimated. Factors such as the tax treatment of compliance costs can increase complexity. Accounting for the combined effect of overlapping policies presents additional challenges and such estimates are subject to numerous limitations.

END BOX 13.9 HERE

Other policies, such as fossil fuel subsidies, may provide incentives to increase emissions thus limiting the effectiveness of the mitigation policy (Section 13.6.3.6). Those effects may be complex and difficult to identify. In most countries trade policy provides an implicit subsidy to CO₂ emissions (Shapiro 2020). The analysis of emissions from energy use in buildings in Chapter 9 illustrates the factors that support and counteract mitigation policies.

Furthermore, emissions pricing policies encourage reduction of emissions whose marginal abatement cost is lower than the tax/allowance price, so they have limited impact on emissions with higher abatement costs such as industrial process emissions (Bataille et al. 2018a; Davis et al. 2018). EU ETS emission reductions have been achieved mainly through implementation of low cost measures such as energy efficiency and fuel switching rather than more costly industrial process emissions.

Estimating the overall effectiveness of mitigation policies is difficult because of the need to identify which observed changes in emissions and their drivers are attributable to policy effort and which to other factors. Cross-Chapter Box 10 in Chapter 14 brings together several lines of evidence to indicate that mitigation policies have had a discernible impact on mitigation for specific countries, sectors and technologies and led to avoided global emissions to date by several billion tonnes CO₂-eq annually (*medium evidence, medium agreement*).

13.6.2 Evaluation criteria

Policy evaluation is a “careful, retrospective assessment of merit, worth and value of the administration, output and outcomes of government interventions” (Vedung 2005). The inherent complexity of climate mitigation policies calls for the application of multiple criteria, and reflexivity of analysis with regard to governments’ and societies’ objectives for policies (Huitema et al. 2011).

Evaluation of climate mitigation policy tends to focus on the environmental effectiveness and economic efficiency or cost-effectiveness of GHG mitigation policies, with distributional equity sometimes as an additional criterion. In policy design and implementation there is rising interest in co-benefits and side-effects of climate policies, as well as institutional requirements for implementation and the potential of policies to have transformative effect on systems. Table 13.2 elaborates.

Not all criteria are applicable to all instruments or in all circumstances and the relative importance of different criteria depend on the objectives in the specific the context. A given policy instrument may score highly on only some assessment criteria. In practice, the empirical evidence seldom exists for assessment of a policy instrument across all criteria.

Table 13.2 Criteria for evaluation and assessment of policy instruments and packages

Criterion	Description
Environmental effectiveness	Reducing GHG emissions is the primary goal of mitigation policies and therefore a fundamental criterion in evaluation. Environmental effectiveness has temporal and spatial dimensions.
Economic effectiveness	Climate change mitigation policies usually carry economic costs, and/or bring economic benefits other than through avoided future climate change. Economic effectiveness requires minimizing costs and maximizing benefits.
Distributional effects	The costs and benefits of policies are usually distributed unequally among different groups within a society (Zachmann et al. 2018), for example between industry, consumers, taxpayers; poor and rich households; different industries; different regions and countries. Policy design affects distributional effects, and equity can be taken into account in policy design in order to achieve political support for climate policies (Baranzini et al. 2017).
Co-benefits, negative side-effects	Climate change mitigation policies can have effects on other objectives, either positive co-benefits (Mayrhofer and Gupta 2016; Karlsson et al. 2020) or negative side-effects. Conversely, impacts on emissions can arise as side-effects of other policies. There can be various interactions between climate change mitigation and the Sustainable Development Goals (Liu et al. 2019).
Institutional requirements	Effective implementation of policies requires that specific institutional prerequisites are met. These include effective monitoring of activities or emissions and enforcement, and institutional structures for the design, oversight and revision and updating of policies. Requirements differ between policy instruments. A

separate consideration is the overall feasibility of a policy within a jurisdiction, including political feasibility (Jewell and Cherp 2020).

Transformative potential

Transformational change is a process that involves profound change resulting in fundamentally different structures (Nalau and Handmer 2015), or a substantial shift in a system's underlying structure (Hermwille et al. 2015). Climate change mitigation policies can be seen as having transformative potential if they can fundamentally change emissions trajectories, or facilitate technologies, practices or products with far lower emissions.

13.6.3 Economic instruments

Economic instruments, including carbon taxes, emissions trading systems (ETS), purchases of emission reduction credits, subsidies for energy efficiency, renewables and research and development and fossil fuel subsidy removal, provide a financial incentive to reduce emissions. Pricing instruments, especially ETS and carbon taxes, have become more prevalent in recent years (Section 13.6.1). They have proven effective in promoting implementation of the low-cost emissions reductions, and practical experience has driven progress in market mechanism design (*robust evidence, high agreement*).

13.6.3.1 Carbon taxes

A carbon tax is a charge on carbon dioxide or other greenhouse gases imposed on specified emitters or products. In practice features such as exemptions and multiple rates can lead to debate as to whether a specific tax is a carbon tax (Haites 2018). While other taxes can also reduce emissions by increasing the price of GHG emitting products, the result may be inefficient unless the tax rate is proportional to the emissions intensity. A tax on value of fossil fuels, for example, could raise the price on natural gas more than the price of coal, and hence increase emissions if the resulting substitution towards coal were to outweigh reductions in energy use.

As of April 2021, 27 carbon taxes had been implemented by national governments, mostly in Europe (World Bank 2021a). Most of the taxes apply to fossil fuels used for transportation and heating and cover between 3% and 79% of the jurisdiction's emissions. Several countries also tax F-gases. Tax rates vary widely from less than USD1 to over USD137 per tCO₂-eq. A few jurisdictions lowered existing fuel taxes when they implemented the carbon tax, thus reducing the effective tax rate (OECD 2021a). How the tax revenue is used varies widely by jurisdiction.

Carbon taxes tend to garner the least public support among possible mitigation policy options (Rhodes et al. 2017; Rabe 2018; Maestre-Andrés et al. 2019; Criqui et al. 2019) although some regulations also meet with opposition (Attari et al. 2009). Policymakers sometimes use the revenue to build support for the tax, allocating some to address regressivity, to address competitiveness claims by industry, to reduce the economic cost by lowering existing taxes, and to fund environmental projects (Gavard et al. 2018; Klenert et al. 2018; Levi et al. 2020).

Carbon tax rates can be adjusted for inflation, increases in income, the effects of technological change, changing policy ambition, or the addition or subtraction of other policies. In practice numerous jurisdictions have not increased their tax rates annually and some scheduled tax increases have not been implemented (Haites et al. 2018). Predictability of future tax rates helps improve economic performance (Bosetti and Victor 2011; Brunner et al. 2012). Uncertainty about the future existence of a carbon price can hinder investment (Jotzo et al. 2012) and uncertainty about future price levels can increase the resource costs of carbon pricing (Aldy and Armitage 2020).

13.6.3.2 Emission trading systems

The most common ETS design – cap-and-trade – sets a limit on aggregate GHG emissions by specified sources, distributes tradable allowances approximately equal to the limit, and requires regulated emitters to submit allowances equal to their verified emissions. The price of allowances is determined by the market, except in cases where government determined price floors or ceilings apply.

ETSs for GHGs were in place in 38 countries as of April 2021 (World Bank 2021a). The EU ETS, which covers 30 countries, was recently displaced by China’s national ETS as the largest. ETSs tend to cover emissions by large industrial and electricity generating facilities.³ Allowance prices as of April 1, 2021 ranged from just over USD1 to USD50, and coverage between 9 and 80% of the jurisdiction’s emissions.

Multiple regional pilot ETSs with different designs have been implemented in China since 2013 to provide input to the design of a national system that is to become the world’s largest ETS (Jotzo et al. 2018; Qian et al. 2018; Stoerk et al. 2019). Assessments have identified potential improvements to emissions reporting procedures (Zhang et al. 2019) and the pilot ETS designs (Deng et al. 2018). China’s national ETS covering over 2,200 heat and power plants with annual emissions of about 4 billion tCO₂ took effect in 2021 (World Bank 2021a).

All of the ETSs for which data are available have accumulated surplus allowances which reduces their effectiveness (Haites 2018). Surplus allowances indicate that the caps set earlier were not stringent relative to emissions trends. Most of those ETSs have implemented measures to reduce the surplus including removal/cancellation of allowances and more rapid reduction of the cap. Several ETSs have adopted mechanisms to remove excess allowances from the market when supply is abundant and release additional allowances into the market when the supply is limited, such as the EU “market stability reserve” (Hepburn et al. 2016; Bruninx et al. 2020). Initial indications are that this mechanism is at least partially successful in stabilizing prices in response to short term disruptions such as the COVID-19 economic shock (Gerlagh et al. 2020; Bocklet et al. 2019).

Some ETS also include provisions to limit the range of market prices, making them ‘hybrids’ (Pizer 2002). A price floor assures a minimum level of policy effect if demand for allowances is low relative to the ETS emissions cap. It is usually implemented through a minimum price at auction, as for example in California’s ETS (Borenstein et al. 2019). A price ceiling allows the government to issue unlimited additional allowances at a pre-determined price to limit the maximum cost of mitigation. Price ceilings have not been activated to date.

13.6.3.3 Evaluation of carbon pricing experience

A carbon tax or GHG ETS increases the prices of emissions intensive goods thus creating incentives to reduce emissions (see (Stavins 2019) for a comparison of a tax and ETS). The principal advantage of a pricing policy is that it promotes implementation of low cost reductions; for a carbon tax, reductions whose cost per tCO₂-eq reduced is lower than the tax and for an ETS the lowest cost (per tCO₂-eq) reductions sufficient to meet the cap. Both a tax and an ETS can be designed to limit adverse economic impacts on regulated sources and emissions leakage.

The corresponding limitations of pricing policies are that they have limited impact on adoption of mitigation measures when decisions are not sensitive to prices and do not encourage adoption of higher cost mitigation measures. Their effectiveness in influencing long-term investments depends on the expectation that the policy will continue and expectations related to future tax rates or allowance prices (Brunner et al. 2012). Other policies can be used in combination with carbon pricing to address these limitations.

FOOTNOTE ³ The UK was a member of the EU ETS until December 31, 2020. A UK Emissions Trading Scheme (UK ETS) came into effect on January 1, 2021.

The number of pricing policies has increased steadily and covered 21.5% of global GHG emissions in 2020 (World Bank 2021a). Effective coverage is lower because virtually all jurisdictions with a pricing policy have other policies that affect some of the same emissions. For example, a few jurisdictions reduced existing fuel taxes when they introduced their carbon tax thus reducing the effective tax rate, and many jurisdictions have two or more pricing policies

Environmental effectiveness and co-benefits

There is abundant evidence that carbon pricing policies reduce emissions. Statistical studies of emissions trends in jurisdictions with and without carbon pricing find a significant impact after controlling for other policies and structural factors (Best et al. 2020; Rafaty et al. 2020). Numerous assessments of specific policies, especially the EU ETS and the British Columbia carbon tax, conclude that most have reduced emissions (Narassimhan et al. 2018; FSR Climate 2019; Haites et al. 2018; Metcalf and Stock 2020; Rafaty et al. 2020; Green 2021; Aydin and Esen 2018; Pretis 2019; Andersson 2019; Arimura and Abe 2021; Bayer and Aklin 2020; Diaz et al. 2020) (*robust evidence, high agreement*).

Estimating the emission reductions due to a specific policy is difficult due to the effects of overlapping policies and exogenous factors such as fossil fuel price changes and economic conditions. Studies that attempt to attribute a share of the reductions achieved to the EU ETS place its contribution at 3-25% (FSR Climate 2019; Bayer and Aklin 2020; Chèze et al. 2020). The relationship between a carbon tax and the resulting emission reductions is complex and is influenced by changes in fossil fuel prices, changes in fossil fuel taxes, and other mitigation policies (Aydin and Esen 2018). But the effectiveness of a carbon tax generally is higher in countries where it constitutes a large part of the fossil fuel price (Andersson 2019).

Few of the world's carbon prices are at a level consistent with various estimates of the carbon price needed to meet the Paris Agreement goals. In modelling of mitigation pathways likely to limit warming to 2°C (Chapter 3, 3.6.1) marginal abatement costs of carbon in 2030 are about 60 to 120 USD₂₀₁₅/tCO₂, and about 170 to 290 USD₂₀₁₅/tCO₂ in pathways that limit warming to 1.5°C with no or limited overshoot (3.6). One synthesis study estimates necessary prices at USD40–80 per tCO₂ by 2020 (High-Level Commission on Carbon Prices 2017). Only a small minority of carbon pricing schemes in 2021 had prices above USD40 per tCO₂, and all of these were in European jurisdictions (World Bank 2021a). Most carbon pricing systems apply only to some share of the total emissions in a jurisdiction, so the headline carbon price is higher than the average carbon price that applies across an economy (World Bank 2021a).

Where ETS or carbon taxes exist, they apply to different proportions of the jurisdiction's greenhouse gas emissions. The share of emissions covered by ETSs in 2020 varied widely, ranged from 9% (Canada) to 80% (California) while the share of emissions covered by carbon taxes ranged from 3% (Latvia and Spain) to 80% (South Africa) (World Bank 2021a). Where carbon pricing policies are effective in reducing GHG emissions, they usually also generate co-benefits including better air quality. For example, a Chinese study of air quality benefits from lower fossil fuel use under carbon pricing suggests that prospective health co-benefits would partially or fully offset the cost of the carbon policy (Li et al. 2018). Depending upon the jurisdiction (for example, if there are fossil fuel subsidies) carbon pricing could also reduce the economic distortions of fossil fuel subsidies, improve energy security through greater reliance on local energy sources and reduce exposure to fossil fuel market volatility. Substantial carbon prices would be in the domestic self-interest of many countries if co-benefits were fully factored in (Parry et al. 2015).

Economic effectiveness

Economic theory suggests that carbon pricing policies are on the whole more cost effective than regulations or subsidies at reducing emissions (Gugler et al. 2021). Any mitigation policy imposes costs on the regulated entities. In some cases entities may be able to recover some or all of the costs through higher prices (Neuhoff and Ritz 2019; Cludius et al. 2020). International competition from less stringently regulated firms limits the ability of emissions-intensive, trade-exposed (EITE) firms to raise their prices. Thus a unilateral mitigation

policy creates a risk of adverse economic impacts, including loss of sales, employment, profits, for such firms and associated emissions leakage (see Section 13.6.6.1).

Pricing policies can be designed to minimize these risks; free allowances can be issued to EITE participants in an ETS and taxes can provide exemptions or rebates. An extensive ex post literature finds no statistically significant adverse impacts on competitiveness or leakage (13.6.6.1).

An ex post analysis of European carbon taxes finds no robust evidence of a negative effect on employment or GDP growth (Metcalf and Stock 2020). The British Columbia carbon tax led to a small net increase in employment (Yamazaki 2017) with no significant negative impacts on GDP possibly due to full recycling of the tax revenue (Bernard and Kichian 2021). Few carbon taxes apply to EITE sources (Timilsina 2018), so competitiveness impacts usually are not a particular concern.

Government revenue generated by carbon pricing policies globally was approximately USD53 billion in 2020 split almost evenly between carbon taxes and ETS allowance sales (World Bank 2021). Revenue raised though carbon pricing is generally considered a relatively efficient form of taxation and a large share of revenue enters general government budgets (Postic and Fetet 2020). Some of the revenue is returned to emitters or earmarked for environmental purposes. Allowance allocation and revenue spending measures have been used to create public support for many carbon pricing policies including at every major reform stage of the EU ETS (Dorsch et al. 2020; Klenert et al. 2018; see also Box 5.11).

Distributional effects

The most commonly studied distributional impact is the direct impact of a carbon tax on household income. Typically it is regressive; the tax induced increase in energy expenditures represents a larger share of household income for lower income households (Grainger and Kolstad 2010; Timilsina 2018; Dorband et al. 2019; Ohlendorf et al. 2021). Governments can rebate part or all of the revenue to low income households, or implement other changes to taxation and transfer systems to achieve desired distributional outcomes (Jacobs and van der Ploeg 2019; Saelim 2019; Saltee 2019) (see also Box 5.11). The full impact of the tax – after any distribution of tax revenue to households and typically adverse effects on investors – generally is less regressive or progressive (Williams III et al. 2015; Goulder et al. 2019). Where the tax revenue is treated as general revenue the government relies on existing income redistribution policies (such as income taxes) and social safety net programs to address the distributional impacts.

Carbon taxes on fossil fuels have effects similar to the removal of fossil fuel subsidies (Ohlendorf et al. 2021) (see also Section 13.6.3.6). Even if a carbon tax is progressive it increases prices for fuels, electricity, transport, food and other goods and services that adversely affect the most economically vulnerable. Redistribution of tax revenue is critical to address the adverse impacts on low income groups (Dorband et al. 2019) (see also Box 5.11). In countries with a limited capacity to collect taxes and distribute revenues to low income households, such as some developing countries, carbon taxes may have greater distributional consequences.

Distributional effects have generally not been a significant issue for ETSs. Equity for industrial participants typically is addressed through free allocation of allowances. Impacts on household incomes, with the exception of electricity prices, are too small or indirect to be a concern. Some systems are designed to limit electricity price increases (Petek 2020) or use some revenue for bill assistance to low-income households (RGGI 2019).

Technological change

Carbon pricing, especially an ETS that covers industrial sources, stimulates technological change by participants and others (Calel and Dechezleprêtre 2016; FSR Climate 2019; van den Bergh and Savin 2021) (see also Section 13.6.6.3 and Chapter 16). The purpose of pricing policies is to encourage implementation of the lowest cost mitigation measures. Pricing policies therefore are more likely to stimulate quick, low cost innovation such as fuel switching and energy efficiency, rather than long-term, costly technology

development such as renewable energy or industrial process technologies (Calel 2020; Lilliestam et al. 2021). To encourage long-term technology development carbon pricing policies need to be complemented by other mitigation and R&D policies.

13.6.3.4 Offset credits

Offset credits are voluntary GHG emission reductions for which tradable credits are issued by a supervisory body (Michaelowa et al. 2019b). A buyer can use purchased credits to offset an equal quantity of its emissions. In a voluntary market governments, firms and individuals purchase credits to offset emissions generated by their actions, such as air travel. A compliance market allows specified offset credits to be used for compliance with mitigation policies, especially ETSs, carbon taxes and low carbon fuel standards. (Newell et al. 2013; Bento et al. 2016; Michaelowa et al. 2019a).

When used for compliance, governments typically specify a maximum quantity of offset credits that can be used, as well as the types of emission reduction actions, the project start dates and the geographic regions eligible credits. Initially, the EU ETS, Swiss ETS and New Zealand ETS accepted credits issued under the Kyoto Protocol (Chapter 14), but they terminated or severely constrained the quantity of international credits allowed for compliance use after 2014 (Shishlov et al. 2016)(see 13.6.6).

A key question for any offset credit is whether the emission reductions are ‘additional’: reductions that only happen because of the offset credit payment (Millard-Ball and Ortolano 2010; van Benthem and Kerr 2013; Burke 2016; Bento et al. 2016; Greiner and Michaelowa 2003). To assess additionality and to determine the quantity of credits to be issued, regulators develop methodologies to estimate baseline (business-as-usual) emissions in the absence of offset payments (Newell et al. 2013; Bento et al. 2016). Credits are issued for the difference between the baseline and actual emissions with adjustments for possible emissions increases outside the project boundary (Rosendahl and Strand 2011). Some research suggests that procedural and measurement advances can significantly reduce the risk of severe non-additionality (Mason and Plantinga 2013; Bento et al. 2016; Michaelowa et al. 2019a).

13.6.3.5 Subsidies for mitigation

Subsidies for mitigation encourage individuals and firms to invest in assets that reduce emissions, changes in processes or innovation. Subsidies have been used to improve energy efficiency, encourage the uptake of renewable energy and other sector-specific emissions saving options (Chapters 6 to 11), and to promote innovation. Targeted subsidies can achieve specific mitigation goals yet have intrinsically narrower coverage than more broad-based pricing instruments. Subsidies are often used not only to achieve emissions reductions but to address market imperfections or to achieve distributional or strategic objectives. Subsidies are often used alongside or in combination with other policy instruments, and are provided at widely differing cost per unit of emissions reduced.

Governments routinely provide direct funding for basic research, subsidies for R&D to private companies, and co-funding of research and deployment with industry (Dzonzi-Undi and Li 2016). Research subsidies have been found to be positively correlated with green product innovation in a study in Germany, Switzerland and Austria (Stucki et al. 2018). Government subsidies for R&D have been found to greatly increase the green innovation performance of energy intensive firms in China (Bai et al. 2019). For more detail see Chapter 16.

Subsidies of different forms are often provided for emissions savings investments to businesses and for the retrofit of buildings for energy efficiency. Emissions reductions from energy efficiencies can often be achieved at low cost, but evidence for some schemes suggests lower effectiveness in emissions reductions than expected ex ante (Fowlie et al. 2018; Valentová et al. 2019). Tax credits can be used to encourage firms to produce or invest in low-carbon emission energy and low-emission equipment. Investment subsidies have been found to be more effective in reducing costs and uncertainties in solar energy technologies than production subsidies (Flowers et al. 2016).

Subsidies have been provided extensively and in many countries for the deployment of household rooftop solar systems, and increasingly also for commercial scale renewable energy projects, typically using ‘feed-in tariffs’ that provide a payment for electricity generated above the market price (Pyrgou et al. 2016). Such schemes have proven effective in deploying renewable energy, but lock in subsidies for long periods of time. In some cases they provide subsidies at higher levels than would be required to motivate deployment (del Río and Linares 2014). High levels of net subsidies have been shown to diminish incentives for optimal siting of renewable energy installations (Penasco et al. 2019).

A variant of subsidies for deployment of renewable energy are auctioned feed-in tariffs or auctioned contracts-for-difference, where commercial providers bid in a competitive process. Auctions typically lead to lower price premiums (Eberhard and Kåberger 2016; Roberts 2020) but efficient outcomes depend on auction design and market structure (Grashof et al. 2020), although an emergent literature also questions whether spread of auctions is due to performance or the dynamics of the policy formulation process (Fitch-Roy et al. 2019b; Grashof et al. 2020; Grashof 2021). The prequalification requirements or the assessment criteria in the auctions sometimes also include local co-benefits such as local economic diversification (Buckman et al. 2019; White et al. 2021).

Support for rollout clean technologies at high prices can be economically beneficial in the long run if costs are reduced greatly as a function of deployment (Newbery 2018). Deployment support, much of it in the form of feed-in tariffs in Germany, enabled the scaling up of the global solar photovoltaic industry and attendant large reductions in production costs that by 2020 made solar power cost competitive with fossil fuels (Buchholz et al. 2019). There is also evidence for increased innovation activity as a result of solar feed-in tariffs (Böhringer et al. 2017b).

Many governments have also provided subsidies for the purchase of electric vehicles, including with strong effect in China (Ma et al. 2017), Norway (Baldursson et al. 2021) and other countries, and sometimes at relatively high rates (Kong and Hardman 2019).

13.6.3.6 Removal of fossil fuel subsidies

Many governments subsidize fossil fuel consumption and/or production through a variety of mechanisms (Burniaux and Chateau 2014) (see Figure 13.5). Different approaches exist to defining the scope and estimating the magnitude of fossil fuel subsidies (Koplow 2018), and all involve estimates, so the magnitudes are uncertain. Rationalizing inefficient fossil fuel subsidies is one of the indicators to measure progress toward Sustainable Development Goal 12 -- Ensure sustainable consumption and production patterns (UNEP 2019a).

Consumption subsidies represent approximately 70% of the total. Most of the subsidies go to petroleum, which accounts for roughly 50% of the consumption subsidies and 75% of the production subsidies (IEA 2020; OECD 2020). Much of the variation in the consumption subsidies is due to fluctuations in the world price of oil which is used as the reference price.

Reducing fossil fuel subsidies would lower CO₂ emissions, increase government revenues (Dennis 2016; Gass and Echeverria 2017; Rentschler and Bazilian 2017; Monasterolo and Raberto 2019; Jakob et al. 2015), improve macroeconomic performance (Monasterolo and Raberto 2019), and yield other environmental and sustainable development benefits (Solarin 2020; Rentschler and Bazilian 2017; Jakob et al. 2015) (*robust evidence, medium agreement*). The benefits of gasoline subsidies in developing countries accrue mainly to higher income groups, so subsidy reduction usually will reduce inequality (Coady et al. 2015; Dennis 2016; Monasterolo and Raberto 2019; Labeaga et al. 2021). Some subsidies, like tiered electricity rates, benefit low income groups. Reductions of broad subsidies lead to price increases for fuels, electricity, transport, food and other goods and services that adversely affect the most economically vulnerable (Coady et al. 2015; Zeng and Chen 2016; Rentschler and Bazilian 2017). Distributing some of the revenue saved can mitigate the adverse economic impacts on low income groups (Dennis 2016; Zeng and Chen 2016; Labeaga et al. 2021; Schaffitzel et al. 2020).

The emissions reduction that could be achieved from fossil fuel subsidy removal depends on the specific context such as magnitude and nature of subsidies, energy prices and demand elasticities, and how the fiscal savings from reduced subsidies are used. Modelling studies of global fossil fuel subsidy removal result in projected emission reductions of between 1 and 10 per cent by 2030 (Delpiazzi et al. 2015; IEA 2015; Jewell et al. 2018; IISD 2019) and between 6.4 and 8.2 per cent by 2050 (Schwanitz et al. 2014; Burniaux and Chateau 2014).

An extensive literature documents the difficulties of phasing out fossil fuel subsidies (Schmidt et al. 2017; Skovgaard and van Asselt 2018; Kyle 2018; Perry 2020; Gass and Echeverria 2017; Gençsü et al. 2020). Fossil fuel industries lobby to maintain producer subsidies and consumers protest if they are adversely affected by subsidy reductions (Fouquet 2016; Coxhead and Grainger 2018). Yemen (2005 and 2014), Cameroon (2008), Bolivia (2010), Nigeria (2012), Ecuador (2019) all abandoned subsidy reform attempts following public protests (Mahdavi et al. 2020; Rentschler and Bazilian 2017). Indonesia is an example where fossil fuel subsidy removal was successful, helped by social assistance programs and a communication effort about the benefits of reform (Chelminski 2018; Burke and Kurniawati 2018). To-date instances of fossil fuel subsidy reform or removal have been driven largely by national fiscal and economic considerations (Skovgaard and van Asselt 2019).

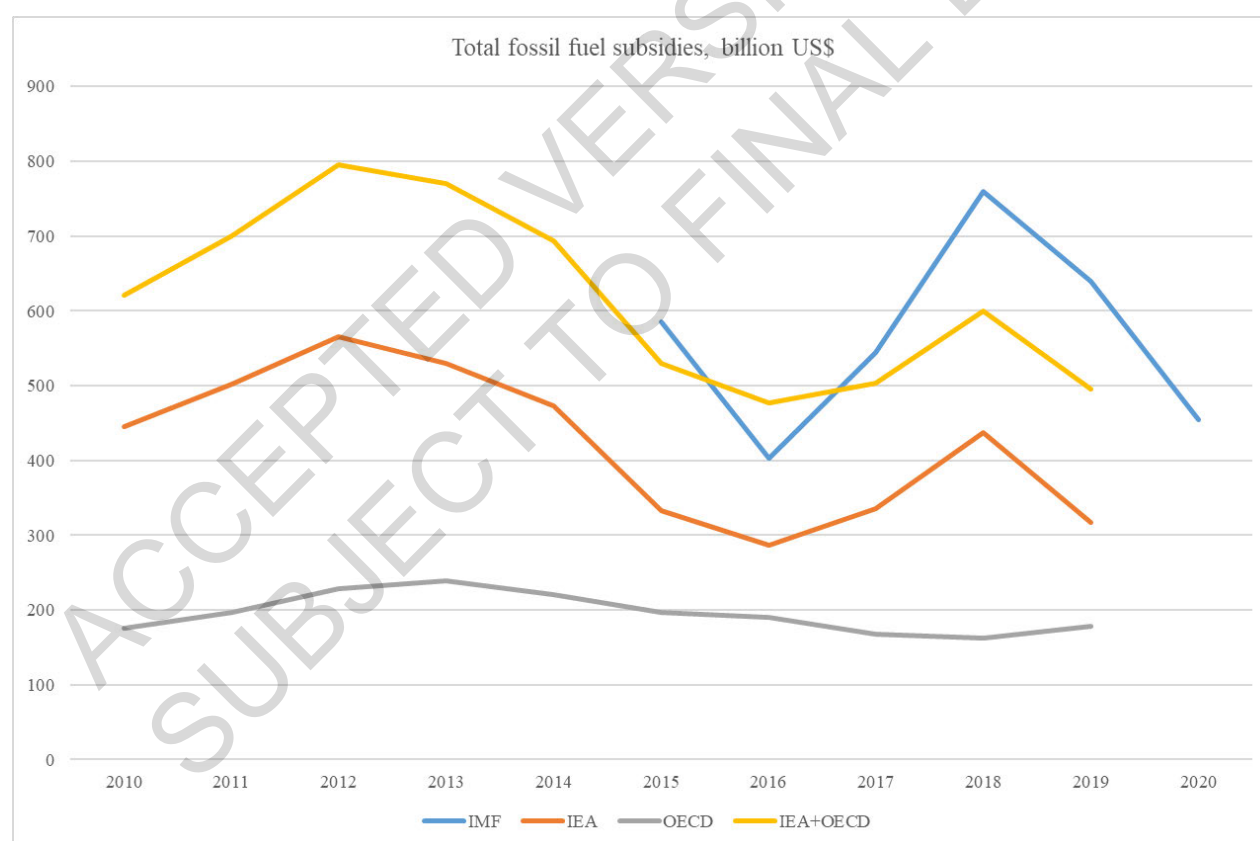


Figure 13.5 Total fossil fuel subsidies, 2010-19, in USD billion (USD2021 for IMF, USD2019 for others).

Source: OECD (2020) (43 countries, mainly production subsidies), IEA (2020) (40 countries, mainly consumption subsidies), IMF ((Parry et al. 2021); explicit subsidies for all countries).

13.6.4 Regulatory instruments

Regulatory instruments are applied by governments to cause the adoption of desired processes, technologies, products (including energy products) or outcomes (including emission levels). Failure to comply incurs financial penalties and/or legal sanctions. Regulatory instruments range from performance standards, which prescribe compliance outcomes – and in some cases allow flexibility to achieve compliance, including the trading of credits – to more prescriptive technology-specific standards, also known as command-and-control regulation. Regulatory instruments play an important role to achieve specific mitigation outcomes in sectoral applications (*robust evidence, high agreement*). Mitigation by regulation often enjoys greater political support but tends to be more economically costly than mitigation by pricing instruments (*robust evidence, medium agreement*).

13.6.4.1 Performance standards, including tradable credits

Performance standards grant regulated entities freedom to choose the technologies and methods to reach a general objective, such as a minimum market share of zero-emission vehicles or of renewable electricity, or a maximum emissions intensity of electricity generated. Tradable performance standards allow regulated entities to trade compliance achievement credits; under-performers can buy surplus credits from over-performers thereby reducing the aggregate cost of compliance (Fischer 2008).

Tradable performance standards have been applied to numerous sectors including electricity generation, personal vehicles, building energy efficiency, appliances, and large industry. An important application is Renewable Portfolio Standards (RPS) for electricity supply, which require that a minimum percentage of electricity is generated from specified renewable sources sometimes including nuclear and fossil fuels with CCS when referred to as a clean electricity standard (Young and Bistline 2018)(see also Chapter 6). This creates a price incentive to invest in renewable generation capacity. Such incentives can equivalently be created through feed-in tariffs, a form of subsidy (Section 13.6.3) and some jurisdictions have had both instruments (Matsumoto et al. 2017). RPS can differ in features and stringency are in operation in many countries and sub-national jurisdictions, including a majority of US States (Carley et al. 2018).

Vehicle emissions standards are a common form of performance standard with flexibility (Chapter 9). A corporate fuel efficiency standard specifies an average energy use and/or GHG emissions per kilometre travelled for vehicles sold by a manufacturer. Another version of this policy, the zero-emission vehicle (ZEV) standard, requires vehicle sellers to achieve minimum requirements for sales of zero-emission vehicles (Bhardwaj et al. 2020). Both instruments allow manufacturers to use tradable credits to achieve compliance.

Low carbon fuel standards (LCFS), which set an average life-cycle carbon intensity for energy that declines over time, are another example. LCFS are in place in many different jurisdictions (Chapter 9) and have been applied to petroleum products, natural gas, hydrogen and electricity (Yeh et al. 2016). An LCFS allows regulated entities to trade credits creating the potential for high carbon intensity fuel suppliers to cross-subsidize low carbon intensity transport energy providers including low-carbon biofuels, hydrogen and electricity (Axsen et al. 2020).

Trading and other flexibility mechanisms improve the economic efficiency of standards by harmonizing the marginal abatement costs among companies or installations subject to the standard. Nevertheless tradable performance standards are less economically efficient in achieving emissions reductions than carbon pricing, sometimes by a significant amount (Giraudet and Quirion 2008; Chen et al. 2014; Holland et al. 2015; Fox et al. 2017; Zhang et al. 2018).

13.6.4.2 Technology standards

Technology standards take a more prescriptive approach by requiring a specific technology, process or product. They typically take one of three forms: requirements for specific pollution abatement technologies; requirements for specific production methods; or requirements for specific goods such as energy efficient appliances. They can also take the form of phase-out mandates, as applied for example to planned bans of

internal combustion engines for road transport (Bhagavathy and McCulloch 2020), coal use (e.g. Germany's decisions to phase out coal (Oei et al. 2020)), and some industry processes and products (e.g. HFCs and use of SF₆ in some products (see Box 13.10 on Non-CO₂ gases). Technology standards are also referred to as command-and-control standards, prescriptive standards, or design standards.

Technology standards are a common climate policy particularly at the sector level (Chapters 6-11). Technology standards tend to score lower in terms of economic efficiency than carbon pricing and performance standards (Besanko 1987). But they may be the best instrument for situations where decisions are not very responsive to price signals such as consumer choices related to energy efficiency and recycling and decisions relating to urban land use and infrastructure choices.

By mandating specific compliance pathways, technology standards risk locking-in a high-cost pathway when lower cost options are available or may emerge through market incentives and innovation (Raff and Walter 2020). Furthermore, standards may require high-cost GHG reductions in one sector while missing low-cost options in another sector. Technology standards can also stifle innovation by blocking alternative technologies from entering the market (Sachs 2012). Benefits of technology standards include their potential to achieve emission reductions in a relatively short timeframe and that their effectiveness can be estimated with some confidence (Montgomery et al. 2019).

13.6.4.3 Performance of regulatory instruments

Regulatory policy instruments tend to be more economically costly than pricing instruments, as explained above. However, regulatory policies may be preferred for other reasons.

In some cases, regulatory policy can elicit greater political support than pricing policy (Tobler et al. 2012; Lam 2015; Drews and van den Bergh 2016). For example, U.S. citizens have expressed more support for flexible regulation like the RPS than for carbon taxes (Rabe 2018). And a survey in British Columbia a few years after the simultaneous implementation of a carbon tax and two regulations – the LCFS and a clean electricity standard – found much less strong opposition to the regulations, even after being informed that they were costlier to consumers (Rhodes et al. 2017). The degree of public support for regulations depends, however, on the type of regulation, as outright technology prohibitions can be unpopular (Attari et al. 2009; Cherry et al. 2012).

In comparison to economic instruments, regulatory policies tend to cause greater cost of living increases in percentage terms for lower income consumers – called policy regressivity (Levinson 2019; Davis and Knittel 2019). And unlike carbon taxes, regulations do not generate revenues that can be used to compensate lower income groups.

A renewable energy procurement obligation in South Africa successfully required local hiring with perceived positive results (Walwyn and Brent 2015; Pahle et al. 2016), a clean energy regulation in Korea was perceived to provide greater employment opportunities (Lee 2017), and a UK obligation on energy companies to provide energy retrofits to low-income households improved energy affordability according to participants (Elsharkawy and Rutherford 2018).

From an energy system transformation perspective, technology standards, including phase-out mandates, have particular promise to achieve profound change in specific sectors and technologies (Tvinnereim and Mehling 2018). As such policies change the technologies available in the market, then economic instruments can also have a greater effect (Pahle et al. 2018).

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Box 13.10 Policies to limit emissions of Non-CO₂ Gases

Non-CO₂ gases weighted by their 100 year GWPs represent approximately 25% of global GHG emissions, of which methane (CH₄) accounts for 18%, nitrous oxide (N₂O) – 4%, and fluorinated gases (HFCs, PFCs, SF₆ and NF₃) – 2% (Minx et al. 2021). Only a small share of these emissions are subject to mitigation policies.

Methane. Anthropogenic sources include agriculture, mainly livestock and rice paddies, fossil fuel extraction and processing, fuel combustion, some industrial processes, landfills, and wastewater treatment (US EPA 2019). Atmospheric measurements indicate that methane emissions from fossil fuel production are larger than shown in emissions inventories (Schwietzke et al. 2016). Only a small fraction of global CH₄ emissions is regulated. Mitigation policies focus on landfills, coal mines, and oil and gas operations.

Regulations and incentives to capture and utilize methane from coal seams came into effect in China in 2010 (Tan 2018; Tao et al. 2019). Inventory data suggest that emissions peaked and began a slow decline after 2010 (Gao et al. 2020) though satellite data indicate that China's methane emissions, largely attributable to coal mining, continued to rise in line with pre-2010 trends (Miller et al. 2019). Methane emissions from sources including agriculture, waste and industry are included in some offset credit schemes, including the CDM and at national level in Australia's Emissions Reductions Fund (Australian Climate Change Authority 2017) and the Chinese Certified Emission Reduction (CCER) scheme (Lo and Cong 2017).

Nitrous Oxide. N₂O emissions are produced by agricultural soil management, livestock waste management, fossil fuel combustion, and adipic acid and nitric acid production (US EPA 2019). Most N₂O emissions are not regulated and global emissions have been increasing. N₂O emissions by adipic and nitric acid plants in the EU are covered by the ETS (Winiwarter et al. 2018). N₂O emissions are included in some offset schemes. China, the United States, Singapore, Egypt, and Russia produce 86% of industrial N₂O emissions offering the potential for targeted mitigation action (US EPA 2019).

HFCs. Most HFCs are used as substitutes for ozone depleting substances. The Kigali Amendment (KA) to the Montreal Protocol will reduce HFC use by 85% by 2047 (UN Environment 2018). To help meet their KA commitments developed country parties have been implementing regulations to limit imports, production and exports of HFCs and to limit specific uses of HFCs.

The EU, for example, issues tradable quota for imports, production and exports of HFCs. Prices of HFCs have increased as expected (Kleinschmidt 2020) which has led to smuggling of HFCs into the EU (European Commission 2019b). HFC use has been slightly (1 to 6%) below the limit each year from 2015 through 2018 (EEA 2019). China and India released national cooling action plans in 2019, laying out detailed, cross-sectoral plans to provide sustainable, climate friendly, safe and affordable cooling (Dean et al. 2020).

PFCs, SF₆ and NF₃. With the exception of SF₆, these gases are emitted by industrial activities located in the European Economic Area (EEA) and a limited number (fewer than 30) of other countries. Regulations in Europe, Japan and the US focus on leak reduction as well as collection and reuse of SF₆ from electrical equipment. Other uses of SF₆ are banned in Europe (European Union 2014).

PFCs are generated during the aluminium smelting process if the alumina level in the electrolytic bath falls below critical levels (US EPA 2019). In Europe these emissions are covered by the EU ETS. The industry is eliminating the emissions through improved process control and a shift to different production processes.

The semiconductor industry uses HFCs, PFCs, SF₆ and NF₃ for etching and deposition chamber cleaning (US EPA 2019) and has a voluntary target of reducing GHG emissions 30% from 2010 by 2020 (World Semiconductor Council 2017). Europe regulates production, import, export, destruction and feedstock use of PFCs and SF₆, but not NF₃ (EEA 2019). In addition, fluorinated gases are taxed in Denmark, Norway, Slovenia and Spain.

<<END BOX 13.10 HERE>>

In some jurisdictions, the analysis of regulatory instruments is subject to an assessment on the basis of a shadow cost of carbon, which can influence the choice and design of regulations that affect GHG emissions (Box 13.11).

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Box 13.11 Shadow cost of carbon in regulatory analysis

In some jurisdictions, public administrations are required to apply a shadow cost of carbon to regulatory analysis

Traditionally, for example in widespread application in the United States, the shadow cost of carbon is calibrated to an estimate of the social cost of carbon as an approximation of expected future cumulative economic damage from a unit of greenhouse gas emissions (Metcalf and Stock 2017). Social cost of carbon is usually estimated using integrated assessment models and is subject to fundamental uncertainties (Pezzey 2019). An alternative approach, used for example in regulatory analysis in the United Kingdom since 2009, is to define a carbon price that is thought to be consistent with a particular targeted emissions outcome. This approach also requires a number of assumptions, including about future marginal costs of mitigation (Aldy et al. 2021).

END BOX 13.11 HERE

13.6.5 Other policy instruments

A range of other mitigation policy instruments are in use, often playing a complementary role to pricing and standards.

13.6.5.1 Transition support policies

Effective climate change mitigation can cause economic and social disruption where there is transformative change, such as changes in energy systems away from fossil fuels (See 13.9). Transitional assistance policies can be aimed to ameliorate effects on consumers, workers, communities, corporations or countries (Green and Gambhir 2020) in order to create broad coalitions of supporters or to limit opposition (Vogt-Schilb and Hallegatte 2017).

13.6.5.2 Information programs

Information programs, including energy efficiency labels, energy audits, certification, carbon labelling and information disclosure, are in wide use in particular for energy consumption. They can reduce GHG emissions by promoting voluntary technology choices and behavioural changes by firms and households.

Energy efficiency labelling is in widespread use, including for buildings, and for end users products including cars and appliances. Carbon labelling is used for example for food (Camilleri et al. 2019) and tourism (Gössling and Buckley 2016). Information measures also include specific information systems such as smart electricity meters (Zangheri et al. 2019). Chapters 5 and 9 provide detail.

Information programs can correct for a range of market failures related to imperfect information and consumer perceptions (Allcott 2016). Alongside mandatory standards (13.6.4), information programmes can nudge firms and consumers to focus on often overlooked operating cost reductions (Carroll et al. 2022). For example, consumers who are shown energy efficiency labels on average buy more energy efficient appliances than those who are not (Stadelmann and Schubert 2018). Information policies can also support the changing of social norms about consumption choices, which have been shown to raise public support for pricing and regulatory policy instruments (Gössling et al. 2020).

Energy audits provide tailored information about potential energy savings and benchmarking of best practices through a network of peers. Typical examples include the United States Better Buildings Challenge that has provided energy audits to support US commercial and industrial building owners, energy savings have been estimated at 18% to 30% (Asensio and Delmas 2017); and Germany's energy audit scheme for SMEs achieving reductions in energy consumption of 5 to 70 percent (Kluczek and Olszewski 2017).

Consumption-oriented policy instruments seek to reduce GHG emissions by changing consumer behaviour directly, via retailers or via the supply chain. Aspects that hold promise are technology lists, supply chain procurement by leading retailers or business associations, a carbon-intensive materials charge and selected infrastructure improvements (Grubb et al. 2020).

The information provided to consumers in labelling programs is often not detailed enough to yield best possible results (Davis and Metcalf 2016). Providing information about running costs tends to be more effective than providing data on energy use (Damigos et al. 2020). Sound implementation of labelling programs requires appropriate calculation methodology and tools, training and public awareness (Liang Wong and Krüger 2017). In systems where manufacturers self-report performance of their products, there tends to be misreporting and skewed energy efficiency labelling (Goeschl 2019).

A new form of information programs are financial accounting standards as frameworks to encourage or require companies to disclose how the transition risks from shifting to a low carbon economy and physical climate change impacts may affect their business or asset values (Chapter 15). The most prominent such standard was issued in 2017 by the Financial Stability Board's Task Force on Climate-related Financial Disclosures. It has found rapid uptake among regulators and investors (O'Dwyer and Unerman 2020).

Traditionally, corporate reporting has treated climate risks in a highly varied and often minimal way (Foerster et al. 2017). Disclosure of climate related risks creates incentives for companies to improve their carbon and climate change exposure, and ultimately regulatory standards for climate risk (Eccles and Krzus 2018). Disclosure can also reinforce calls for divestment in fossil fuel assets predominantly promoted by civil society organisations (Ayling and Gunningham 2017), raising moral principles and arguments about the financial risks inherent in fossil fuel investments (Green 2018; Blondeel et al. 2019).

13.6.5.3 Public procurement and investment

National, subnational and local governments determine many aspects of infrastructure planning, fund investment in areas such as energy, transport and the built environment, and purchase goods and services, including for government administration and military provisioning.

Public procurement rules usually mandate cost effectiveness but only in some cases allow or mandate climate change consideration in public purchasing, for example in EU public purchasing guidelines (Martinez Romera and Caranta 2017). Green procurement for buildings has been undertaken in Malaysia (Bohari et al. 2017). A paper cites Taiwan's green public procurement law, which has contributed to reduced emissions intensity (Tsai 2017). In practice, awareness and knowledge of 'green' public procurement techniques and procedures is decisive for climate-friendly procurement (Testa et al. 2016). Experiences in low-carbon infrastructure procurement point to procedures being tailored to concerns about competition, transaction costs and innovation (Kadefors et al. 2020).

Infrastructure investment decisions lock in high or low emissions trajectories over long periods. Low-emissions infrastructure can enable or increase productivity of private low-carbon investments (Jaumotte et al. 2021) and is typically only a little more expensive over its lifetime, but faces additional barriers including higher upfront costs, lack of pricing of externalities, or lack of information or aversion to novel products (Granoff et al. 2016). In low-income developing countries, where infrastructure has historically lagged developed countries, some of these hurdles can be exacerbated by overall more difficult conditions for public investment (Gurara et al. 2018).

Governments can also promote low-emissions investments through public-private partnerships and government owned ‘green banks’ that provide loans on commercial or concessional basis for environmentally friendly private sector investments (David and Venkatachalam 2019; Ziola et al. 2019). Public funding or financial guarantees such as contracts-for-difference can alleviate financial risk in the early stages of technology deployment, creating pathways to commercial viability (Bataille 2020).

Government provision can also play an important role in economic stimulus programs, including as implemented in response to the pandemic of 2020-21. Such programs can support low-emissions infrastructure and equipment, and industrial or business development (Elkerbout et al. 2020; Hainsch et al. 2020; Barbier 2020; Hepburn et al. 2020).

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Box 13.12 Technology and R&D policy

Private businesses tend to under-invest in R&D because of market failures (Geroski 1995), hence there is a case for governments to support research and technology development. A range of different policy instruments are used, including government funding, preferential tax treatment, intellectual property rules, and policies to support the deployment and diffusion of new technologies. Chapter 16 treats innovation policy in-depth.

END BOX 13.12 HERE

13.6.5.4 Voluntary agreements

Voluntary Agreements result from negotiations between governments and industrial sectors that commit to achieve agreed goals (Mundaca and Markandya 2016). When used as part of a broader policy framework, they can enhance the cost effectiveness of individual firms in attaining emission reductions while pricing or regulations drive participation in the agreement (Dawson and Segerson 2008).

Public voluntary programs, where a government regulator develops programs to which industries and firms may choose to participate on a voluntary basis, have been implemented in numerous countries. For example, the United States Environmental Protection Agency introduced numerous voluntary programmes with industry to offer technical support in promoting energy efficiency and emissions reductions, among other initiatives (United States Environmental Protection Agency 2017). A European example is the EU Ecolabel Award program (European Commission 2020b). Agreements for industrial energy efficiency in Europe (Cornelis 2019) and Japan (Wakabayashi and Arimura 2016) have been particularly effective in addressing information barriers and for smaller companies. The International Civil Aviation Organization’s CORSIA scheme (Prussi et al. 2021) is an example of an international industry-based public voluntary program.

Voluntary agreements are often implemented in conjunction with economic or regulatory instruments, and sometimes are used to gain insights ahead of implementation of regulatory standards, as in the case of energy efficiency PVPs in South Korea (Seok et al. 2021). In some cases, industries use voluntary agreements as partial fulfilment of a regulation (Rezessy and Bertoldi 2011; Langpap 2015). For example, the Netherlands have permitted participating industries to be exempt from certain energy taxes and emissions regulations (Veum 2018).

13.6.6 International interactions of national mitigation policies

One country's mitigation policy can impact other countries in various ways including changes in their GHG emissions (leakage), creation of markets for emission reduction credits, technology development and diffusion (spillovers), and reduction in the value of their fossil fuel resources.

13.6.6.1 Leakage effects

Compliance with a mitigation policy can affect the emissions of foreign sources via several channels over different time scales (Zhang and Zhang 2017) (also see Box 13.13). The effects may interact and yield a net increase or decrease in emissions. The leakage channel that is of most concern to policymakers is adverse international competitiveness impacts from domestic climate policies.

START BOX 13.13 HERE

Box 13.13 Possible sources of leakage

Competitiveness: Mitigation policy raises the costs and product prices of regulated sources which causes production to shift to unregulated sources, increasing their emissions.

Fossil fuel channel: Regulated sources reduce their fossil fuel use, which lowers fossil fuel prices and increases consumption and associated emissions by unregulated sources.

Land use channel: Mitigation policies that change land use lead to land use and emissions changes in other jurisdictions (Bastos Lima et al. 2019).

Terms of trade effect: Price increases for the products of regulated sources shift consumption to other goods, which raises emissions due to the higher output of those goods.

Technology channel: Mitigation policy induces low carbon innovation, which reduces emissions by sources that adopt the innovations that may include unregulated sources (Gerlagh and Kuik 2007).

Abatement resource effect: Regulated sources increase use of clean inputs, which reduces inputs available to unregulated sources and so limits their output and emissions (Baylis et al. 2014).

Scale channel: Changes to the output of regulated and unregulated sources affect their emissions intensities so emissions changes are not proportional to output changes (Antweiler et al. 2001).

Intertemporal channel: Capital stocks of all sources are fixed initially but change over time affecting the costs, prices, output and emissions of regulated and unregulated products.

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In principle, implementation of a mitigation policy in one country creates an incentive to shift production of tradable goods whose costs are increased by the policy to other countries with less costly emissions limitation policies (see Section 12.6.3 in Chapter 12). Such 'leakage' could to some extent negate emissions reductions in the first country, depending on the relative emissions intensity of production in both countries.

Ex ante modelling studies typically estimate significant leakage for unilateral policies to reduce emissions due to production of emissions intensive products such as steel, aluminium, and cement (Carbone and Rivers 2017). However, the results are highly dependent on assumptions and typically do not reflect policy designs specifically aimed at minimizing or preventing leakage (Fowlie and Reguant 2018).

Numerous *ex post* analyses, mainly for the EU ETS, find no evidence of any or significant adverse competitiveness impacts and conclude that there was consequently no or insignificant leakage (Branger et al. 2016; Koch and Basse Mama 2019; Venmans et al. 2020; FSR Climate 2019; Kuusi et al. 2020; aus dem

Moore et al. 2019; Verde 2020; Borghesi et al. 2020; Haites et al. 2018) (*medium evidence, medium agreement*). This is attributed to large allocations of free allowances to emissions-intensive, trade-exposed sources, relatively low allowance prices, the ability of firms in some sectors to pass costs on to consumers, energy's relatively low share of production costs, and small but statistically significant effects on innovation (Joltreau and Sommerfeld 2019). Few carbon taxes apply to emissions-intensive, trade-exposed sources (Timilsina 2018), so competitiveness impacts usually are not a particular concern.

Policies intended to address leakage include a border carbon adjustment (Ward et al. 2019; Ismer et al. 2020). A border carbon adjustment (BCA) imposes costs – a tax or allowance purchase obligation – on imports of carbon-intensive goods equivalent to those borne by domestic products possibly mirrored by rebates for exports (Böhringer et al. 2012; Fischer and Fox 2012; Zhang 2012; Böhringer et al. 2017c) (see also Chapter 14). A BCA faces the practical challenge of determining the carbon content of imports (Böhringer et al. 2017a) and the design needs to be consistent with WTO rules and other international agreements (Cosbey et al. 2019; Mehling et al. 2019). Model estimates indicate that a BCA reduces but does not eliminate leakage (Branger and Quirion 2014). No BCA has yet been implemented for international trade although such a measure is currently under consideration by some governments.

13.6.6.2 Market for emission reduction credits

A mitigation policy may allow the use of credits issued for emission reductions in other countries for compliance purposes (see also 13.6.3.4 on offset credits and Chapter 14 on international credit mechanisms). Creation of international markets for emission reduction credits tends to benefit other countries through financial flows in return for emissions credit sales (*medium evidence, high agreement*).

The EU, New Zealand and Switzerland allowed participants in their emissions trading systems to use credits issued under the Kyoto Protocol mechanisms, including the Clean Development Mechanism (CDM), for compliance. From 2008 through 2014 participants used 3.76 million imported credits for compliance of which 80% were CDM credits (Haites 2016).⁴ Use of imported credits has fallen to very low levels since 2014 (World Bank 2014; Shishlov et al. 2016).⁵

The Clean Development Mechanism (CDM) is the world's largest offset program (Chapter 14). From 2001 to 2019 over 7,500 projects with projected emission reductions in excess of 8,000 MtCO₂-eq were implemented in 114 developing countries using some 140 different emissions reduction methodologies (UNFCCC 2012; UNEP DTU Partnership 2020). Credits reflecting over 2,000 MtCO₂-eq of emission reductions by 3,260 projects have been issued. To address additionality and other concerns the CDM Executive Board frequently updated its approved project methodologies.

13.6.6.3 Technology spillovers

Mitigation policies stimulate low-carbon R&D by entities subject to those policies and by other domestic and foreign entities (FSR Climate 2019). Policies to support technology development and diffusion tend to have positive spillover effects between countries (see section 16.3) (*medium evidence, high agreement*).

Innovation activity in response to a mitigation policy varies by policy type (Jaffe et al. 2002) and stringency (Johnstone et al. 2012). In addition, many governments have policies to stimulate R&D, further increasing low-carbon R&D activity by domestic researchers. Emitters in other countries may adopt some of the new low-carbon technologies thus reducing emissions elsewhere. Technology development and diffusion is reviewed in Chapter 16.

FOOTNOTE ⁴ 2010 through 2014 for the New Zealand ETS.

FOOTNOTE ⁵ All three ETSs were modified after 2012 including provisions that affected compliance use of imported credits.

13.6.6.4 Value of fossil fuel resources

Fossil fuel resources are a significant source of exports, employment and government revenues for many countries. The value of these resources depends on demand for the fuel and competing supplies in the relevant international markets. Discoveries and new production technologies reduce the value of established resources. Mitigation policies that reduce the use of fossil fuels also reduce the value of these resources. A single policy in one country is unlikely to have a noticeable effect on the international price, but similar policies in multiple countries could adversely affect the value of the resources. For fossil fuel exporting countries, mitigation policies consistent with the Paris Agreement goals could result in greater costs from changes in fossil fuel prices due to lower international demand than domestic policy costs (Liu et al. 2020) (*medium evidence, high agreement*).

The impact on the value of established resources will be mitigated, to some extent, by the reduced incentive to explore for and develop new fossil fuel supplies. Nevertheless, efforts to lower global emissions will mean substantially less demand for fossil fuels, with the majority of current coal reserves and large shares of known gas and oil reserves needing to remain unused, with great diversity in impacts between different countries (McGlade and Ekins 2015) (See also Chapters 3, 6, 15).

Estimates of the potential future loss in value differ greatly. There is uncertainty about remaining future fossil fuel use under different mitigation scenarios, as well as future fossil fuel prices depending on extraction costs, market structures and policies. Estimates of total cumulative fossil fuel revenue lost range between US 5-67 trillion dollars (Bauer et al. 2015) with an estimate of the net present value of lost profit of around US 10 trillion dollars (Bauer et al. 2016). Policies that constrain supply of fossil fuels in the context of mitigation objectives could limit financial losses to fossil fuel producers (See also Chapter 14).

13.7 Integrated policy packages for mitigation and multiple objectives

Since AR5, the literature on climate policies and policy-making has expanded in two significant directions. First, there is growing recognition that mitigation policy occurs in the context of multiple climate and development objectives (Chapter 4). Different aspects of these linkages are discussed across the WGIII report, including concepts and framings (Section 1.6.2 in Chapter 1), shifting sustainable development pathways (Section 4.3 in Chapter 4 and Cross-chapter Box 5 in Chapter 4), cross-sectoral interactions (Sections 12.6.1 and 12.6.2 in Chapter 12), evidence of co-impacts (Section 17.3 in Chapter 17), links with adaptation (Section 4.4.2 in Chapter 4) and accelerating the transition (Section 13.9 in chapter 13 and Sections 17.1.1, 17.4.5 and 17.4.6 in Chapter 17). While the concept of development pathways is salient in all countries, it may particularly resonate with policymakers in developing countries focused on providing basic needs and addressing poverty and inequality, including energy poverty (Ahmad 2009; Fuso Nerini et al. 2019; Bel and Teixidó 2020; Caetano et al. 2020; Röser et al. 2020). Consequently, some countries may frame policies predominantly in terms of accelerating mitigation, while in others a multiple objectives approach linked to development pathways may dominate, depending on their specific socio-economic contexts and priorities, governance capacities (McMeekin et al. 2019) and perceptions of historical responsibility (Winkler and Rajamani 2014; Friman and Hjerpe 2015; Pan et al. 2017; Winkler et al. 2015).

Second, since AR5 there is growing attention to enabling transitions over time. Literature on socio-technical transitions, rooted in innovation studies, highlights the need for different policy focus at different stages of a transition (Geels et al. 2017b,a; Köhler et al. 2019) (also see Section 1.7.3 in Chapter 1). Other literature examines how broad patterns of development drive both social and mitigation outcomes through shifts in policies and a re-alignment of enabling conditions (Chapter 4). Explicit efforts to shift development pathways, for example by shifting patterns of energy demand and urbanisation, therefore offer broader mitigation opportunities (Cross-Chapter Box 5 in Chapter 4). Common to both approaches is an emphasis beyond the short term, and enabling longer-term structural shifts in economies and societies.

1 Taking these trends into account, Figure 13.6 outlines the climate policy landscape, and how it maps to
2 different parts of this Working Group III report. One axis of variation captures alternative framings of desired
3 outcomes in national policy-making – mitigation versus multiple objectives, while the second captures the
4 shift in policymaking from an initial focus on shifting incentives through largely individual policy
5 instruments, to explicit consideration of how policies and economy-wide measures, including those that shift
6 incentives, can combine to enable transitions. As a result, Figure 13.6 represents interconnected policy ideas,
7 but backed by distinct strands of literature. Notably, each of these categories is salient to climate policy-
8 making, although the balance may differ depending on country context.

9
10

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		Framing of Outcome	
		Enhancing Mitigation	Addressing Multiple Objectives of Mitigation and Development
Approach to Policy-making	Shifting Incentives	<p>“Direct Mitigation Focus” (Sec. 13.6; 2.8)</p> <p><i>Objective:</i> Reduce GHG emissions now</p> <p><i>Literature:</i> How to design and implement policy instruments, with attention to distributional and other concerns</p> <p><i>Examples:</i> carbon tax, cap and trade, border carbon adjustment, disclosure policies</p>	<p>“Co-benefits” (Sec. 17.3; 5.6.2; 12.4.4)</p> <p><i>Objective:</i> Synergies between mitigation and development</p> <p><i>Literature:</i> Scope for and policies to realise synergies and avoid trade-offs across climate and development objectives.</p> <p><i>Examples:</i> Appliance standards, fuel taxes, community forest management, sustainable dietary guidelines, green building codes, packages for air pollution, packages for public transport</p>
	Enabling Transition	<p>“Socio-technical transitions” (Sec. 1.7.3; 5.5; 10.8; 6.7; Cross-Chapter Box 12 in Chapter 16)</p> <p><i>Objective:</i> Accelerate low-carbon shifts in socio-technical systems</p> <p><i>Literature:</i> Understand socio-technical transition processes, integrated policies for different stages of a technology ‘S curve’ and explore structural, social and political elements of transitions.</p> <p><i>Examples:</i> Packages for renewable energy transition and coal phase-out; diffusion of electric vehicles, process and fuel switching in key industries.</p>	<p>“System transitions to shift development pathways” (Sec. 11.6.6; 7.4.5; 13.9; 17.3.3; Cross-Chapter Box 5 in Chapter 4; Cross-Chapter Box 9 in Chapter 13)</p> <p><i>Objective:</i> Accelerate system transitions and shift development pathways to expand mitigation options and meet other development goals</p> <p><i>Literature:</i> Examines how structural development patterns and broad cross-sector and economy wide measures drive ability to mitigate while achieving development goals through integrated policies and aligning enabling conditions.</p> <p><i>Examples:</i> Packages for sustainable urbanisation, land-energy-water nexus approaches, green industrial policy, regional just transition plans</p>

Figure 13.6 Mapping the landscape of climate policy

This section particularly focuses on climate policymaking for transition – both socio-technical transitions and shifts in development pathways, while direct climate policies and co-benefits are addressed in other parts of the report, as indicated in Figure 13.6. This section focuses in particular on lessons for designing policy packages for transitions, and is complemented by discussion in Section 13.8 on integration between

adaptation and mitigation, and Section 13.9 on economy-wide measures and the broader enabling conditions necessary to accelerate mitigation.

13.7.1 Policy packages for low carbon sustainable transitions

Since AR5 an emergent multi-disciplinary literature on policy packages, or policy mixes, has emerged that examine how policies may be combined for sustainable low-carbon transitions (Rogge and Reichardt 2016; Kern et al. 2019). This literature covers various sectors including: energy (Rogge et al. 2017); transport (Givoni et al. 2013); industry (Scordato et al. 2018); agri-food (Kalfagianni and Kuik 2017); and forestry (Scullion et al. 2016).

A central theme in the literature is that transitions require policy interventions to address system level changes, thereby going beyond addressing market failures in two ways. First, structural system changes are needed for low-carbon transitions, including building low-carbon infrastructure (or example aligning electricity grids and storage with the requirements of new low-carbon technology), and adjusting existing institutions to low-carbon solutions (for example by reforming electricity market design) (Bak et al. 2017; Patt and Lilliestam 2018). Second, explicit transformational system changes are necessary, including efforts at directing transformations, such as clear direction setting through the elaboration of shared visions, and coordination across diverse actors across different policy fields, such as climate and industrial policy, and across governance levels (Uyarra et al. 2016; Nemet et al. 2017).

There are some specific suggestions for policy packages: Van den Bergh et al. (2021) suggest that innovation support and information provision combined with a carbon tax or market, or adoption subsidy leads to both effective and efficient outcomes. Others question the viability of universally applicable policy packages, and suggest packages need to be tailored to local objectives (del Río 2014). Consequently, much of the literature focuses on broad principles for design of policy packages and mixes, as discussed below.

Comprehensiveness, balance and consistency are important criteria for policy packages or mixes (Carter et al. 2018; Santos-lacueva and González 2018; Rogge and Reichardt 2016; Scobie 2016) (*robust evidence, high agreement*). Comprehensiveness assesses the extensiveness of policy packages, including the breadth of system and market failures it addresses (Rogge and Reichardt 2016). For example, instrument mixes that include only moderate carbon pricing, but are complemented by policies supporting new low-carbon technologies and a moratorium on coal-fired power plants may not only be politically more feasible than stringent carbon pricing alone, but may also limit efficiency losses and lower distributional impacts (Bertram et al. 2015b). Balance captures whether policy instruments are deployed in complementary ways given their different purposes, combining for example technology-push approaches such as public R&D with demand-pull approaches such as an energy tax. A combination of technology-push and demand-pull approaches has been shown to support innovation in energy efficient technologies in OECD countries (Costantini et al. 2017). Consistency addresses the alignment of policy instruments among each other and with the policy strategy, which may have multiple and not always consistent objectives (Rogge 2019). Consistency of policy mixes has been identified as an important driver of low-carbon transformation, particularly for renewable energy (Lieu et al. 2018; Rogge and Schleich 2018). Box 13.14 summarises the economics literature on how policies interact, to inform design of packages.

START BOX 13.14 HERE

Box 13.14 Policy interactions of carbon pricing and other instruments

The economics literature provides insights on policy interactions among the multiple overlapping policies that directly or indirectly affect GHG emissions, including when different levels of government are involved. Multiple mitigation policies can be theoretically justified if there are multiple objectives or market failures

or to achieve distributional objectives and increase policy effectiveness (Stiglitz 2019). Examples include the coexistence of the EU ETS with vehicle emission standards and energy efficiency standards (Rey et al. 2013), and the fact that 85% of the emissions covered by California's ETS are also subject to other policies (Bang et al. 2017; Mazmanian et al. 2020). Policy interactions are also widespread among energy efficiency policies (Wiese et al. 2018).

Interactive effects can influence the costs of policy outcomes. With multiple overlapping and possibly non-optimal policies, the effect on total cost is not clear. A modelling study of US mitigation policy finds the costs of using heterogeneous subnational policies to achieve decarbonisation targets is 10 % higher than national uniform policies (Peng et al. 2021). When multiple policy goals are sought, such as mitigation and R&D, a portfolio of optimal policies achieves the goals at significantly lower cost (Fischer and Newell 2008). In some cases, overlapping mitigation policies can raise the cost of mitigation (Böhringer et al. 2016) while lowering the cost of achieving other goals, such as energy efficiency improvements and expansion of renewable energy (Rosenow et al. 2016; Lecuyer and Quirion 2019). It is possible that one or more of the policies is made redundant (Aune and Golombek 2021).

While overlapping policies may raise the cost of mitigation, they increase the likelihood of achieving an emission reduction goal. Policy overlap will lead to different optimal carbon prices across jurisdictions (Bataille et al. 2018b). The existence of overlapping policies will usually increase administrative and compliance costs. However, ex-post analysis shows that transaction costs of mitigation policies are low and are not a decisive factor in policy choice (Joas and Flachsland 2016).

The effectiveness, as well as economic and distributional effects, of a given mitigation policy will depend on the interactions among all the policies that affect the targeted emissions. Because a market instrument interacts with every other policy that affects the targeted emissions, interactions tend to be more complex for market instruments than for regulations that mandate specific emission reduction actions by targeted sources independent of other policies.

An ETS scheme implemented with existing mitigation policies may be subject to the 'waterbed effect' - emission reductions undertaken by some emitters may be offset by higher emissions by other ETS participants due to overlapping mitigation policies (Schatzki and Stavins 2012). This reduces the impact of the ETS and lowers carbon trading prices (Perino 2018). However *ex post* assessments find net emissions reductions. ETS design features such as a price floor and 'market stability reserve' can limit the waterbed effect (Edenhofer et al. 2017; Kollenberg and Taschini 2019; Narassimhan et al. 2018; FSR Climate 2019).

A carbon tax, unlike the allowance price, does not change in response to the effect of overlapping policies but those policies may reduce emissions by sources subject to the tax and so lower the emission reductions achieved by the tax (Goulder and Stavins 2011).

Policy interactions often occur with the introduction of new mitigation policy instruments. For example, in China several sub-national ETSs exist alongside policies to reduce emission intensity, increase energy efficiency and expand renewable energy supplies (Zhang 2015). These quantity-based ETSs interact with many other policies (Duan et al. 2017), for example price-based provincial carbon intensity targets (Qian et al. 2017). They also interact with the level of market regulation; for example, full effectiveness of emissions pricing would require electricity market reform in China (Teng et al. 2017).

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Policy packages aimed at low carbon transitions are more effective when they include elements to enhance the phase out of carbon-intensive technologies and practices – often called exnovation -- in addition to supporting low carbon niches (Kivimaa and Kern 2016; David 2017). Such policies include stringent carbon pricing; changes in regime rules such as design of electricity markets; reduced support for dominant regime technologies such as removing tax deductions for private motor transport based on internal combustion

engines; and changes in the balance of representation of incumbents versus new entrants in deliberation and advisory bodies. For example, CGE modelling for China's fossil fuel subsidy reform found that integrating both creation and destabilization policies is able to reduce rebound effects and make the policy mix more effective (Li et al. 2017). Sweden's pulp and paper industry shows that destabilisation policies including deregulation of the electricity market and a carbon tax were an important complement to support policies (Scordato et al. 2018), and other studies show complementary results for Finland's building sector (Kivimaa et al. 2017b) and Norway's transport and energy sector (Ćetković and Skjærseth 2019).

Policy packages for low-carbon transitions are more successful if they take into account the potential for political contestation and resistance from incumbents who benefit from high-carbon systems (Roberts et al. 2018; Kern and Rogge 2018; Rosenbloom 2018; Geels 2014) (*medium evidence, high agreement*). To do so, policies can be sequenced so as to address political obstacles, for example, by initially starting with policies to facilitate the entry of new firms engaged in low-carbon technologies (Pahle et al. 2018). Such policies can generate positive feedbacks by creating constituencies for continuation of those policies, but need to be designed to do so from the outset (Edmondson et al. 2019, 2020). For example, supporting renewable energies through feed-in tariffs can buttress coalitions for more ambitious climate policy, such as through carbon pricing (Meckling et al. 2015). However, negative policy feedback may also arise from ineffective policy instruments that lose public support, or create concentrated losses that arouse oppositional coalitions (Edmondson et al. 2019). Feedback loops can operate through changes in resources available to actors; changes in expectations; and changes in government capacities, (Edmondson et al. 2019).

Another promising strategy is to design short term policies which might help to provide later entry points for more ambitious climate policy (Kriegler et al. 2018) and supportive institutions. The sequencing of policies can build coalitions for climate policy, starting with green industrial policy (e.g. supporting renewable energies through feed-in tariffs) and introducing or making carbon pricing more stringent when supportive coalitions of stringent climate policy have been formed (Meckling et al. 2015). Similarly, investing in supportive institutions, with competencies compatible with low-carbon futures, are a necessary supportive element of transitions (Domorenok et al. 2021; Rosenbloom et al. 2019; Pahle et al. 2018).

13.7.2 Policy integration for multiple objectives and shifting development pathways

This sub-section assesses policy integration and packages required to enable shifts in development pathways, with a particular focus on sectoral scale transitions. However, because shifting development pathways requires broad transformative change, it complements discussion on broader shifts in policy-making such as fiscal, educational, and infrastructure policies (Cross-Chapter Box 5 in Chapter 4) and to the alignment of a wide range of enabling conditions required for system transitions (Section 13.9).

In many countries, and particularly when climate policy occurs in the context of sustainable development, policymakers seek to address climate mitigation in the context of multiple economic and social policy objectives (Halsnæs et al. 2014; Campagnolo and Davide 2019; Cohen et al. 2019) (*medium evidence, robust agreement*). Studies suggest that co-benefits of climate policies are substantial, especially in relation to air quality, and can yield better mitigation and overall welfare, yet these are commonly overlooked in policy-making (Nemet et al. 2010; Ürge-Vorsatz et al. 2014; von Stechow et al. 2015; Mayrhofer and Gupta 2016; Roy et al. 2018; Karlsson et al. 2020; Bhardwaj et al. 2019) (*robust evidence, robust agreement*). Other studies have shown the existence of strong complementarities between the SDGs and realisation of NDC pledges by countries (McCollum et al. 2018). An explicit attention to development pathways can enhance the scope for mitigation, by paying explicit attention to development choices that lock-in or lock-out opportunities for mitigation, such as around land use and infrastructure choices (Cross-Chapter Box 5 in Chapter 4). While the pay-offs are considerable to an approach to mitigation that takes into account linkages to multiple objectives and the opportunity to shift development pathways, there are also associated challenges with implementing this approach to policymaking.

1 First, spanning policy arenas and addressing multiple objectives places considerable requirements of
2 coordination on the policy-making process (Howlett and del Rio 2015; Obersteiner et al. 2016). Climate
3 policy integration suggests several steps should precede actual policy-formulation, beginning with a clear
4 articulation of the policy frame or problem statement (Adelle and Russel 2013; Candel and Biesbroek 2016).
5 For example, a greenhouse gas limitation framework versus a co-benefits framing would likely yield
6 different policy approaches. It is then useful to identify the range of actors and institutions involved in climate
7 governance – the policy subsystem, the goals articulated, the level at which goals are articulated and the links
8 with other related policy goals such as energy security or energy access (Candel and Biesbroek 2016). The
9 adoption of specific packages of policy instruments should ideally follow these prior steps that define the
10 scope of the problem, actors and goals.

11 In practice, integration has to occur in the context of an already existing policy structure, which suggests the
12 need for finding windows of opportunity to bring about integration, which can be created by international
13 events, alignments with domestic institutional procedures, and openings created by policy entrepreneurs
14 (Garcia Hernandez and Bolwig 2020). Integration also has to occur in the context of existing organisational
15 routines and cultures, which can pose a barrier to integration (Uittenbroek 2016). Experience from the EU
16 suggests that disagreements at the level of policy instruments are amenable to resolution by deliberation,
17 while normative disagreements at the level of objectives require a hierarchical decision structure (Skovgaard
18 2018). As this discussion suggests, the challenge of integration operates in two dimensions: horizontal --
19 between sectoral authorities such as ministries or policy domains such as forestry -- or vertical -- either
20 between constitutional levels of power or within the internal mandates and interactions of a sector (Howlett
21 and del Rio 2015; Di Gregorio et al. 2017). There are also important temporal dimensions to policy goals, as
22 policy and benchmarks have to address not just immediate success but also indications of future
23 transformation (Dupont and Oberthür 2012; Dupont 2015).

24 Second policy-making for shifting development pathways has to account for inherent uncertainties in future
25 development paths (Moallemi and Malekpour 2018; Castrejon-Campos et al. 2020). These uncertainties may
26 be greater in developing countries that are growing rapidly and where structural features of the economy
27 including infrastructure and urbanisation patterns are fluid. For example, reviews of modelling studies of
28 Chinese (Grubb et al. 2015) and Indian emissions futures (Spencer and Dubash 2021) find that differences
29 in projections can substantially be accounted for by alternative assumptions about future economic structural
30 shifts. Consequently, an important design consideration is that policy packages should be robust, that is,
31 perform satisfactorily for all key objectives under a broad range of plausible futures (Castrejon-Campos et
32 al. 2020; Kwakkel et al. 2016; Maier et al. 2016). Such an approach to decision making can be contrasted
33 with one that tries to design an optimal policy package for the “best guess” future scenario (Maier et al.
34 2016). Moreover, policy packages can usefully be adapted dynamically to changing circumstances as part of
35 the policy process (Haasnoot et al. 2013; Maier et al. 2016; Hamarat et al. 2014) including by using
36 exploratory modelling techniques that allow comparison of trade-offs across alternative future scenarios
37 (Hamarat et al. 2014). Another approach is to link quantitative models with a participatory process that
38 enables decision-makers to test the implications of alternative interventions (Moallemi and Malekpour 2018).
39 Rosenbloom et al. (2019) suggest that because policy mixes should adapt to changing circumstances, instead
40 of stability of a particular mix, transitions require embedding policies within a long-term orientation toward
41 a low-carbon economy, including a transition agenda, social legitimacy for this agenda, and an appropriate
42 ecosystem of institutions.

43 Third, achieving changes in development pathways requires engaging with place-specific context. It requires
44 attention to existing policies, political interests that may gain or lose from a transition, and locally specific
45 governance enablers and disablers. As a result, while there may be approaches that carry over from one
46 context to another, implementation requires careful tailoring of transition approaches to specific policy and
47 governance contexts. Cross-Chapter Box 9 in this chapter summarises case studies of sectoral transitions

from other chapters in this report (Chapters 5-12) to illustrate this complexity. Broader macro-economic transformative shifts are discussed in more detail in Section 13.9.

Common to all the sectoral cases in Cross-Chapter Box 9 is a future-oriented vision of sectoral transition often focused on multiple objectives, such as designing tram-based public transport systems in Bulawayo, Zimbabwe to simultaneously stimulate urban centers, create jobs and enable low carbon transportation. Sectoral transitions are enabled by policy mixes that bring together different combinations of instruments – including regulations, financial incentives, convening, education and outreach, voluntary agreements, procurement and creation of new institutions – to work together in a complementary manner. The effectiveness of a policy mix depends on conditions beyond design considerations and also rests on the larger governance context within which sector transitions occur, which can include enabling and disabling elements. Enabling factors illustrated in Cross-Chapter Box 9 include strong high level political support, for example to address deforestation in Brazil despite powerful logging and farmer interests, or policy design to win over existing private interests, for example, by harnessing distribution networks of kerosene providers to new LPG technology in Indonesia. Disabling conditions include local institutional contexts, such as the lack of tree and land tenure in Ghana, which, along with the monopoly of the state marketing board, posed obstacles to Ghana's low carbon cocoa transition. These examples emphasize the importance of attention to local context if policy integration and the design of policy mixes are to effectively lead to transitions guided by multiple climate and development objectives.

START CROSS-CHAPTER BOX 9 HERE

Cross-Chapter Box 9: Case studies of integrated policymaking for sector transitions

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Real world sectoral transitions reinforce critical lessons on policy integration: a high-level strategic goal (Column A), the need for a clear sector outcome framing (column B), a carefully coordinated mix of policy instruments and governance actions (column C), and the importance of context-specific governance factors (column D). Illustrative examples, drawn from sectors, help elucidate the complexity of policymaking in driving sectoral transitions.

Cross-Chapter Box 9, Table 1 Case studies of integrated policymaking for sector transitions

A. Illustrative Case	B. Objective	C. Policy mix	D. Governance Context	
			Enablers	Barriers
Shift in mobility service provision in Kolkata, India [Box 5.8]	<ul style="list-style-type: none"> - Improve system efficiency, sustainability and comfort - Shift public perceptions of public transport 	<ul style="list-style-type: none"> - Strengthen co-ordination between modes - Formalize and green auto-rickshaws - Procure fuel efficient, comfortable low floor AC buses - Ban cycling on busy roads - Deploy policy actors as change-agents, mediating between interest groups 	<ul style="list-style-type: none"> - Cultural norms around informal transport sharing, linked to high levels of social trust - Historically crucial role of buses in transit - App-cab companies shifting norms and formalizing mobility sharing - Digitalization and safety on board 	<ul style="list-style-type: none"> - Complexity: multiple modes with separate networks and meanings - Pushback from equity-focused social movements against 'premium' fares, cycling ban
LPG Subsidy ("Zero Kero") Program, Indonesia [Box 6.3]	Decrease fiscal expenditures on kerosene subsidies for cooking	<ul style="list-style-type: none"> - Subsidize provision of Liquefied Petroleum Gas (LPG) cylinders and initial equipment - Convert existing kerosene suppliers to LPG suppliers 	<ul style="list-style-type: none"> - Provincial Government and industry support in targeting beneficiaries and implementation - Synergies in kerosene and LPG distribution infrastructures 	<ul style="list-style-type: none"> - Continued user preference for traditional solid fuels - Reduced GHG benefits as subsidy shifted between fossil fuels
Action Plan for Prevention and Control of Deforestation in the Legal Amazon, Brazil [Box 7.9]	Control deforestation and promote sustainable development	<ul style="list-style-type: none"> - Expand protected areas; homologation of indigenous lands - Improve inspections, satellite-based monitoring - Restrict public credit for enterprises and municipalities with high deforestation rates - Set up a REDD+ mechanism (Amazon Fund) 	<ul style="list-style-type: none"> - Participatory agenda-setting process - Cross-sectoral consultations on conservation guidelines - Mainstreaming of deforestation in government programs and projects 	<ul style="list-style-type: none"> - Political polarization leading to erosion of environmental governance - Reduced representation & independence of civil society in decision-making bodies - Lack of clarity around land ownership
Climate smart cocoa (CSC) production, Ghana [Box 7.12]	<ul style="list-style-type: none"> - Promote sustainable intensification of cocoa production - Reduce deforestation - Enhance incomes & adaptive capacities 	<ul style="list-style-type: none"> - Distribute shade tree seedlings - Provide access to agronomic information and agro-chemical inputs - Design a multi-stakeholder program including MNCs, farmers and NGOs 	<ul style="list-style-type: none"> - Local resource governance mechanisms ensuring voice for smallholders - Community governance allowed adapting to local context - Private sector role in popularising CSC 	<ul style="list-style-type: none"> - Lack of secure tenure (tree rights) - Bureaucratic & legal hurdles to register trees - State monopoly on cocoa marketing, export

Coordination mechanism for joining fragmented urban policymaking in Shanghai, China [Box 8.3]	Integrate policymaking across objectives, towards low-carbon urban development	<ul style="list-style-type: none"> - Combine central targets and evaluation with local flexibility for initiating varied policy experiments - Establish a local leadership team for coordinating cross-sectoral policies involving multiple institutions - Create a direct program fund for implementation and capacity-building 	<ul style="list-style-type: none"> - Strong vertical linkages between Central and local levels - Mandate for policy learning to inform national policy - Experience with mainstreaming mitigation in related areas (e.g. air pollution) 	<ul style="list-style-type: none"> - Challenging starting point - low share of RE, high dependency on fossil fuels - Continued need for high investments in a developing context
Policy package for building energy efficiency, EU [Box SM 9.1]	Reduce energy consumption, integrating RE and mitigating GHG emissions from buildings	<ul style="list-style-type: none"> - Energy performance standards, set at nearly zero energy for new buildings - Energy performance standards for appliances - Energy performance certificates shown during sale - Long Term Renovation Strategies 	<ul style="list-style-type: none"> - Binding EU-level targets, directives and sectoral effort sharing regulations - Supportive urban policies, coordinated through city partnerships - Funds raised from allowances auctioned under ETS 	<ul style="list-style-type: none"> - Inadequate local technical capacity to implement multiple instruments - Complex governance structure leading to uneven stringency
African Electromobility-Trackless trams with solar in Bulawayo and e-motorbikes in Kampala [Box 10.4]	<ul style="list-style-type: none"> - Leapfrog into a decarbonized transport future - Achieve multiple social benefits beyond mobility provision 	<ul style="list-style-type: none"> - Develop urban centres with solar at station precincts - Public-private partnerships for financing - Sanction demonstration projects for new electric transit and new electric motorbikes (for freight) 	<ul style="list-style-type: none"> - 'Achieving SDGs' was an enabling policy framing - Multi-objective policy process for mobility, mitigation and manufacturing - Potential for funding through climate finance - Co-benefits such as local employment generation 	<ul style="list-style-type: none"> - Economic decline in the first decade of the 21st century - Limited fiscal capacity for public funding of infrastructure - Inadequate charging infrastructure for e-motorbikes
Initiative for a climate-friendly industry in North Rhine Westphalia (NRW), Germany [Box 11.3]	- Collaboratively develop innovative strategies towards a net zero industrial sector, while securing competitiveness	<ul style="list-style-type: none"> - Build platform to bring together industry, scientists and government in self-organized innovation teams - Intensive cross-branch cooperation to articulate policy/infrastructure needs 	<ul style="list-style-type: none"> - NRW is Germany's industrial heartland, with an export-oriented industrial base - Established govt.-industry ties - Active discourse between industry and public 	- Compliance rules preventing in-depth co-operation
Food2030 Strategy, Finland [Box 12.2]	<ul style="list-style-type: none"> - Local, organic and climate friendly food production - Responsible and healthy food consumption - A competitive food supply chain 	<ul style="list-style-type: none"> - Target funding and knowledge support for innovations - Apply administrative means (legislation, guidance) to increase organic food production and procurement - Use education and information instruments to shift behaviour (media campaigns, websites) 	<ul style="list-style-type: none"> - Year-long deliberative stakeholder engagement process across sectors - Institutional structures for agenda-setting, guiding policy implementation and reflexive discussions 	<ul style="list-style-type: none"> - Weak role of integrated impact assessments to inform agenda-setting - Monitoring and evaluation close to ministry in charge - Lack of standardized indicators of food system sustainability

END CROSS-CHAPTER BOX 9 HERE**13.8 Integrating adaptation, mitigation and sustainable development**

There is growing consensus that integration of adaptation and mitigation will advance progress towards sustainable development, and that ambitious mitigation efforts will reduce the need for adaptation in the long term (IPCC 2014a) (*robust evidence, high agreement*). There is no level of mitigation, however, that will completely erase the need for adaptation to climate change (Mauritsen and Pincus 2017) (*robust evidence, high agreement*). It is therefore urgent to design and implement a multi-objective policy framework for mitigation, adaptation, and sustainable development that considers issues of equity and long-term developmental pathways across regions (Jordan et al. 2018a; Mills-Novoa and Liverman 2019; Wang and Chen 2019) (*robust evidence, high agreement*). This section explores the logic behind the integration of adaptation and mitigation in practice (Section 13.8.1), the approaches to this integration including climate-resilient pathways, ecosystem-based solutions, and a nexus approach (Section 13.8.2); examples of the adaptation and mitigation relationships and linkages (Section 13.8.3); and enabling and disabling factors for governance of mitigation and adaptation.

13.8.1 Synergies between adaptation and mitigation

Integrated climate-development actions require a context-specific understanding of synergies and trade-offs with other policy priorities (see Figure 13.6) with the aim of implementing mitigation/adaptation policies that reduce GHG emissions while simultaneously strengthening resilience and reducing vulnerability (Klein et al. 2005; IPCC 2007; Mills-Novoa and Liverman 2019; Solecki et al. 2019; Zhao et al. 2018) (*robust evidence, high agreement*). Efficient, equitable and inclusive policies which also acknowledge and contribute directly to other pressing priorities such reducing poverty, improving health, providing access to clean water, and fostering sustainable consumption and production practices are helpful for mitigation/adaptation goals (Landauer et al. 2019; Grafakos et al. 2020) (*robust evidence, high agreement*).

Adaptation and mitigation are deeply linked in practice – at the local level, for instance, asset managers address integrated low-carbon resilience to climate change impacts and urban planners do the same (Ürge-Vorsatz et al. 2018; Grafakos et al. 2020) (see Table 13.3 for details). Similarly, ecosystem-based (or nature-based) solutions, may generate co-benefits by simultaneously sinking carbon, cooling urban areas through shading, purifying water, improving biodiversity, and offering recreational opportunities that improve public health (Raymond et al. 2017). Accurately identifying and qualitatively or quantitatively assessing these co-benefits (Leiter and Pringle 2018; Leiter et al. 2019; Stadelmann et al. 2014)– is central to an integrated adaptation and mitigation policy evaluation.

Some studies press the need to consider the complex ways that power and interests influence how collective decisions are made, and who benefits from and pays for these decisions, of climate policy and to be aware of unintended consequences, especially for vulnerable people living under poor conditions (Mayrhofer and Gupta 2016; De Oliveira Silva et al. 2018). The specific adaptation and mitigation linkages will differ by country and region, as illustrated by Box 13.15.

START BOX 13.15 HERE**Box 13.15 Adaptation and mitigation synergies in Africa**

Synergies between mitigation and adaptation actions and sustainable development that can enhance the quality and pace of development in Africa exist at both sectoral and national levels. Available data on NDCs show the top mitigation priorities in African countries include energy, forestry, transport and agriculture and waste, and adaptation priorities focus on agriculture, water, energy and forestry. The energy sector dominates in mitigation actions and the agricultural sector is the main focus of adaptation measures, with the latter sector being a slightly larger source of greenhouse gases than the former (Mbeva et al. 2015; African Development Bank 2019; Nyiwul 2019).

Renewable energy development can support synergies between mitigation and adaptation by stimulating local and national economies through microenterprise development; providing off-grid affordable and accessible solutions; and contributing to poverty reduction through increased locally available resource use and employment and increased technical skills (Dal Maso et al. 2020; Nyiwul 2019). The Paris Agreement's technology transfer and funding mechanisms could reduce renewable energy costs and providing scale economics to local economies.

Barriers to achieving these synergies include the absence of suitable macro- and micro- level policy environments for adaptation and mitigation actions; coherent climate change policy frameworks and governance structures to support adaptation; institutional and capacity deficiencies in climate and policy research such as on data integration and technical analysis; and the high financial needs associated with the cost of mitigation and adaptation (African Development Bank 2019; Nyiwul 2019). Strengthening of national institutions and policies can support maximising synergies and co-benefits between adaptation and mitigation to reduce silos and redundant overlaps, increase knowledge exchange at the country and regional levels, and support engagement with bilateral and multilateral partners and mobilising finance through the mechanisms available (African Development Bank 2019).

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13.8.2 Frameworks that enable the integration of adaptation and mitigation

The 5th Assessment report of the IPCC emphasised the importance of climate-resilient pathways -- development trajectories that combine adaptation and mitigation through specific actions to achieve the sustainable development goals (Prasad et al. 2009; Lewison et al. 2015; Fankhauser and McDermott 2016; Romero-Lankao et al. 2016; Solecki et al. 2019) -- from the household to the state level, since risks and opportunities vary by location and the specific local development context (IPCC 2014b; Denton et al. 2015) (*robust evidence, high agreement*).

Synergies between adaptation and mitigation are included in many of the NDCs submitted to the UNFCCC, as part of overall low-emissions climate-resilient development strategies (UNFCCC Secretariat 2016). A majority of developing countries have agreed to develop National Adaptation Plans (NAPs) in which many initiatives contribute simultaneously to the SDGs (Schipper et al. 2020) as well to mitigation efforts (Hönle et al. 2019; Atteridge et al. 2020). For example, developing countries recognize that adaptation actions in sectors such as agriculture, forestry and land use management can reduce GHGs. Nevertheless, other more complex trade-offs also exist between bioenergy production or reforestation and the land needed for agricultural adaptation and food security (African Development Bank 2019; Hönle et al. 2019; Nyiwul 2019, see Chapter 7). For some of the Small Islands Development States (SIDS), forestry and coastal management, including mangrove planting, saltmarsh and seagrass are sectors that intertwine both mitigation and adaptation (Atteridge et al. 2020; Duarte et al. 2013). Integrated efforts also occur at the city level, such as the Climate Change Action Plan of Wellington City, which includes enhancing forest sinks to increase carbon sequestration while at the same time protecting biodiversity and reducing groundwater runoff as rainfall increases (Grafakos et al. 2019).

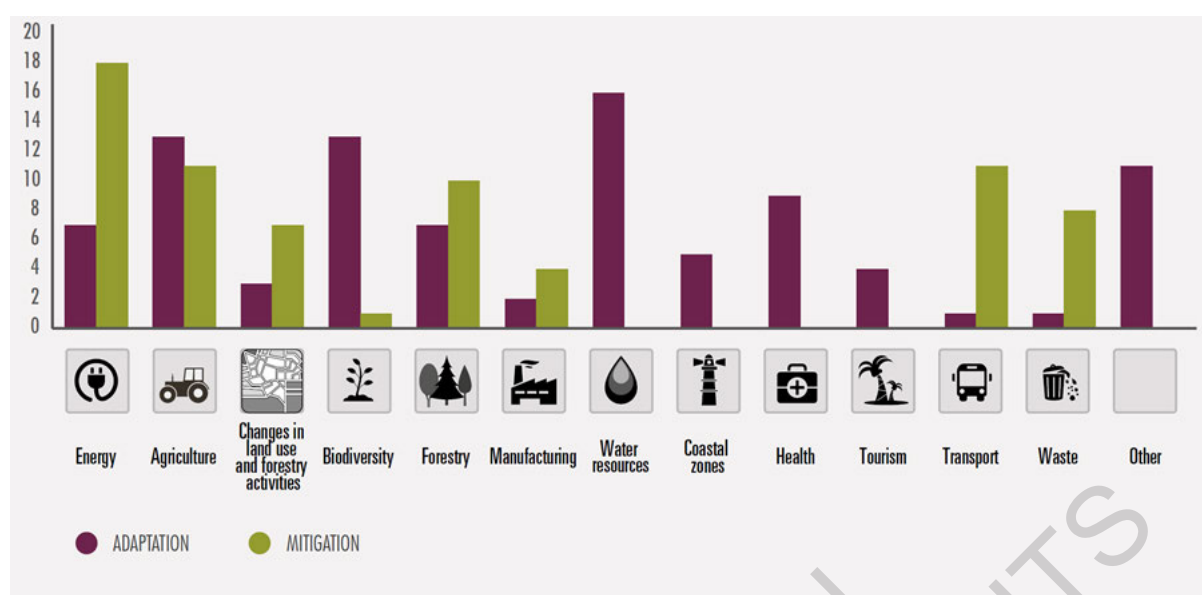
To fully maximise their potential co-benefits and trade-offs of integrating adaptation and mitigation, these should be explicitly sought, rather than accidentally discovered (Spencer et al. 2017; Berry et al. 2015), and policies designed to account for both (Caetano et al. 2020) (*robust evidence, high agreement*). For example, the REDD+ initiative focus on mitigation by carbon sequestration was set up to provide co-benefits such as: nature protection, political inclusion, monetary income, economic opportunities. However, some unintended trade-offs may have occurred such as physical displacement, loss of livelihoods, increased human–wildlife conflicts, property claims, food security concerns, and an unequal distribution of benefits to local population groups (Bushley 2014; Duguma et al. 2014a; Gebara et al. 2014; Anderson et al. 2016; Di Gregorio et al. 2016, 2017; Kongsager and Corbera 2015). Ultimately, ecosystem (or nature-based) strategies, such as the use of wetlands to create accessible recreational areas that improve public health while improving biodiversity, sinking carbon and protecting neighbourhoods from extreme flooding events, may lead to more efficient and cost-effective policies (Locatelli et al. 2011; Klein et al. 2005; Mills-Novoa and Liverman 2019; Kongsager et al. 2016).

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Box 13.16 Latin America region adaptation linking mitigation: REDD+ lessons

Thirty-three countries in the Latin American region have submitted their NDCs, and 70% of their initiatives have included mitigation and adaptation options focusing on sustainable development (Bárcena et al. 2018; Kissinger et al. 2019). However, most of these policies are disconnected across sectors (Loaiza et al. 2017; Locatelli et al. 2017). National governments have identified their relevant sectors as: energy, agriculture, forestry, land-use change, biodiversity, and water resources (see Figure 1 below). The region houses 57% of the primary forest of the planet. REDD+ aims to reduce GHG while provide ecosystems services to vulnerable communities (Bárcena et al. 2018). Lessons from successful REDD+ programs include the benefits of a multilevel structure from international to national down to strong community organization, as well as secure resources funding, with most of the projects relying on external sources of funding (Kissinger et al. 2019; Loaiza et al. 2017) (*medium evidence, high agreement*). However, there is limited evidence of effective adaptation co-benefits, which may be related to the lack of provision of forest standards; a disproportionate focus on mitigation and lack of attention to the well-being of the population in rural and agricultural areas (Kongsager and Corbera 2015).

Conflicts have emerged over political views, government priorities of resources (oil, bioenergy, hydropower), and weak governance among national and local authorities, indigenous groups and other stakeholders such as NGOs which play a critical role in the technological and financial support for the REDD+ initiative (Reed 2011; Kashwan 2015; Gebara et al. 2014; Locatelli et al. 2011, 2017). A more holistic approach which recognises these social, environmental and political drivers would appear to have benefits but assessment is needed to allow evidence based actionable policy statements.



Box 13.16, Figure 1 Latin America and the Caribbean: High priority sectors for mitigation and adaptation. Number of countries that name the following sector in their national climate change plans and/or communications. The purple and green bars represent adaptation and mitigation respectively.

Source: Reproduced from Bárcena et al. 2018

END BOX 13.16 HERE

The ‘nexus’ approach is another widely used framework that describes the linkages between water, energy, food, health and other socio-economic factors in some integrated assessment approaches (Rasul and Sharma 2016). The Food-Energy-Water (FEW) nexus, for example, considers how water is required for energy production and supply (and thus tied to mitigation), how energy is needed to treat and transport water, and how both are critical to adaptable and resilient food production systems (Mohtar and Daher 2014; Biggs et al. 2015). Climate change impacts all these dimensions in the form of multi-hazard risk (Froese and Schilling 2019). Although integrative, the FEW nexus faces many challenges including: limited knowledge integration; coordination between different institutions and levels of government; politics and power; cultural values; and ways of managing climate risk (Leck and Roberts 2015; Romero-Lankao et al. 2017; Mercure et al. 2019). More empirical assessment is needed to identify potential overlaps between sectoral portfolios, as this could help to delineate resources allocation for synergies and to avoid trade-offs.

13.8.3 Relationships between mitigation and adaptation measures

There are multiple ways that mitigation and adaptation may be integrated. Table 13.3 sets out those relationships broken down into four areas: adaptation that contributes to mitigation; mitigation that contributes to adaptation; holistic, sustainability first strategies; and trade-offs. The table shows that more holistic and sustainability-oriented policies can open up the possibility for accelerated transitions across multiple priority domains (*robust evidence, high agreement*).

Table 13.3 Relationships between adaptation and mitigation measures

Policy/action	Interrelation explained	Reference
<i>Adaptation that contributes to mitigation</i>		
Coastal adaptation and blue carbon; developing strategies for conservation and restoration of blue carbon ecosystems generating resilient communities and landscapes. <ul style="list-style-type: none"> • Contributes to carbon storage and sequestration. 	Conservation of habitats and ecosystems, protect communities from extreme events, increase food security, and provide ecosystem services. At the same time, restoration of mangroves, tidal marshes, and seagrasses have high rates of carbon sequestration, act as long-term carbon sinks, and are contained within clear national jurisdictions. Example: Conservation programs on Brazilian mangroves, Spanish seagrass meadows, the Great Barriers Reef in Australia, and Coastal Management Strategy in New Zealand	(Andresen et al. 2012; Herr and Landis 2016; Duarte 2017; Doll and Oliveira 2017; Howard et al. 2017; Gattuso et al. 2018; Cooley et al. 2019; Karani and Failler 2020; Lovelock and Reef 2020)
Nature-based Solutions (NbS); Nature-based solutions are interventions that use the natural functions of healthy ecosystems to protect the environment but also provide numerous economic and social benefits. <ul style="list-style-type: none"> • Contributes to carbon storage and sequestration using individual and clustered trees. 	NbS complement and shares common elements with a wide variety of other approaches to building the resilience of social-ecological systems. Policies at national and subnational level include community-based adaptation, ecosystem-based disaster risk reduction, climate-smart agriculture, and green infrastructure, and often place emphasis on using participatory and inclusive processes and community/stakeholder engagement. Examples: Mexico and the United Kingdom provide support for NbS in their national biodiversity strategies and action plans some related to water management. UK launched the Green Recovery Challenge Fund to create jobs with a focus on tree planting and the rehabilitation of peatlands.	(Doswald and Osti 2011; Secretariat of the Convention on Biological Diversity 2019; Ihobe - Environmental Management Agency 2017; Zwierchowska et al. 2019; Seddon et al. 2020; Choi et al. 2021; OECD 2021b)
Ecosystem-based Adaptation (EbA); use biodiversity and ecosystem services to help people to adapt to the adverse effects of climate change, aiming to maintain and increase the resilience and reduce the vulnerability of ecosystems and people <ul style="list-style-type: none"> • Contributes to carbon storage and sequestration 	EbA involves the conservation, sustainable management and restoration of ecosystems, such as forests, grasslands, wetlands, mangroves or coral reefs to reduce the harmful impacts of climate hazards including shifting patterns or levels of rainfall, changes in maximum and minimum temperatures, stronger storms, and increasingly variable climatic conditions. Examples: Some NDCs include EbA and NbS harmonizing national policies (e.g.: National Adaptation Plan) with other national climate and development policy processes, such as: water resources management plan, disaster risk reduction strategies, land planning codes.	(IPBES 2019; Doswald et al. 2014; Secretariat of the Convention on Biological Diversity 2009; McAllister 2007; Colls et al. 2009; Rubio 2017; Raymond et al. 2017; Duarte 2017; Gattuso et al. 2018)
Urban Greening; urban forestry, planting in road reserves and tree planting along main streets. <ul style="list-style-type: none"> • Contributes to carbon storage and sequestration • Energy use reduction 	Urban afforestation and reforestation produce cooling effect and water retention while helping to reducing carbon dioxide from the atmosphere. Green walls and rooftops increase energy efficiency of buildings and decrease water runoff and provide insulation for the buildings. Examples: Wellington City Council and other entities must comply with the New Zealand Emission Trading System regulatory framework that provides guidance and requirements of climate change planning and implementation for both M&A.	(Santamouris 2014; Sharifi and Yamagata 2016; Grafakos et al. 2018; Pasimeni et al. 2019; Anderson et al. 2016)

Climate adaptation plans at city level; Subnational policies that would lead to carbon reduction to support climate mitigation. Contribution to mitigation: <ul style="list-style-type: none"> • Carbon storage and sequestration • Energy use reduction • Renewable energy 	<p>Cities with Climate Actions Plans include urban spatial planning and capacity-building initiatives. Some cities with adaptation and mitigation combined climate change action plans are: Bangkok, Chicago, Montevideo, Wellington, Durban, Paris, Mexico City, and Melaka. And cities with A&M actions are: Los Angeles, Vancouver, Barcelona, London, Accra, Santiago de Chile, Bogota, Curitiba, and other.</p> <p>Co-benefits generated by climate actions at cities: heat stress reduction; water scarcity, stormwater and flood management; air quality improvement, human health and well being, aesthetic/ amenity, recreation / tourism, environmental justice, real estate value, food production, green jobs opportunities.</p>	<p>(Garcetti 2019; Horne 2020; Barcelona City Council 2018; Greater London Authority 2018; Accra Metropolitan Assembly 2020; Choi et al. 2021; Grafakos et al. 2019; Nakano et al. 2017; Peng and Bai 2018; Zen et al. 2019; Bai et al. 2018)</p>
<i>Mitigation that contributes to adaptation</i>		
Green Infrastructure; Policies to support the design and implementation of a hybrid network of natural, semi-natural, and engineered features within, around, and beyond urban areas at all scales, to provide multiple ecosystem services and benefits. <ul style="list-style-type: none"> • Carbon storage and sequestration • Reduced energy consumption 	<p>Adaptation benefits: flood management, heat stress reduction individually, or jointly, coastal protection, water scarcity management, groundwater resources, ecosystem resilience improvement, air quality, water supply, flood control, water quality improvement, groundwater recharge. Social co-benefits: aesthetic, recreation, environmental education, improved human health/wellbeing, social cohesion, and poverty reduction. Policy examples: National building code guidelines, flood safety standards, local land-use plans, local building codes, integrated water management for flood control,</p>	<p>(Atchison 2019; Conger and Chang 2019; Schoonees et al. 2019; De la Sota et al. 2019; Choi et al. 2021; Zwierzchowska et al. 2019)</p>
REDD+ Strategies; An incentive for developing countries to increase carbon sinks, to protect their forest resources and coastal wetlands. Mostly are national strategies led by the state with contribution of international donors. <ul style="list-style-type: none"> • Contributes to carbon storage and sequestration • Renewable energy 	<p>REDD+ strategies aim to generate social benefits such as poverty reduction, and ecological services such as water supply, water quality enhancement, conserves soil and water by reducing erosion. For example; indigenous communities of Socio Bosque in Ecuador have sustained livelihoods and maintaining ties to land, place, space, and <i>cosmovision</i> While in Cameroon, upfront contextual inequities with respect to technical capabilities, power, gender, level of education, and wealth have been barriers to individuals' likelihood of participating in and benefiting from the projects.</p>	<p>(McBurney 2021; Tegegne et al. 2021; Anderson et al. 2016; Busch et al. 2011; Bushley 2014; Dickson and Kapos 2012; Froese and Schilling 2019; Gebara et al. 2014; Pham et al. 2014; Jodoin 2017)</p>
Household energy-efficiency and renewable energy measures; Energy policies may improve socioeconomic development. <ul style="list-style-type: none"> • Energy use reduction 	<p>Energy Efficiency (EE) emerges as a feasible and sustainable solution in Latin America, to minimise energy consumption, increase competitiveness levels and reduce carbon footprint. Achieving high levels of EE in the building sector requires new policies and strengthening their legal framework. Microenterprise development contributes to poverty reductions as renewable energy stimulate local and national economies</p>	<p>(Chan et al. 2017; Silvero et al. 2019; Zabaloy et al. 2019; Alves et al. 2020; Nyiwlul 2019; Dal Maso et al. 2020)</p>
<i>Sustainability first: Holistic approaches</i>		
Integrated community sustainability plans.	<p>Climate change mitigation and adaptation are embedded in a plan to improve affordability, biodiversity, public health, and other aspects of communities.</p>	<p>(Burch et al. 2014; Shaw et al. 2014; Stuart et al. 2016; Dale et al. 2020)</p>

Inclusive future visioning using social-ecological systems or socio-technical systems thinking.	Participatory processes that highlight the cultural and social dimensions of climate change responses and synergies/trade-offs between priorities rather than an exclusive focus on technical aspects of solutions.	(Gillard et al. 2016; Krzywoszynska et al. 2016)
Climate Resilience Cities; integrating New Urban Agenda (NUA), SDGs, climate actions for A&M, and Disaster Risk Reduction (DRR) for local and subnational governments, and DRR within a multi-hazard approach based on Sendai Framework.	Resilient cities are including SDGs, targets, A&M options and DRR to build a resilient plan for urban planning, health, life quality and jobs creation. Climate mitigation and sustainable energy actions adopted at the local level are interconnected. For instance, cities with Sustainable Energy and Climate Action Plan, which required the establishment of a baseline emission inventory and the adoption of policy measures, are already showing a tangible achievement regarding sustainable goals.	(Barcelona City Council 2018; Garcetti 2019; Accra Metropolitan Assembly 2020; Blok 2016; Giampieri et al. 2019; Gomez Echeverri 2018; Long and Rice 2019; Pasimeni et al. 2019; Romero-Lankao et al. 2016)
Trade-offs		
Land use strategies; for mitigation or adaptation considered in isolation, may cause a conflict in land planning. <ul style="list-style-type: none">• Carbon storage and sequestration• Energy use reduction• Renewable energy	Increasing density of land use, land use mix and transit connectivity could increase climate stress and reduce green open spaces. It may increase the urban heat island impacting human health, and expose population to coastal inundation. Some of the policies and strategies to minimise this are: land use planning, zoning, land-use permits, mobilizing private finance in the protection of watersheds, integrated coastal zone management, flood safety standards, and other. More assessment is needed prior to new land use to reduce or prevent actions which negatively alter ecosystem services and environmental justice	(O'Donnell 2019; Bush and Doyon 2019; Grafakos et al. 2019; Landauer et al. 2015; Viguié and Hallegatte 2012; Floater et al. 2016; Xu et al. 2019; Landauer et al. 2019)
Low-carbon, net zero and climate change resilient building codes that fail to account for affordability. <ul style="list-style-type: none">• Energy reduction• Renewable energy	Low carbon or net zero emissions have multi-objective strategies, integrated policies, regulations, and actions at the national and sub-national levels. Trade-offs may be related to policy mechanisms that must be implemented comprehensively, not individually. However, different administrative levels and institutions may create a barrier to inter-sectoral coordination. For example: "Greening" programmes may produce positive mitigation and adaptation outcomes but may also accelerate displacement and gentrification at city level.	(Chaker et al. 2021; del Río and Cerdá 2017; Choi et al. 2021; Papadis and Tsatsaronis 2020; Wolch et al. 2014; Garcia-Lamarca et al. 2021; Haase et al. 2017; Sharifi 2020; Viguié and Hallegatte 2012; del Río 2014)

13.8.3.1 Governing the linkages between mitigation and adaptation at the local, regional, and global scales

International policy frameworks, such as the 2015 Paris Agreement, the Sendai Framework for Disaster Risk Reduction, and the New Urban Agenda for sustainable urban systems, provide an integrated approach for both adaptation and mitigation, while promoting sustainable development and climate resilience across scales (from global, regional, to local government actions (Nachmany and Setzer 2018; Duguma et al. 2014b; Heidrich et al. 2016; Di Gregorio et al. 2017; Locatelli et al. 2017; Mills-Novoa and Liverman 2019) (*robust evidence, high agreement*). Even so, the specific ways that these linkages are governed vary widely depending on institutional and jurisdictional scale, competing policy priorities, and available capacity (Landauer et al. 2019).

Supranational levels of action such as the EU climate change policy have influenced the development and implementation of Climate Change Action Plans (CCAPs) at the subnational level (Reckien et al. 2018; Villarroel Walker et al. 2017; Heidrich et al. 2016). While adaptation is gaining prominence and is increasingly included in the NDCs of EU nations, the implementation of adaptation and mitigation by EU states are at different stages (Fleig et al. 2017). Fleig et al. (2017) found that all EU states, with the exception of Hungary, have adopted a framework of laws tackling mitigation and adaptation to climate change. However, an assessment of climate legislation in Europe pointed out that there has been little coordination between mitigation and adaptation, and that implementation varies according to different national conditions (Nachmany et al. 2015). More recently, however, integrated adaptation/mitigation plans have been prepared in Europe under the Covenant of Mayors, in which synergies and trade-offs can be better revealed and assessed (Bertoldi et al. 2020).

Local governments and cities are increasingly emerging as important climate change actors (Gordon and Acuto 2015) (see also Section 13.5). While cities and local governments are developing Climate Change Action Plans (CCAPs), plans that explicitly integrate the design and implementation of adaptation and mitigation are a minor percentage, with few cities establishing inter-relationships between them (Nordic Council of Ministers 2017; Grafakos et al. 2018). Compared to national climate governance, local governments are more likely to develop and advance climate policies, generating socio-economic or environmental co-benefits, and improve communities' quality of life (Gill et al. 2007; Bowen et al. 2014; Deng et al. 2017; Hennessey et al. 2017; Mayrhofer and Gupta 2016; Duguma et al. 2014b). There may be a disconnect, however, between the responsibility that a particular jurisdiction has over mitigation and adaptation (city officials, for instance) and the scale of resources or capacities that they have available to bring to bear on the problem (regional to national provision of energy and transport) (Di Gregorio et al. 2019; Dale et al. 2020).

13.8.4 Integrated governance including equity and sustainable development

Climate policy integration carries implications for the pursuit of the SDGs, given that it is nearly impossible to achieve the desired socio-economic gains if fundamental environmental issues, such as climate change, are not addressed (Gomez-Echeverri 2018). Research on climate resilient development pathways (Roy et al. 2018), for instance, argues for long term policy planning that combines the governance of national climate and SD goals, builds institutional capacity across all sectors, jurisdictions, and actors, and enhances participation and transparency (*robust evidence, high agreement*) (also see Chapter 4 and 17).

In the Global South, climate change policies are often established in the context of sustainable development and of other pressing local priorities (e.g., air pollution, health, and food security). National climate policy in these countries tends to give prominence to adaptation based on country vulnerability, climatic risk, gender-based differences in exposure to that risk, and the importance of local/traditional and indigenous knowledge (Beg et al. 2002; Duguma et al. 2014b). Despite the evidence that integrated mitigation and adaptation policies can be effective and efficient (Klein et al. 2005) and can potentially reduce trade-offs,

there is still limited evidence of how such integrated policies would specifically contribute to progress on the SDGs (Antwi-Agyei et al. 2018; De Coninck et al. 2018; Di Gregorio et al. 2017; Campagnolo and Davide 2019; Kongsager et al 2016) (*robust evidence, high agreement*).

Where mainstreaming of environmental concerns has been attempted through national plans, they have had success in some cases when backed by strong political commitments that support a vertical coordination structure rather than horizontal structures led by the focus ministry (Nunan et al. 2012). Such political commitments are therefore crucial to success but insufficient in and of themselves (Runhaar et al. 2018; Wamsler et al. 2020). Integration of the budget process is particularly important, as are aligned timeframes across different objectives (Saito 2013). Recognition of the functional interactions across policy sectors is improved by a translation of long-term policy objectives into a plan that aligns with integration goals (Corry 2012; Oels 2012; Dupont 2019).

There are important links between inequality, justice and climate change (Ikeme 2003; Bailey 2017). Many of these operate through the benefits, costs and risks of climate action (distributive justice), while others focus on differential participation and recognition of subnational actors and marginalized groups (procedural justice) (Bulkeley and Castán Broto 2013; Bulkeley et al. 2013; Hughes 2013; Romero-Lankao and Gnatz 2019; Reckien et al. 2018).

Justice principles are rarely incorporated in climate change framing and action (Sovacool and Dworkin 2015; Genus and Theobald 2016; Heikkinen et al. 2019; Romero-Lankao and Gnatz 2019). Yet, equity is salient to mitigation debates, because climate change mitigation policies can have also negative impacts (Brugnach et al. 2017; Ramos-Castillo et al. 2017; Klinsky 2018), exacerbated by poverty, inequality and corruption (Markkanen and Anger-Kraavi 2019; Reckien et al. 2018). The siting of facilities and infrastructure that advance decarbonisation (such as public transit infrastructure, renewable energy facilities etc.) may have implications for environmental justice. Integrated attention to justice in climate, environment and energy, as well as involvement of host communities in siting assessments and decision-making processes, can help to avoid such conflict (McCord et al. 2020; Hughes and Hoffmann 2020). As a result, successful policy integration goes beyond optimizing public management routines, and must resolve key trade-offs between actors and objectives (Meadowcroft 2009; Nordbeck and Steurer 2016).

The potential for transformative climate change policy that delivers both adaptation and mitigation is also shaped by a number of enabling and disabling factors tied to governance processes (Burch et al. 2014)(also see Section 13.9) (*robust evidence, high agreement*).

START BOX 13.17 HERE

Box 13.17 Enabling and disabling factors for integrated governance of mitigation and adaptation

Ensuring participatory governance and social inclusion: Interlinkages in the food-energy-water nexus highlight the importance of inclusive processes (Cook and Chu 2018; Shaw et al. 2014; Nakano et al. 2017; Romero-Lankao and Gnatz 2019). The cultivation of urban grassroots innovations and social innovation may accelerate progress (Wolfram and Frantzeskaki 2016), as may the development of carefully-designed climate and energy dialogues that enable learning among multiple stakeholders (Cashore et al. 2019).

Considering synergies and trade-offs with broader sustainable development priorities: The explicit consideration of synergies and trade-offs will enable more integrated policy making (von Stechow et al. 2015; Dang et al. 2003). Policy frameworks to do so are just emerging, such as analysis of trade-offs between energy and water policies and agriculture (Huggel et al. 2015; Antwi-Agyei et al. 2018).

Employing a diverse set of tools to reach targets: Building codes, land use plans, public education initiatives, and nature-based solutions such as green ways may impact adaptation and mitigation simultaneously (Burch et al. 2014). Ecological restoration provides another suite of tools, for instance the Brazilian target of

restoring and reforesting 0.12 million km² of forests by 2030, which can enhance biodiversity and ecosystem services while also sinking carbon (Bustamante et al. 2019). Mandatory retrofits to improve indoor air quality can also increase energy efficiency and resilience to climate change impacts (Friel et al. 2011; Houghton 2011).

Monitoring and evaluating key indicators, beyond only greenhouse gas emissions, such as biodiversity, water quality, and affordability: An integrated approach requires robust process for collecting data on these indicators. Challenges are related to the limited evidence-base on synergies, co-benefits, and trade-offs across sectors and jurisdictions (Di Gregorio et al. 2016; Kongsager et al. 2016; Locatelli et al. 2017; Zen et al. 2019). Moreover, adaptation policies mostly lack measurable targets or expected outcomes increasing the challenge of designing an integrated framework (OECD 2017).

Iterative and adaptive management: Adaptive management helps to address the underlying uncertainty (Kundzewicz et al. 2018) that characterizes implementation of integrated approaches to adaptation and mitigation. Policy integration needs to be considered iteratively along the process of development, implementation, and evaluation of climate policies.

Strategic partnerships that coordinate efforts: Strategic partnerships among diverse actors, therefore, bring diverse technical skills and capacities to the endeavour (Burch et al. 2016; Islam and Khan 2017). However, realising strategic approaches for joint adaptation and mitigation require adequate financial, technical and human resources.

Participatory and collaborative planning approaches can help overcome injustices and address power differentials: Participatory and collaborative planning approaches can provide multiple spaces of deliberation where marginalised voices can be heard (Blue and Medlock 2014; UN Habitat 2016; Castán Broto and Westman 2017; Waisman et al. 2019). These tools organise climate and sustainability action by addressing its democratic deficit and facilitating the recognition of multiple perspectives in environmental planning alongside material limits of development (Agyeman 2013).

END BOX 13.17 HERE

13.9 Accelerating mitigation through cross sectoral and economy wide system change

13.9.1 Introduction

Section 13.9 assesses literature related to economy wide and cross - sector systemic change as an approach to accelerate climate mitigation.

It focuses specifically on policy and institutions, as two of the six enabling conditions for economy wide system change and thus provides a third dimension of the role of policy and institutions to climate mitigation. Enabling conditions in general are discussed in Chapter 4 of the SR1.5 (IPCC 2018), as well as Chapter 4 of this report. This section follows on from Section 13.6 (single policy instruments) and 13.7 (policy packages). Section 13.9 literature follows closely on from Section 13.7 literature on policy packages, which discusses change within one system, although there remains an overlap.

Section 13.9.2 provides a brief introduction to policy and institutions as 2 of the 6 dimensions of enabling conditions, and the importance of enabling conditions to systemic change and climate mitigation. Section 13.9.3 briefly introduces actions for transformative justice, which seek to restructure the underlying system framework that produces mitigation inequalities. Section 13.9.4 provides a brief overview of Net Zero policies and targets (often no more than aspirational), which imply economy wide measures and system change. Section 13.9.5 assesses the literature arguing for a system restructuring approach to climate mitigation, based on systemic restructuring. Section 13.9.6 assesses the literature on stimulus packages and

green new deals which aim for systemic change, sometimes with value for climate mitigation. And finally, Section 13.9.7 assesses emerging literatures which argues that there are existing challenges to accelerating climate mitigation that may be overcome by systemic change and targeted actions.

13.9.2 Enabling acceleration

IPCC AR6 WG3, particularly Chapter 4, following on from the IPCC WG3 SR1.5 (IPCC 2018), has highlighted the importance of enabling conditions for delivering successful climate mitigation actions. The AR6 Glossary term for enabling conditions is: ‘enabling conditions include *finance, technological innovation, strengthening policy instruments, institutional capacity, multi-level governance, and changes in human behaviour and lifestyles* (See Glossary) (*medium evidence, high agreement*). The IPCC SR1.5 report adds to these 6 dimensions saying enabling conditions also includes ‘inclusive processes, attention to power asymmetries and unequal opportunities for development and reconsideration of values’ (IPCC 2018) (*medium evidence, high agreement*). Not only is the presence of enabling conditions necessary for delivering the successful implementation of single policy instruments and policy packages, but also for delivering systemic change (de Coninck et al. 2018; IPCC 2018; Waisman et al. 2019) (*medium evidence, high agreement*). The feasibility of 1.5°C compatible pathways is contingent upon enabling conditions for systemic change (de Coninck et al. 2018; Waisman et al. 2019) (*medium evidence, high agreement*).

At the same time, again following on from SR1.5 report, Section 1.8.1 explains that there are six feasibility dimensions of successful delivery of climate goals. These feasibility dimensions include geophysical; environmental & ecological; technological; economic; behaviour and lifestyles and institutional dimensions. The presence or absence of enabling conditions would affect the feasibility of mitigation as well as adaptation pathways and can reduce trade-offs whilst amplifying synergies between options (Waisman et al. 2019). Policies and institutions, which are two of the six enabling conditions, are therefore central to accelerated mitigation and systemic change. Identifying, and ensuring, the presence of all the enabling conditions for any given goal, including systemic transformation and acceleration of climate mitigation, is an important first step (Roberts et al. 2018; Le Treut et al. 2021; Singh and Chudasama 2021) (*medium evidence, medium agreement*).

13.9.3 Transformative justice action and climate mitigation

Chapter 4 is the lead chapter of this Report for justice and climate mitigation issues, and includes an overview of institutions which have been set up to ensure a Just climate transition (see Section 4.5 in Chapter 4). Chapter 13 has sought to integrate justice issues in Section 13.2 in reference to procedural justice and the impact of inequalities on sub-national institutions, 13.6 in regard to distribution, and 13.8 in relation to integrating mitigation and adaptation policies.

This sub-section introduces the concept of transformative justice as part of measures intending to accelerate mitigation. Fair and effective climate policymaking requires institutional practices to: consider the distributional impacts of climate policy in the design and implementation of every policy (Agyeman 2013; Castán Broto and Westman 2017); align mitigation with other objectives such as inclusion and poverty reduction (Hughes and Hoffmann 2020; Rice et al. 2020; Hess and McKane 2021); represent a variety of voices, especially those of the most vulnerable (Bullard et al. 2008; Temper et al. 2018); and rely on open processes of participation (Anguelovski et al. 2016; Bouzarovski et al. 2018; Rice et al. 2020) (*robust evidence, high agreement*).

Distributive approaches to climate justice address injustices related to access to resources and protection from impacts. There is an important difference between affirmative and transformative justice action (Agyeman et al. 2016; Castán Broto and Westman 2019; Fraser 1995): Affirmative action includes policies and strategies that seek to correct inequitable outcomes without disturbing the underlying political

framework while transformative action seeks to correct inequitable outcomes by restructuring the underlying framework that produces inequalities.

Transformative action that responds to distributive justice concerns include economy wide actions via stimulus packages (such as the European Green Deal and the New Green Deal in the US (see Section 13.9.5)). Other examples are the increasing number of climate litigation suits that are transforming the way distributive dimensions of climate justice are understood (Section 13.4.2).

13.9.4 Net zero emissions targets

The last few years have seen a proliferation of net zero emission targets set by national and regional governments, cities as well as companies and institutions (NewClimate Institute and Data Driven EnviroLab 2020; Black et al. 2021; Rogelj et al. 2021) (see also Cross-Chapter Box 3 in Chapter 3). Meeting these targets implies economy wide systemic change (*medium evidence, high agreement*).

The Energy & Climate Intelligence Unit (ECIU) Net Zero Tracker divides countries in to those which have net zero emissions achieved, have it in law, have proposed legislation, have it in policy documents or have emission reduction targets under discussion in some form. A recent study estimated that 131 countries have either adopted, announced or are discussing net zero GHG emissions targets, covering 72% of global emissions (Höhne et al. 2021). Out of those, as of 1st October 2021, the ECIU Net Zero Tracker states that Germany, Sweden, the European Union, Japan, United Kingdom, France, Canada, South Korea, Spain, Denmark, New Zealand, Hungary and Luxembourg have net zero targets set in law (ECIU 2021).

Some have argued that the expansion of these emission reduction targets marks an important increase in climate mitigation momentum since the Paris Agreement of 2015 and the 2018 IPCC Special Report on Global Warming of 1.5°C (Black et al. 2021; Höhne et al. 2021). On the other hand net zero emission targets in their current state vary enormously in scope, quality and transparency – with many countries at the discussion stage - and this makes scrutiny and comparison difficult (NewClimate Institute and Data Driven EnviroLab 2020; Black et al. 2021; Rogelj et al. 2021).

In order to realise the mitigation potential of net zero emission targets some areas within the targets might need to be changed. For example, this includes clearer definitions; well defined timeframes and scopes; focusing on direct emission reductions within their own territory; minimal reliance on offsets; scrutiny of use and risks of CO₂ removal; attention to equity, near-term action coupled with long-term intent setting; and ongoing monitoring and review (Levin et al. 2020; NewClimate Institute and Data Driven EnviroLab 2020; Black et al. 2021; Höhne et al. 2021; Rogelj et al. 2021; World Bank 2021b) (*medium evidence, high agreement*).

13.9.5 Systemic responses for climate mitigation

There is now a significant body of work which explicitly states, or implicitly accepts, that systemic change may be necessary to deliver successful climate mitigation, including net zero targets. Newell phrases this as the difference between ‘plug and play’ mitigation applications where one aspect of a system is changed while everything in the system remains the same compared to systemic change, with change affecting all the system (Newell 2021a,b). This section highlights an emergent, multi-disciplinary literature since IPCC AR5, which suggests that acceleration to decarbonised systems via a sustainable development pathway may be better achieved by moving from a single policy instrument or mix of policies approach to a systemic economy wide approach (see Figure 13.6).

The complexity and multi-faceted challenges of rapidly decarbonising our current interconnected systems (such as energy, food, health) in a just way has led Michaelowa et al. (2018) to conclude that implementation of strong mitigation policy packages that are needed requires a systemic change in policymaking.

Multiple modelling assessments of different development and mitigation pathways are available. Most of these analyses which lead to significant climate mitigation assume significant systemic change across social, technological, and economic aspects of a country (for example, India (Gupta et al. 2020); Japan (Sugiyama et al. 2021)) and the globe (Rogelj et al. 2015; Dejuán et al. 2020).

UNEP (2020) argued that major, long term sectoral transformation across multiple systems is needed to reach net zero GHG emissions. Bernstein and Hoffmann (2019) and Rockström et al. (2017) argue that the presence of multi-level, multi-sectoral lock-ins of overlapping and interdependent political, economic, technological and cultural forces mean that a new approach of co-ordinated, cross-economy, systemic climate mitigation is necessary. Creutzig et al. (2018) propose a resetting of the approach to consumption and use of resources to that of demand side solutions, which would have ongoing economy-wide systemic implications.

Others focus more on single system reconfigurations, such as the energy system (Matthes 2017; Tozer 2020); urban systems (Holtz et al. 2018); or the political system (Somerville 2020; Newell and Simms 2020). Becken (2019) argues that only systemic changes at a large scale will be sufficient to break or disrupt existing arrangements and routines in the tourism industry

Others argue for thinking about mitigation in even wider ways. O'Brien (2018) posits that sector-focused, or a silo approach, to mitigation may need to give way to decisions and policies which reach across sectoral, geographic and political boundaries and involve a broad set of interrelated processes – practical, political and personal. Gillard et al. (Gillard et al. 2016) argue that a response to climate change has to move beyond incremental responses, aiming instead for a society wide transformation which goes beyond a system perspective to include learning from social theory; while Eyre et al. (2018) argue that moving beyond incremental emissions reductions will require expanding the focus of efforts beyond the technical to include people, and their behaviour and attitudes. Stoddard et al. (2021) argue that 'more sustainable and just futures require a radical reconfiguration of long-run socio-cultural and political economic norms and institutions'. They focus on nine themes: international climate governance, the vested interests of the fossil fuel industry, geopolitics and militarism, economics and financialisation, mitigation modelling, energy supply systems, inequity, high carbon lifestyles and social imaginaries.

13.9.6 Economy-wide measures

Economy wide stimulus packages which have occurred post COVID-19, and in some cases in response to environmental concerns, have the ability to undermine or aid climate mitigation (*medium evidence, high agreement*). Attention in the early efforts of their development and design can contribute to shifting sustainable development pathways and net zero outcomes, whilst meeting short term economic goals (Hepburn et al. 2020; Hanna et al. 2020) (*medium evidence, high agreement*)

Economy-wide packages, as a way to stimulate and/or restructure domestic economies to deliver particular, desired outcomes is a widely accepted tool of government (for example the Roosevelt's New Deal packages in the US between 1933 and 1939). A number of country-level stimulus package were put in place after the 2008 Global Recession, and there was support for a Global Green New Deal from UNEP (Steiner 2009; Barbier 2010). Cross-economy structural change packages may provide opportunities for another approach to accelerate climate mitigation.

This approach has already been taken up to some degree by a number of countries / blocs. For example, California as well as Germany, through the German *Energiewende*, are early examples of a US state and a country which have tried to link their economies to a sustainable future through energy-wide efforts of structural change (Morris and Jungjohann 2016; Burger et al. 2020a).

In addition to these economy wide measures, there have since been cross-economy Green New Deals implemented such as the European Green Deal (Elkerbout et al. 2020; Hainsch et al. 2020; UNEP 2020)(see

also Box 13.1) with calls for other New Deals (e.g. a Blue New Deal (Dundas et al. 2020)) or deals to bring together climate and justice goals (Hathaway 2020; MacArthur et al. 2020).

The COVID-19 Pandemic has resulted in global economic recession, which many Governments have responded to with economic stimulus programs. See also Cross-Chapter Box 1 in Chapter 1 on COVID-19. It has also led to more analysis of the potential of cross-economy stimulus packages to benefit climate goals, including what lessons can be learned from the stimulus packages put in place as a result of the 2008-9 Global Recession.

The United Nations Environment Programme (UNEP) reviewed the green stimulus plans of the G20 following the 2008-9 recession to examine what worked; what did not; and the lessons which could be learnt (Barbier 2010). This work was updated (Barbier 2020) and concluded that the constituents of successful green stimulus frameworks were long term commitments in public spending; pricing reform; ensuring concerns about affordability were overcome; and minimising unwanted distributional impacts. Others argue that post 2008 recession stimulus package outcomes benefited both environmental and industrial objectives and that a long-term policy commitment to the transition to a sustainable, low carbon economy makes sense from both an environmental and industrial strategy point of view (Fankhauser et al. 2013).

With the outbreak of the COVID-19 Pandemic in 2020, past stimulus packages have been further investigated. One study interviewed 231 central bank officials and identified 5 key policies for both economic multipliers and climate impacts metrics (Hepburn et al. 2020). These were expenditure on clean physical infrastructure; building energy efficiency retrofits; investment in education and training; natural capital investment; and clean R and D. However, the mix of effective policies may differ in lower and middle income countries: rural support spending was more relevant, while clean R and D was less so. The study illuminated that there were different phases to recovery packages: the initial ‘rescue’ spending but then a second ‘recovery’ phase that can be more fairly rated green or not green. Recovery phase policies can deliver both economic and climate goals -- co-benefits can be captured (i.e. support for EV infrastructure can also reduce local air pollution etc.) -- but package design is important (Hepburn et al. 2020).

Others provide a framework which allows a systematic evaluation of options, given objectives and indicators, for COVID-19 stimulus packages (e.g. (Dupont et al. 2020; Jotzo et al. 2020; OECD 2021c)). Jotzo et al. (2020) conclude that the programmes that most closely match green stimulus are afforestation and ecosystem restoration programmes, energy efficiency upgrades and RE projects. These type of policies provide short term goals of COVID-19 whilst also making progress on longer terms objectives (Jotzo et al. 2020). The IMF concluded that a comprehensive mitigation policy package combining carbon pricing and government green infrastructure spending (that is partly debt financed) can reduce emissions substantially while boosting economic activity, supporting the recovery from the COVID-19 pandemic (Jaumotte et al. 2020).

Conversely, other short term fiscal or recovery measures in stimulus packages may perpetuate high carbon and environmental damaging systems. These include fossil fuel based infrastructure investment; fiscal incentives for high carbon technologies or projects; waivers or roll-backs of environmental regulation; bailouts of fossil fuel intensive companies without conditions for low carbon transitions or environmental sustainability (UNEP 2020; O’Callaghan and Murdock 2021; Vivid Economics 2021).

Of the USD17.2 trillion so far spent on stimulus packages, USD4.8 trillion (28% of the total as of July 2021) is linked to environmental outcomes (Vivid Economics 2021). This study relates to 30 countries: the G20 and 10 others. The packages in EU, Denmark, Canada, France, Spain, the UK, Sweden, Finland and Germany (German Federal Ministry of Finance 2020; Vivid Economics 2021) result in net benefits for the environment. A number of studies provide differing conclusions with respect to net benefits or otherwise for the environment for a number of countries (Climate Action Tracker 2020; UNEP 2020; Vivid Economics 2021). An OECD database found that, as of mid-July 2021, 21% of economic recovery spending in OECD, EU and Key Partners is allocated to environmentally positive measures (OECD 2021c). O’Callaghan and Murdock (2021) reviewed the 50 countries with the greatest stimulus spend in 2020 and find that 13% of the

spend is directed to long term recovery type measures, of which 18% is spent on green recovery. This is a total of 2.5% of total spend or USD368bn on green initiatives.

13.9.7 Steps for acceleration

The multi-disciplinary literature exploring how to accelerate climate mitigation and transition to low GHG economies and systems has grown rapidly over the last few years. Acceleration is also confirmed as an important sub-theme of the more specific transition literature (Köhler et al. 2019). While literature focusing on how to accelerate the impact of climate mitigation is derived from empirical evidence, there is very little *ex post* evidence of directed acceleration approaches.

The overlapping discussions of how to accelerate climate mitigation; transition to low carbon economies; and shift development pathways depends heavily on country specific dynamics in political coalitions, material endowments, industry strategy, cultural discourses, and civil society pressures (Sections 13.2, 13.3, 13.4, 13.7, and 13.8). Ambition for acceleration at different scales and stringency (whether for cities, country climate policies, country industrial strategies, or national economic restructuring) increase governance challenges, including coordination across stakeholders, institutions, and scales. ‘There is therefore no “one-size-fits-all” blueprint for accelerating low-carbon transitions’ (Geels et al. 2017a; Roberts et al. 2018) (*medium evidence, high agreement*).

Markard et al. (2020) describe the key challenges to accelerating climate mitigation and sustainability transitions as:

1. the ability for low carbon innovations to emerge in whole systems. Two critical issues need to occur to overcome this challenge a) complementary interactions between different elements. For example, in an electricity system, the integration of renewable energy requires complementary storage technologies etc. and b) changes in system architecture. Thus in the accelerating phase, policy has to shift from stimulating singular innovations towards managing wider system transformation.
2. the need for greater interactions between adjacent systems: interactions between multiple systems increases the complexity of the transition. Policies are linked to institutions or government departments, and they are often compartmentalised into different policy areas (eg energy policy and transport policy). Increasing and coordinating that interaction adds complexity.
3. the resistance from declining industries; acceleration of sustainability transitions will involve the phase out of unsustainable technologies. As a result acceleration towards a sustainability transition may be resisted – whether business models, or where jobs are involved. Political struggles and conflicts are an inherent part of accelerating transitions, one strategy to deal with this resistance is to accomplish wide societal support for long term transition targets and to form broad constituencies of actors in favour of those transitions.
4. the need for changes in consumer practices and routines; this challenge relates to changes in social practices that may be required for mainstreaming of sustainable technologies. For example, electric vehicles require changes in trip planning and refuelling practices. Reducing levels or types of consumption is also desirable.
5. coordination challenges in policy and governance. There is an increasing complexity of governance which can be overcome by stronger vertical and horizontal policy coordination across systems.

The acceleration literature links two over-arching actions: first, a strategic targeting approach to overcoming the challenges to acceleration by a parallel focus on undermining high carbon systems whilst simultaneously encouraging low carbon systems; and second, focusing on a coordinated, cross-economy systemic response, including harnessing enabling conditions (Geels et al. 2017b; Rosenbloom and Rinscheid 2020; Hvelplund and Djørup 2017; Gomez Echeverri 2018; Markard 2018; Tvinnereim and Mehling 2018; European Environment Agency 2019; Newell and Simms 2020; Otto et al. 2020; Rogelj et al. 2015; Strauch 2020;

O'Brien 2018; Roberts et al. 2018; Hess 2019; Kotilainen et al. 2019; Victor et al. 2019; Burger et al. 2020a; Hsu et al. 2020b; Rosenbloom et al. 2020) (*robust evidence, high agreement*).

Strategic targeting, or the identifying of specific intervention points (Kanger et al. 2020), points of leverage (Abson et al. 2017), or upward cascading tipping points (Sharpe and Lenton 2021), broadly means choosing particular actions which will lead to a greater acceleration of climate mitigation across systems. For example, Dorninger et al (2020) provide a quantitative systematic review of empirical research addressing sustainability interventions. They take 'leverage points' – places in complex systems where relatively small changes can lead to potentially transformative systemic changes – to classify different interventions according to their potential for system wide transformative change. They argue that 'deep leverage points' – the goals of a system, its intent, and rules – need to be addressed more directly, and they provide analysis of the food and energy systems.

The strategic choosing of policies and points of intervention is linked to the importance of choosing self-reinforcing actions for acceleration (for example, (Rosenbloom et al. 2018; Butler-Sloss et al. 2021; Sharpe and Lenton 2021; Jordan and Moore 2020; Bang 2021). Butler-Sloss et al. (2021) explains the types of self-reinforcing actions (or feedback loops) which can encourage or undermine rapid transformation of energy systems.

An example of this first overarching action, the strategic targeting of the challenges to acceleration, is the focus on undermining carbon-intensive systems, thereby reducing opposition to more generalised acceleration policies, including the encouragement of low carbon systems (Rosenbloom 2018; Roberts and Geels 2019; Hvelplund and Djørup 2017; Victor et al. 2019; Rosenbloom et al. 2020; Rosenbloom and Rinscheid 2020) (*robust evidence, high agreement*). Undermining high carbon systems includes deliberately phasing out unsustainable technologies and systems (Kivimaa and Kern 2016; David 2017; Johnsson et al. 2019; UNEP 2019b; Carter and McKenzie 2020; European Environment Agency 2019; Newell and Simms 2020); confronting the issues of incumbent resistance (Roberts et al. 2018); and avoiding future emissions and energy excess by reducing demand (Rogelj et al. 2015; UNEP 2019b; Victor et al. 2019).

Other strategic goals include tackling the equity and justice issues of 'stranded regions' (Spencer et al. 2018); paying greater attention to system architecture to enable increased acceleration to low carbon electricity supply, in this case in the wind industry (McMeekin et al. 2019); and the importance of maintaining global ecosystem of low carbon supply chains (Goldthau and Hughes 2020).

Other strategic goals combine national and global action. For example, global NGO coalitions have formed around strategic policy outcomes such as the 'Keep it in the Ground' movement (Carter and McKenzie 2020), and are supported via coordinated networks, such as the Powering Past Coal Alliance (Jewell et al. 2019), and with knowledge dissemination, for example, the 'Fossil Fuel Cuts Database' (Gaulin and Le Billon 2020).

The second overarching point highlighted by the literature is the benefits of focusing on a coordinated, cross-economy systemic response. Coordination is central to this. For example, coordination of actions and coherent narratives across sectors and cross economy, including within and between all governance levels and scales of actions, is beneficial for acceleration (Zürn and Faude 2013; Hawkey and Webb 2014; Huttunen et al. 2014; Magro et al. 2014; Warren et al. 2016; Köhler et al. 2019; Kotilainen et al. 2019; McMeekin et al. 2019; Victor et al. 2019; Hsu et al. 2020b) (*robust evidence, high agreement*). Victor et al. (2019) provide a framework of how to prioritise the most urgent actions for climate mitigation and they give practical case studies of how to improve coordination to accelerate reconfiguration of systems for economy wide climate mitigation in sectors such as power; cars; shipping; aviation; buildings; cement; and plastics.

However, coordination is a necessary but insufficient condition of acceleration. All enabling conditions are required to deliver systemic transformation (Section 13.9.2).

Other disciplines argue that social transformation is likely to be as important as the technical challenges in a coordinated, cross-economy approach to acceleration. For example, some argue for social tipping interventions (STI) alongside other technical and political interventions so that they can ‘activate contagious processes of rapidly spreading technologies, behaviours, social norms, and structural reorganisation’ (Otto et al. 2020). They argue that these STIs are *inter alia*: removing fossil fuel subsidies and incentivising decentralised energy generation; building carbon neutral cities; divesting from assets linked to fossil fuels; revealing the moral implications of fossil fuels; strengthening climate education and engagement; and disclosing information of GHG emissions (Otto et al. 2020). Others illuminate the importance of narratives and framings in the take-up (or not) of acceleration actions (Sovacool et al. 2020). Others are optimistic about the possibilities of transformation but also highlight the importance of political economy for rapid and just transitions (Newell and Simms 2020; Newell 2021).

In summary, a synthesis of the multi-disciplinary, acceleration literature suggests that climate mitigation is a multifaceted problem which spans cross-economy and society issues, and that solutions to acceleration may lie in coordinated systemic approaches to change and strategic targeting of leverage points. Broadly, this literature agrees on a dual approach of non-incremental systemic change and a targeting of specific acceleration challenges, with tailored actions drawing on enabling conditions. The underlying argument of this is that there is a strategic logic to focusing on actions which undermine high carbon systems at the same time as encouraging low carbon systems. If high carbon systems are weakened then this may reduce the opposition to policies and actions aimed at accelerating climate mitigation, enabling more support for low carbon systems. In addition, targeting of actions which may create ‘tipping point cascades’ which increase the rate of decarbonisation may also be beneficial. Finally, new modes of governance may be better suited to this approach in the context of transformative change.

13.10 Further research

Research has expanded in a number of areas relevant to climate mitigation, yet there is considerable scope to add to knowledge. Key areas for research exist in climate institutions and governance, politics, policies and acceleration of action. In each area there is an overarching need for more *ex post* analysis of impact, more cases from the developing world, and understanding how institutions and policies work in combination with each other.

13.10.1 Climate institutions, governance and actors

- The different approaches to framework legislation, how it can be tailored to country context and evolve over time, how it diffuses across countries, and *ex post* analysis of its impact.
- Approaches to mainstreaming climate governance across sectors and at different scales, and developing governmental and non-governmental capacity to bring about long-term low-carbon transformations and associated capacity needs.
- The drivers of subnational climate action, the scope for coordination or leakage with other scales of action, and the effect, in practice on GHG outcomes.
- Comparative research on how countries develop NDCs, and whether and how that shapes national policy processes.

13.10.2 Climate politics

- The full range of approaches that governments and non-governmental actors may take to overcome lock-in to carbon-intensive activities including through addressing material endowments, cultural values, institutional settings and behaviours.
- The factors that influence emergence of popular movements for and against climate actions, and their direct and indirect impacts.
- The role of civic organizations in climate governance, including religious organisations, consumer groups, indigenous communities, labour unions, and development aid organizations.
- The relationship between climate governance approaches and differing political systems, including the role of corruption on climate governance.
- The impacts of media – traditional and social – on climate mitigation, including the role of disinformation.
- The role of corporate actors in climate governance across a broad range of industries.
- Systematic comparative research on the differing role of climate litigation across various juridical systems.

13.10.3 Climate policies

- Greater *ex post* empirical studies of mitigation policy outcomes, their design features, the impacts of policy instruments under different conditions of implementation, especially in developing countries. Such research needs to assess the effectiveness, economic and distributional effects, co-benefits and side effects, and transformational potential of mitigation policies.
- Understand how packages of policies are designed and implemented, including with attention to local context and trade-offs.
- Policy design and institutional needs for the explicit purpose of net zero transitions.
- Greater understanding of the differences between, and benefits of, policy packages and economy wide measures for in-system and cross-system structural change.
- Policies and packages for emissions sources that are unregulated or under-regulated, including industrial and non-CO₂ emissions.
- The existence and extent of carbon leakage across countries, the relative impact of different channels of leakage, and the implications of policy instruments designed to address leakage.

13.10.4 Coordination and acceleration of climate action

- How to ensure a just transition that gains wide popular support through research on actual and perceived distributional effects across countries and contexts.
- How to coordinate and integrate for climate mitigation, between what actors, sectors, governance scale and goals, and how to evaluate.
- Knowledge on the political and policy related links between adaptation and mitigation across sectors and countries.

- Further theoretical and empirical research on the necessary institutional, cultural, social and political conditions to accelerate climate mitigation.
- How to transform developed and developing economies and societies for acceleration, including by shifting development pathways.
- The approaches to, and value of, coordinated, cross economy structural change, including Green New Deal approaches, as a way to accelerate GHG reduction.

Frequently Asked Questions (FAQs)

FAQ 13.1 What roles do national play in climate mitigation, and how can they be effective?

Institutions and governance underpin mitigation. Climate laws provide the legal basis for action, organisations through which policies are developed and implemented, and frameworks through which diverse actors interact. Specific organisations, such as expert committees, can inform emission reduction targets, inform the creation of policies and packages, and strengthen accountability. Institutions enable strategic thinking, building consensus among stakeholders and enhanced coordination.

Climate governance is constrained and enabled by countries' political systems, material endowments and their ideas, values and belief systems, which leads to a variety of country specific approaches to climate mitigation.

Countries follow diverse approaches. Some countries focus on greenhouse gases emissions by adopting comprehensive climate laws and creating dedicated ministries and institutions focused on climate change. Others consider climate change among broader scope of policy objectives, such as poverty alleviation, energy security, economic development and co-benefits of climate actions, with the involvement of existing agencies and ministries. See also FAQ 13.3 on subnational climate mitigation.

FAQ 13.2 What policies and strategies can be applied to combat climate change?

Institutions can enable creation of mitigation and sectoral policy instruments; policy packages for low-carbon system transition, and economy wide measures for systemic restructuring. Policy instruments to reduce greenhouses gas emissions include economic instruments, regulatory instruments and other approaches.

Economic policy instruments directly influence prices to achieve emission reductions through taxes, permit trading, offset systems, subsidies, and border tax adjustments, and are effective in promoting implementation of low-cost emissions reductions. Regulatory instruments help achieve specific mitigation outcomes particularly in sectoral applications, by establishing technology or performance requirements. Other instruments includes information programs, government provision of goods, services and infrastructure, divestment strategies, and voluntary agreements between governments and private firms.

Climate policy instruments can be sector-specific or economy-wide and could be applied at national, regional, or local levels. Policymakers may directly target GHG emission reduction or seek to achieve multiple objectives, such as urbanization or energy security, with the effect of reducing emissions. In practice, climate mitigation policy instruments operate in combination with other policy tools, and require attention to the interaction effects between instruments. At all levels of governance, coverage, stringency and design of climate policies define their efficiency in reducing greenhouse gases emissions.

Policy packages, when designed with attention to interactive effects, local governance context, and harnessed to a clear vision for change, are better able to support socio-technical transitions and shifts in development

1 pathways toward low carbon futures than individual policies. See also Chapter 14 on international climate
2 governance.

3
4 **FAQ 13.3 How can actions at the sub-national level contribute to climate mitigation?**

5 Sub-national actors (e.g. individuals, organizations, jurisdictions and networks at regional, local and city
6 levels) often have a remit over areas salient to climate mitigation, such as land use planning, waste
7 management, infrastructure, housing, and community development. Despite constraints on legal authority
8 and dependence on national policy priorities in many countries, subnational climate change policies exist in
9 more than 120 countries. However, they often lack national support, funding, and capacity, and adequate
10 coordination with other scales. Sub-national climate action in support of specific goals is more likely to
11 succeed when linked to local issues such as travel congestion alleviation, air pollution control.

12 The main drivers of climate actions at sub-national levels include high levels of citizen concern, jurisdictional
13 authority and funding, institutional capacity, national level support and effective linkage to development
14 objectives. Subnational governments often initiate and implement policy experiments that could be scaled to
15 other levels of governance.

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