Module 4

The politics of climate change – towards a low-carbon world

1 Introduction

Modules 1 and 2 outlined the links between the environment and the economy, explained how human activities change the climate, and discussed the observed and anticipated impacts of climate change. Module 3 showed that climate change is the result of a large market failure that can only be corrected by policy interventions at the global level. Such a correction is not easy to achieve, however, because the world is composed of sovereign countries. These countries need to coordinate their efforts to transform their economies into low-carbon economies and thus limit greenhouse gas (GHG) emissions. However, as shown in Module 3, such coordination represents a collective action problem that is difficult to overcome. For the past 25 years, the international community has not found a convincing solution, as global GHG emissions continue to increase. Nevertheless, at the United Nations Climate Change Conference of the Parties in Paris (COP21) in 2015, the international climate change policy framework took a new and promising direction. This module provides an in-depth analysis of climate change policies and the international politics of climate change.[69]

[69] To do so, it relies on, among other sources, the work of the Intergovernmental Panel on Climate Change (IPCC) and on Barrett *et al.* (2015), who present a collection of studies and reviews on climate change policy.

Section 2 discusses the different policy instruments and technological solutions that could enable us to limit climate change. Section 2.1 focuses on policy measures that aim to stabilize the concentrations of greenhouse gases in the atmosphere. Such stabilization requires either reducing the flow of emissions reaching the atmosphere, or extracting the already-emitted greenhouse gases from the atmosphere. Section 2.1.1 discusses policies that aim to directly or indirectly decarbonize our economic systems by pricing CO_2, increasing energy efficiency, and substituting fossil fuels with alternative sources of energy.[70] Section 2.1.2 explains how policy could promote technological solutions to help capture and store already-emitted CO_2 emissions before they reach the atmosphere. Section 2.1.3 discusses the role of policies in promoting carbon geoengineering, a technology that could directly extract CO_2 out of the atmosphere. Unlike the other policy options to stabilize GHG concentrations, carbon geoengineering would not require transforming economies into low-carbon economies. After having discussed the different policy and technological options to stabilize GHG concentrations, Section 2.2 focuses on solar geoengineering, a technology that allows for reflecting additional incoming solar radiation back into space and thus stabilizing temperatures on the planet. While most of the policy measures discussed in Section 2 are subject to the collective action problem explained in Module 3, carbon geoengineering and solar geoengineering are not: they could be implemented by only a few nations. However, these technologies are not yet fully developed, their implementation may entail considerable environmental risks, and carbon geoengineering is currently expected to be very expensive.

[70] While the section focuses on policies capable of reducing CO_2, note that many of the policies discussed simultaneously also reduce other energy-related greenhouse gases like nitrous oxide.

In parallel with policies aimed at limiting climate change, which are discussed in Section 2, societies also need to undertake actions to adapt human and natural systems so that they are better prepared for the anticipated impacts of climate change. These policies are described in Section 3. Adaptation needs differ from one place to another because the anticipated impacts of climate change differ locally. The first step of any comprehensive adaptation policy thus should be to assess local risks and vulnerabilities in order to identify adaptation needs. Only then can specific adaptation options be selected and implemented. The section also presents a schematic overview of adaptation policies drawing on the IPCC's classification of adaptation options, and provides examples of adaptation measures implemented by developing countries.

After having described the different climate change limitation and adaptation policy options, Section 4 focuses on the international climate change policy architecture. The section reviews key international climate change policy developments and explains that of the policy instruments outlined in Sections 2 and 3, international climate change policy negotiations have so far focused mostly on those policy instruments that aim to limit the net flow of emissions. As explained in Module 3, these policy instruments are subject to a severe collective action problem. The section shows that up until now, international policy negotiations have been based on a top-down approach that has been unable to overcome this collective action problem. At COP21, the international climate change policy framework considerably changed with the adoption of the Paris Agreement. Unlike the past 25 years of international climate change policy, the Paris Agreement is based on a bottom-up approach. The section ends by discussing several key issues of the Paris Agreement, with a particular focus on the situation of developing countries.

At the end of this module, readers should be able to:

- Distinguish the two fundamental options to limit climate change;
- Describe different policy instruments to stabilize atmospheric GHG concentrations;

- Analyse advantages and disadvantages of the different policy instruments to stabilize atmospheric GHG concentrations;
- Understand how geoengineering could limit climate change;
- Evaluate the importance of climate adaptation policies;
- Describe the international climate change policy architecture;
- Evaluate the links between the Paris Agreement and development.

To support the learning process, readers will find several exercises and discussion questions in Section 5 covering the issues introduced in Module 4. Useful data sources and additional reading material can be found in Annexes 1 and 2.

2 Policy options and technological solutions to limit climate change

As explained in Section 4 of Module 2, the IPCC anticipates that, compared to the pre-industrial era, mean surface temperature on the planet will increase by roughly 4°C by the end of the 21st century if the world does not implement additional policies to limit climate change. This human-induced temperature increase is expected to trigger "severe, pervasive and irreversible impacts on people and ecosystems" (Field *et al.*, 2015: 62; see also Module 2). If climate change policies could limit the warming to less than 2°C above pre-industrial temperatures, these risks would be substantially reduced (IPCC 2014a, 2014b). Stabilizing temperatures at less than 2°C above pre-industrial levels is thus a crucial policy objective that is currently on the agenda of almost all countries (see Section 4).

To limit warming to 2°C and thereby avoid the main bulk of the negative effects of climate change, humankind has essentially two options (Edenhofer *et al.*, 2015). The first is to stabilize concentrations of greenhouse gases in the atmosphere (see Section 2.1). The second is to offset the expected temperature increase by increasing the amount of reflected incoming solar radiation using solar geoengineering technologies (see Section 2.2). The following sections discuss different policy instruments that could be used to implement both these options.

2.1 Policy instruments and technologies to stabilize concentrations of greenhouse gases in the atmosphere

IPCC (2014b) estimates that the atmospheric concentration of greenhouse gases in 2100 must be stabilized at below 450 parts per million (ppm) CO_2-equivalent (CO_2-eq)[71] if the increase in mean surface temperatures is to stay below 2°C. GHG concentrations can be stabilized by either reducing the flow of GHG emissions towards the atmosphere or by removing those gases from the atmosphere.

While all four major greenhouse gases contribute to the warming of the planet, stabilizing CO_2 concentration is of crucial importance, because climate perturbations from accumulated fossil-fuel-based CO_2 emissions last for thousands of years (Archer *et al.*, 2009). Recall as well that the fifth IPCC assessment report found an almost linear relationship between total cumulative CO_2 emissions emitted since the start of the industrial era and global mean surface warming (see Section 4 of Module 2). This implies that the larger the total sum of emitted CO_2 emissions (and hence the larger atmospheric CO_2 concentrations), the higher the mean temperature will be in the 21st century. Due to the importance of CO_2 in limiting climate change, this section mostly focuses on policies to stabilize the concentration of CO_2 in the atmosphere.[72]

CO_2 concentrations can be stabilized in three complementary ways (Barrett and Moreno-Cruz, 2015): (a) by gradually reducing anthropogenic CO_2 emissions to zero (see Section 2.1.1); (b) by capturing and storing CO_2 emissions before they reach the atmosphere (see Section 2.1.2); and/or (c) by reducing concentrations of CO_2 in the atmosphere through direct removal of CO_2 from the atmosphere (see Section 2.1.3).

The first two options affect the flow of emissions to the atmosphere by either reducing the amount of emitted CO_2 or by preventing the emitted CO_2 from reaching the atmosphere. Policy instruments available for this purpose are listed in Table 7 and further discussed in Sections 2.1.1 and 2.1.2. To meet the 2°C target with a probability of at least 66 per cent – taking all other human influences on the climate into account - IPCC (2014b) estimates that the above policies need to keep total cumulative CO_2 emissions since the start of the industrial era below 2,900 gigatonnes of CO_2 (GtCO2) by 2100. By 2014, roughly 2,000 $GtCO_2$ had already been emitted. Hence, if humans intend to reach the 2°C target, they have roughly 900 $GtCO_2$ left to emit in the future, all else being equal. This does not leave too much space for further emissions, as 900 $GtCO_2$ is equivalent to less than 25 years of emissions at the 2014 level (Edenhofer *et al.*, 2015). Policies aimed at emission reduction and emission capture and storage thus jointly need to limit future CO_2 emissions to 900 $GtCO_2$. Unfortunately, these policy options are subject to

[71] CO_2-equivalent concentration is a measure to compare radiative forcing of a mix of different greenhouse gases. It indicates the concentration of CO_2 that would cause the same radiative forcing as a given mixture of CO_2 and other greenhouse gases (IPCC, 2014c).

[72] Note, however, that several of these policies simultaneously address emissions of other greenhouse gases resulting from fossil fuel combustion

the collective action problem discussed in Module 3. This makes the prospects for transforming current carbon-based economies into low-carbon economies and thereby stabilizing atmospheric CO_2 concentrations below the 450 ppm CO_2-eq concentration level relatively bleak.

The third option is different. It does not reduce the flow of emissions towards the atmosphere as the first two options do, but lowers atmospheric CO_2 concentrations by directly removing the already emitted CO_2 from the atmosphere. As such, this third option – called carbon geoengineering – has the potential to stabilize CO_2 concentrations even if humans continue to emit CO_2 emissions as they do today. The most promising carbon geoengineering technology – industrial air capture (see Table 7) – will be discussed in Section 2.1.3. As we will see, collective action prospects are entirely different for this option.

Table 7

Selected policy options to stabilize concentrations of carbon dioxide in the atmosphere

Ways to stabilize CO_2 emissions	Policy category	Examples of policy instruments
Reducing CO_2 emissions	Price CO_2 emissions (directly or indirectly)	Carbon tax
		Cap and trade system
		Removal of fossil fuel subsidies
		Fuel taxation
	Energy conservation	Promotion of energy efficiency
	Fossil fuel substitution	Promotion of nuclear energy
		Promotion of renewable energy sources
Capturing and storing CO_2 emissions before they reach the atmosphere	Carbon capture and storage	Development and implementation of carbon capture and storage technologies
Directly removing CO_2 from the atmosphere	Carbon geoengineering	Promotion of industrial air capture technologies

Source: Author.

2.1.1 Policy instruments to reduce anthropogenic carbon dioxide emissions

We first look at policy instruments capable of reducing CO_2 emissions that have been at the centre of the international policy debate on climate change mitigation (see Section 4) and have been well known for several decades (see also Module 3). Generally speaking, there are three policy instrument categories directed towards reducing anthropogenic CO_2 emissions. The first contains policy instruments that put a price on carbon dioxide, the second consists of policy instruments that conserve energy, and the third contains policy instruments to directly decarbonize the energy system by substituting energy from fossil fuels with alternative energy sources.

2.1.1.1 Policy instruments that price carbon dioxide emissions

Module 3 showed that GHG emissions are a typical example of a negative externality. Economic actors do not directly bear the climate-change-related costs associated with the emissions, which they can dump free of charge into the atmosphere. Consequently, they produce too much GHG emissions. This externality problem can be partly corrected by putting a price on carbon. If economic actors have to pay a price for emitting CO_2, they directly bear (part) of the climate change-related costs associated with their emissions. As emitting CO_2 would then no longer be free of charge, economic actors would emit less emissions compared to a scenario without a price on carbon. Pricing carbon would reduce emissions not only directly by affecting the decisions of economic actors, but also indirectly by making investments in cleaner technologies and research and development (R&D) of new technologies more attractive. It is thus not surprising that the necessity of putting a price on carbon has been clear for a long time (Barrett *et al.*, 2015). Several policy instruments can be used to price carbon and thereby help decarbonize economies. The most important ones are carbon taxes, cap and trade systems, removal of fossil fuel subsidies, and fuel taxation.

Carbon taxes directly tax the amount of CO_2 emitted. The level of the tax is often expressed per tonne of CO_2 (e.g. US$50 per tonne of CO_2). Carbon can be taxed at various points of the energy supply chain. Usually one distinguishes between so-called upstream and downstream carbon taxes, although combinations of the two approaches are also possible (Wang and Murisic, 2015). Upstream carbon taxes impose a charge on producers or importers of raw materials such as coal, oil, or natural gas that contain CO_2 (Mansur, 2012). The levied charge is designed to be proportional to the amount of carbon contained in the raw material. As upstream carbon taxes directly tax fossil fuel producers or importers, the levies are subsequently passed forward and affect the economy-wide prices of electricity, petroleum products, and energy-intensive goods. Downstream carbon taxes impose a charge on direct sources of CO_2 emissions such as cars, power plants, energy-intensive industries, etc. (Mansur, 2012). The charge levied is proportional to the amount of CO_2 emitted by the source of the emission. A fully inclusive downstream carbon tax thus also affects all prices of commodities whose production or consumption processes involve the release of CO_2 emissions. One of the differences between the two types of carbon taxes is the amount of affected agents and hence the administrative simplicity: upstream carbon taxes are often imposed on relatively few firms (the fossil fuel producers and importers), while downstream carbon taxes, if they are fully inclusive, affect many different agents.

Economists consider carbon taxes the most cost-efficient policy instrument to reduce CO_2 emissions. In their recent review on different carbon pricing policy instruments, Sterner and Köhlin (2015: 252) note that a carbon tax is "generally more efficient than direct regulation of technology, products, and behaviour, as it affects consumption and production levels as well as technologies, it covers all industries and production and provides dynamic incentives for innovation and further emissions reductions. In addition, the tax revenue can be used to facilitate the transition toward renewable energy, cover administrative and implementation costs, or lower taxes on labour.... Furthermore, a tax is easy to incorporate in the existing administration." Besides these direct effects, carbon taxes can also generate considerable national co-benefits. One example of such a co-benefit of carbon taxes is improvement in health: carbon taxes decrease the use of coal and thus have the potential to reduce deaths related to air pollution (Parry *et al.*, 2014).

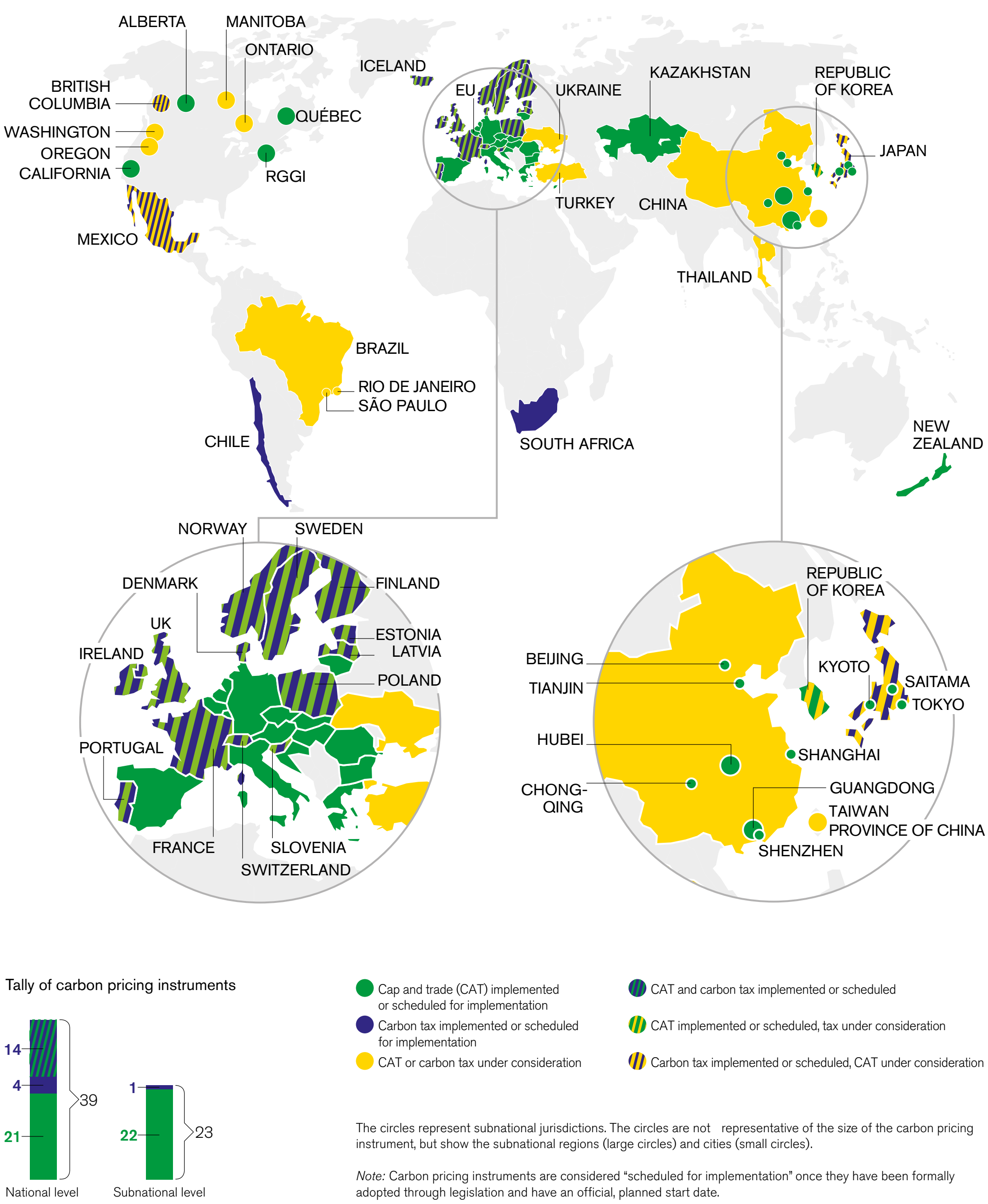
While carbon taxes are an appealing policy instrument from an economic point of view, they face severe political hurdles at the national level. Among them are (a) the presence of strong fossil fuel lobbies actively opposing implementation of carbon taxes; (b) pressure from the public to not implement carbon taxes in order to avoid increases in commodity prices; (c) a general perception that taxes reduce consumption and production and thereby induce welfare losses; (d) the fact that carbon taxes, unlike other policy instruments, clearly identify winners and losers of the policy, leading to stronger opposition; and (e) potential institutional preferences favouring other carbon pricing instruments (Sterner and Köhlin, 2015).

Despite these political hurdles, some countries have already implemented carbon taxes. Figure 36 presents an overview of countries that have implemented carbon taxes or cap and trade systems. Following Finland in 1990, several Northern European countries implemented carbon taxes in the early 1990s. By 2016, 16 countries and one subnational entity (the Canadian province of British Columbia) had implemented a carbon tax.[73] While most of these countries are developed ones, two developing countries (Mexico and South Africa) have implemented a carbon tax and a third one (Chile) plans to implement such a tax in 2017. However, only eight countries (Sweden, Finland, Switzerland, Norway, Denmark, Ireland, Slovenia, and France) and the province of British Columbia have a tax rate that is higher than US$10 per tonne of CO_2 (World Bank, 2015). To put this figure into perspective, most simulations suggest that a global average carbon price of US$80 to US$120 per tonne of CO_2 would be consistent with the 2°C target (World Bank, 2015). Sweden is currently the only country with a carbon price in this range, as it imposes a carbon tax of US$130 per tonne. This tax is by far the highest in the world – the second highest carbon price (US$65 per tonne) is in Switzerland. Hence, besides the fact that carbon taxes are only imposed on a fraction of global CO_2 emissions, there is also a large gap between the required and the actual price of carbon. Having said that, the Swedish experience does clearly illustrate that carbon taxes are effective in reducing CO_2 emissions, as shown in Box 15.

[73] Finland, Poland, Sweden, Norway, Denmark, Latvia, Slovenia, Estonia, Switzerland, Ireland, Iceland, Japan, France, Mexico, Portugal, and South Africa. Note that a 17th country (Chile) plans to implement a carbon tax in 2017.

Figure 36

Overview of implemented or scheduled carbon pricing policy instruments



Source: World Bank (2015: 11).

Note: The Regional Greenhouse Gas Initiative (RGGI) is a cooperative cap and trade effort among the US states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

Box 15

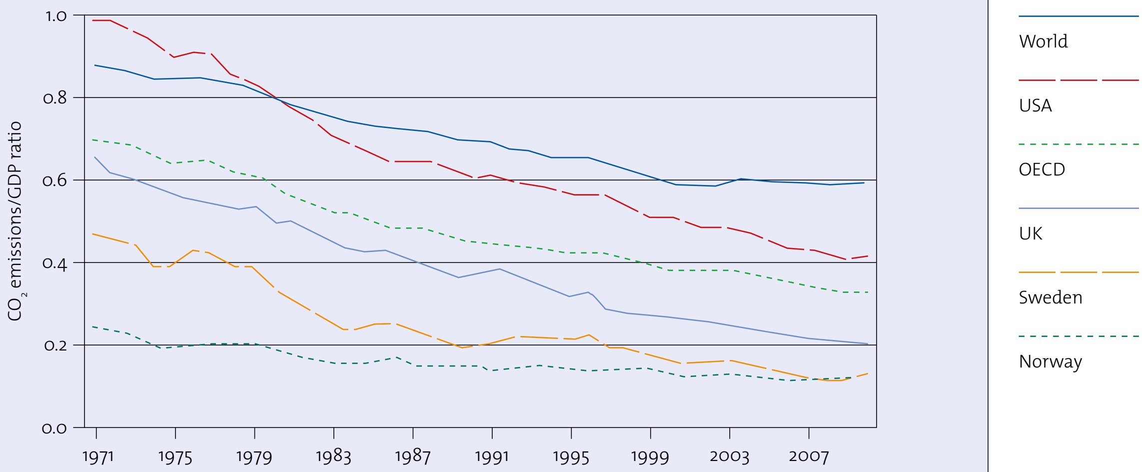
The results of the Swedish carbon tax

Sweden's carbon tax of US$130 per tonne (as of 1 August 2015) is the highest carbon tax worldwide to date. It particularly affects the Swedish transport sector, as the country taxes gasoline and diesel strictly in proportion to carbon emissions. It also applies to commercial use, residential heating, and partly to the industrial sector, which is, however, subject to a reduced tax rate (Sterner and Köhlin, 2015).

Given that Sweden also uses other climate change policies, it is difficult to precisely isolate the impact of the Swedish carbon tax on emissions. Nevertheless, Sterner and Köhlin (2015) note that the tax has achieved a cost-effective and efficient emission reduction over recent decades and has enabled the country to meet the commitments made in the Kyoto Protocol. Since 1990, Swedish CO2 emissions have declined by 22 per cent while the country's economy has been growing. Sterner and Köhlin thus note that the country has successfully managed to decouple domestic CO2 emissions and economic growth and thus made strides towards a low carbon-economy. As illustrated in Figure 37, Sweden's CO2 emissions per US dollar of GDP are about one-third of the world average and have been constantly declining for more than 40 years. Note, however, that this figure does not account for potential carbon leakage effects of the Swedish carbon tax (relocation of polluting industries towards countries with less stringent climate change policies and hence lower costs of emitting CO2).

Figure 37

Carbon dioxide emissions per unit of GDP



Source: Sterner and Köhlin (2015: 254).

Source: Author's elaboration based on Sterner and Köhlin (2015).
Note: OECD: Organisation for Economic Co-operation and Development.

A second policy instrument to price CO2 emissions is known as cap and trade (CAT) systems (also called emissions trading systems - ETS). Unlike carbon taxes, CAT systems do not directly regulate the price of CO2, but rather its quantity. Regulators decide on an upper limit of emissions that a country, region, or specific industry can emit (hence the "cap" in "cap and trade"), and then allocate permits to emit CO2 emissions to different firms. Each permit allows the firm to emit a certain quantity (often a tonne) of CO2. Each firm initially receives a certain quantity of permits, allowing it to emit a certain quantity of emissions. If the quantity emitted is smaller than the quantity of permits the firm possesses, the firm can sell its excess permits. If the quantity emitted is larger than the quantity of permits the firm possesses, the firm has to buy additional permits. In this way, a CAP system creates a market for CO2 emissions (hence the "trade" in "cap and trade"). The basic idea is to generate incentives for firms to reduce their emissions, as they can sell excess permits and make money out of emitting less. At the same time, the system penalizes firms that pollute too much, as they have to spend money to buy additional permits.

Regulators can allocate permits through auctions, free allocation, or a hybrid system that combines free allocation and auctions (Sterner and Köhlin, 2015). If the regulating authority decides to allocate permits by auction, it can generate extra revenue for the government and does not need to devise a specific mechanism for the allocation of permits to firms. If permits are allocated freely, no government revenue is raised, as firms do not have to pay to obtain the initial permits ("free allocation"). In that case, the regulating authority must determine how to distribute the permits. It can, for instance, allocate permits proportional to firm output or based on historical emission levels of firms. Regulators can adapt the cap over time, lowering the total quantity of emissions allowed to be emitted by issuing fewer permits, and thereby tighten the CAT system.

While CAT systems can in theory achieve any amount of emission reduction in a cost-effective way, they face considerable political obstacles, making stringent implementation difficult. Industry lobbying and fears that carbon prices might skyrocket and slow economic development often lead to a lax design of CAT systems with extremely high caps, resulting in only few emission reductions.

Several CAT systems are currently in place and more are scheduled for implementation (see Figure 36). The People's Republic of China, for instance, has already implemented several regional pilot CAT systems. Based on these pilots, it is planning to launch a national CAT system in 2017 that is expected to cover major industry and energy sectors (World Bank, 2015). The largest CAT system currently in place is the European Union's (EU) ETS, which was launched in 2005 and covers approximately 45 per cent of the EU's CO2 emissions (Sterner and Köhlin, 2005). The success of the programme has so far been mixed at best: most studies find evidence of only small if any emission reductions (Anderson and Di Maria, 2010; Bel and Joseph, 2015; Ellerman et al., 2010; Georgiev et al., 2011). The main reason for these mixed results lies in the design of the European system, which has led to issuance of too many permits during the first two phases of the programme (2005–2007 and 2008–2012). This oversupply of emission allowances resulted in an extremely low price of CO2 emissions, reaching even zero euros in 2007. The third phase of the programme, which started in 2013, aimed to correct these initial design flaws. The EU replaced the previous system of national caps with a single EU-wide cap that will be reduced annually by 1.75 per cent, made auctioning (instead of free allocation) the default rule to allocate permits, and included more sectors and gases in the system (European Commission, 2015). The European Commission is confident that due to these design changes, the system will achieve substantial emission reductions in the years to come.[74]

Carbon taxes and CAP systems are the main policy instruments to directly price CO2 emissions. Together, these instruments were applied in roughly 40 countries (including 10 developing and transition countries) and 20 subnational regions in 2015 (World Bank, 2015; see also Figure 36). In many cases both instruments were applied in a complementary way in the same country. The instruments put a price on roughly half of the emissions emitted in these countries and regions, which represent about 12 per cent of global emissions (World Bank, 2015). As long as the international carbon pricing landscape remains this fragmented, carbon leakage may be a major problem for all carbon pricing policy instruments (see Box 16). Based on (rather spare) existing empirical evidence, however, the World Bank (2015) notes that carbon leakage has so far not materialized on a significant scale and that it affects mainly sectors that are both emissions- and trade-intensive.

[74] The European Commission (2015) states that since the start of the third phase, emissions have fallen by 5 per cent and are expected to fall by 21 per cent in 2020 (compared to 2005) and 43 per cent in 2030 (compared to 2005).

Box 16

Carbon leakage, competitiveness, and carbon border tax adjustments

Domestic carbon pricing is a major policy instrument, allowing countries to reduce their domestic CO_2 emissions. In a world marked by a fragmented carbon pricing landscape, costs of emitting CO_2 differ widely among countries. This cost difference raises two major concerns (Flannery, 2016). First, countries that put a high price on CO_2 worry about the international competitiveness of their firms, as high carbon taxes are assumed to increase relative production costs and hence relative prices (especially in energy-intensive sectors). Second, countries worry that the impact their climate change policies have on global emissions might be limited by carbon leakage. Carbon leakage refers to the possibility that firms relocate their production or future investments towards countries with less stringent climate change policies and thereby shift their emissions to these countries.

While carbon leakage does not yet seem to have materialized on a significant scale (World Bank, 2015), and while results from empirical economic analysis suggest that the overall macroeconomic impact on competitiveness, investment, and employment is small and statistically insignificant compared to other factors (Aldy, 2016), policymakers worry about these two possible effects. One possibility to mitigate them is so-called carbon border adjustments (BAs). Kortum and Weisbach (2016: 2) define border adjustments as "taxes or other prices on imports and rebates on exports based on 'embedded carbon,' the additional emissions of carbon dioxide caused by production of a good. For imports, they can be thought of as the carbon tax that would have

Box 16

Carbon leakage, competitiveness, and carbon border tax adjustments

been imposed had the good been produced domestically (but using the production process and fuel that was actually used abroad). They therefore reduce the advantage of producing abroad and selling domestically because the carbon price is the same regardless of where production takes place. For exports, BAs are a rebate of the tax that was previously paid when the exported good was produced. By rebating previously paid taxes or carbon prices on exports, BAs reduce the disadvantage of producing domestically when selling into foreign markets."

Such border tax adjustments can limit potential leakage and competitiveness effects, but in turn they pose several difficulties and risks. BAs are administratively complex instruments that are difficult to design and implement (Flannery, 2016). A major challenge of designing BAs is to avoid conflict with World Trade Organization rules. Moreover, their effects on the welfare of the country imposing them are also difficult to estimate and not necessarily positive (Flannery, 2016).

Source: Author's elaboration based on Flannery (2016).

While carbon taxes and CAP systems are the main policy instruments to tax carbon directly, two other policy instruments can achieve this goal indirectly. The first is removing fossil fuel subsidies that encourage consumption of fossil-fuel-based energy, discourage investments in clean energy sources and energy efficiency, and impose large costs on governments (Sterner and Köhlin, 2015). Phasing out these types of subsidies is an administratively simple way of making carbon-based fuels more expensive, thereby indirectly pricing CO_2 and contributing to lower CO_2 emissions. The second policy instrument, directly linked, is fossil fuel taxation. While fossil fuel taxes do not tax fossil fuels in proportion to their carbon content, they still provide an effective way to indirectly tax CO_2 emissions in the transport sector. As such, they lower total consumption of fossil fuels as people adapt their behaviour (a fuel price increase of 1 per cent is estimated to lead to a reduction in fuel consumption of 0.7 per cent in the long run), create incentives for investments in fuel-saving technologies, and favour the development of energy-efficient cars (Sterner and Köhlin, 2015). Fossil fuel taxes such as taxes on petrol and diesel have been around for a very long time, are frequently applied, and have been well-studied. Reviewing various studies, Sterner (2007), finds that fuel taxation is the policy instrument that has had the highest impact on global carbon emissions.

2.1.1.2 Policy instruments that save energy

Policy instruments that increase the energy efficiency of economies can also contribute to reducing anthropogenic CO_2 emissions, especially if they are implemented together with carbon pricing instruments. By increasingly relying on energy-efficient technologies and thereby using less energy from fossil fuels, CO_2 emissions per US dollar of GDP can be substantially reduced. The emission reduction potential of energy conservation policies is large. For example, the International Energy Agency (IEA) estimated that if its 25 energy efficiency recommendations were implemented globally, up to 7.6 $GtCO_2$ per year (roughly 21 per cent of global CO2 emissions emitted in 2014) could be saved by 2030 (IEA, 2011).

IEA (2011) identified seven priority areas where increases in energy efficiency can substantially affect CO2 emissions. These areas include cross-sectoral energy efficiency increases, and sectoral energy efficiency increases in buildings, appliances and equipment, transport, lighting, industry, and energy utilities. A wide variety of policy instruments are available to increase energy efficiency in these areas, including the following (World Energy Council, 2013):

- Institutional approaches (e.g. setting up energy-efficiency agencies, energy- efficiency laws, or national energy-efficiency programmes);
- Product regulations (e.g. energy labels and/or minimum energy-efficiency standards for cars, buildings, domestic appliances and motors; or bans of specific energy-intensive products);
- Consumer regulations (e.g. mandatory energy audits for selected customers, energy-saving quotas, mandatory energy-consumption reporting, and energy-saving plans);
- Financial and fiscal measures (e.g. energy-efficiency funds, subsidies for energy audits by sector, subsidies or soft loans for energy-efficiency investment and equipment by sector, tax credits or deductions on cars, appliances, and buildings; accelerated depreciation for industry, tertiary or transport sectors; or tax reductions by type of equipment such as appliances, cars, lamps, etc.);
- Cross-cutting measures (e.g. voluntary agreements, mandatory professional training, or promotion of energy-saving companies).

While energy-saving policy instruments can reduce anthropogenic CO2 emissions, their potential to save energy and thus reduce CO2 emissions might be reduced by so-called rebound effects. Rebound effects can be illustrated by the following example: if you buy a more fuel-efficient car you will be driving more often, as you will have to pay less for fuel (Gillingham et al., 2013). Such behavioural changes in reaction to increased availability of energy-efficient technologies might offset parts of the energy-saving potential. However, the literature finds that rebound effects are too small to offset the energy-saving effects of energy-efficiency policy instruments (Gillingham *et al.* 2013).

2.1.1.3 Policy instruments that substitute energy from fossil fuels with alternative energy sources

These instruments aim to reduce the use of energy from fossil fuels and thus facilitate the decarbonization of the global energy system. IPCC (2014a) estimated that by 2100, the share of low-carbon energy sources (e.g. renewable energy sources or nuclear power) in total energy should increase from the current roughly 20 per cent to over 80 per cent. If this is not achieved, it is unlikely that the atmospheric GHG concentration in 2100 will stay below the level compatible with the 2°C temperature target. Fundamental progress in new and more efficient energy technologies is needed for such a transformation, as low-carbon energy technologies are currently not cost-competitive with fossil-fuel-based technologies when applied on a large scale (Toman, 2015).

While carbon pricing and some energy-saving policy instruments alter incentives of economic agents and thus indirectly promote investments in a low-carbon economy, the energy-substitution policy instruments try to directly promote the replacement of fossil-fuel-based energy with low-carbon energy. To decarbonize the energy system, policies need to stimulate the development and implementation of new low-carbon technologies. A priori, policies can promote two technological options: nuclear energy technologies and renewable energy technologies. While next-generation nuclear reactors might replace a share of fossil-fuel-based energy and address the cost and safety issues undermining current generation reactors (Toman, 2015), we focus in this section on the promotion of renewable energy technologies.

Renewable energy technologies – hydropower, wind and solar energy, tidal and wave energy, ocean and geothermal energy, and biomass energy – are expected to play a key role in decarbonizing the energy system (Bossetti, 2015). Renewables not only have the potential to substantially contribute to a low-carbon world, but might also generate important co-benefits, including (a) increased energy security due to more widely diversified energy sources; (b) reduced local pollution as fossil-fuel-based energy carriers such as coal are replaced; (c) promotion of green growth; and (d) new possibilities for development in many regions of the world, as renewables such as solar power are more evenly distributed globally than fossil fuels (Bossetti, 2015). For example, the African Development Bank (2015) estimates that Africa has enormous potential for renewable energy, and that its capacity for renewable energy generation could reach more than 10,000 gigawatts (GW) for solar energy, 109 GW for wind energy, 350 GW for hydro energy, and 15 GW for geothermal energy. The African Development Bank (2015) is confident that when the continent unlocks its full potential for renewable energy, it could tackle fundamental inefficiencies in its energy system, hugely expand power generation, and contribute towards the development goal of universal access to energy. Hence, policies facilitating the adoption, integration, and development of renewable energy sources play a key role in mitigating climate change and can also have huge co-benefits in terms of health and economic development.

The cost of renewable energy technologies can be considerably lowered by publicly funded R&D programmes and by providing incentives (e.g. tax incentives) for private programmes (Bossetti, 2015). These kinds of policies can directly promote development and adoption of renewable energy sources by making them more cost-competitive. A second way to promote adoption is to subsidize renewable energy technologies. Germany's *Energiewende* (see Box 17) is an example of probably the most aggressive subsidy policy to date favouring renewable energy sources. Demand-side promotion policies such as standards, energy certificates, or feed-in tariffs[75] are another policy option directly promoting adoption of renewable energy sources. Such policies have contributed considerably to the adoption of solar and wind power in Europe (Bossetti, 2015). Because renewable energy – unlike energy from fossil fuels - is highly unpredictable and volatile (depending, for instance, on weather conditions in the case of wind or solar energy), infrastructure has to be adapted. Hence, public investments in new energy storage and distribution infrastructure can facilitate the integration of renewables into the existing energy infrastructure.

[75] Feed-in tariffs are policy mechanisms that aim to provide long-term contracts to renewable energy producers based on the cost of the technology, thus stimulating investments in renewable energy production.

Box 17

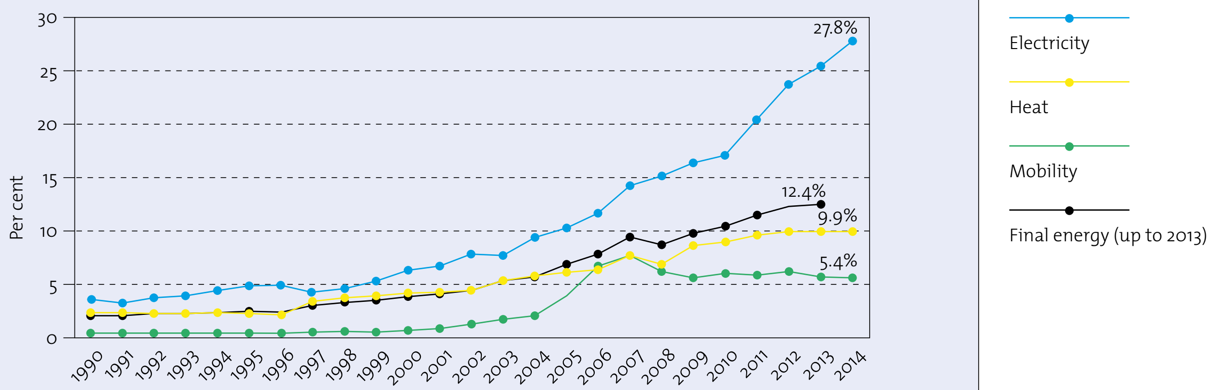
Germany's *Energiewende* policy

Germany has been pursuing an ambitious energy transformation policy for almost two decades based on massively subsidizing solar and wind energy. The policy, known as *Energiewende*, aims to achieve a transition from a coal- and nuclear-power-based energy system to a system relying on renewable energy. Germany intends to reduce its GHG emissions by between 80 and 95 per cent (compared to 1995) within the next four decades. To achieve this target, it plans to increase the share of renewable energy in totally consumed energy to 80 per cent and simultaneously increase energy efficiency by 50 per cent (Sterner and Köhlin, 2015).

From 2000 to 2015, Germany increased its share of renewable energy in the energy production sector from 6 to almost 30 per cent (Figure 38). However, the share of renewable energy in the production of heat (9.9 per cent) and transport (5.4 per cent) is still relatively low. Prices of renewable energy technologies have decreased substantially as a result of the massive subsidies and continue to do so (Sterner and Köhlin, 2015). However, CO2 emissions per kilowatt of produced energy have not yet dropped substantially, which Sterner and Köhlin attribute to the simultaneous phasing out of nuclear energy, which has required continued use of fossil fuel power stations.

Figure 38

Share of renewable energies in Germany's energy market



Source: BEE (2015: 1).

While the *Energiewende* policy has clearly reduced costs and promoted widespread adoption of renewables, the subsidies have also generated important costs for the German government and for German households.

Source: Author's elaboration based on Sterner and Köhlin (2015) and BEE (2015).

2.1.2 Policies to promote technological solutions to capture and store carbon dioxide emissions

Section 2.1.1 described different policy instruments to reduce the production of anthropogenic CO2 emissions. In addition to these emission reduction policy instruments, governments can also implement policies that aim to capture and store already-emitted CO2 emissions before they reach the atmosphere.

Carbon capture and storage (CCS) technologies capture CO_2 emissions from large sources such as coal power plants,[76] transport them to a carbon storage site, and store them there so that they do not reach the atmosphere (Tavoni, 2015). Different technological storage solutions are available, including geological and oceanic storage sites.[77] CCS has the capacity to make the ongoing large-scale use of fossil-fuel-based energy compatible with climate change mitigation targets: if CCS technologies could be sufficiently up-scaled, there would not be an immediate need to decarbonize the economy. Tavoni (2015: 344) notes in his recent review on CCS technologies and policies that "CCS could effectively allow for the procrastinated use of fossil fuels while limiting – if not eliminating – their impact in terms of greenhouse gas emissions." Given the appealing nature of CCS, it is not surprising that it plays an important role in the IPCC's climate mitigation strategies (IPCC, 2014a).

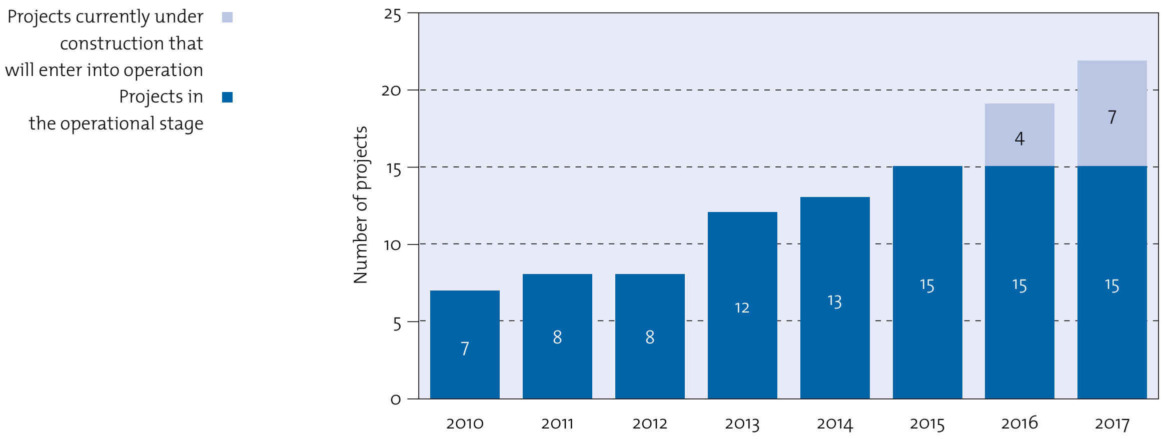
While CCS technologies generate high hopes as an alternative mitigation option to reduce the flow of emissions towards the atmosphere, the technology is still in the early phases of development. In 2016, only 15 large-scale CCS pilot projects were operational on a worldwide scale, with an additional four expected to enter into operation (see Figure 39). These large-scale projects are complemented by small-scale pilot projects. So far, the existing projects have the capacity to capture and store 28 million tonnes of CO_2 per year (Global CCS Institute, 2015).

[76] Theoretically, it is also possible to apply CCS technologies to biomass burning, which could remove CO_2 directly from the atmosphere, creating a so-called "negative emission technology" (Tavoni, 2015; see also Section 2.1.3). Biomass is a renewable resource which extracts and binds CO_2 out of the atmosphere during its process of growing. By burning biomass, CO_2 is emitted back into the atmosphere. If CCS technologies are applied to biomass burning, the CO_2 that biomass extracts from the atmosphere when it is growing could be captured and stored. This is one way to remove CO_2 from the atmosphere. See Section 2.1.3 for a discussion of other negative emission technologies.

[77] Most of these technologies store CO_2 in its supercritical form in geological or oceanic storage sites. Supercritical CO_2 is a fluid state of CO_2 in which it is held at or above its critical temperature and critical pressure.

Figure 39

Number of large-scale carbon capture and storage pilot projects per year



Source: Global CCS Institute (2015: 4).

It should be noted, however, that several technological, political, and economic problems would need to be solved in order to apply CCS technologies on a sufficiently large scale. First, it is still not clear which CCS technology works best and if it will be able to operate at the required scale. Policy measures are therefore required to launch and (partially) fund additional pilot projects to test the different CCS designs (Tavoni, 2015). To do so, it would also be necessary to overcome public fears opposing the installation of CCS infrastructure. This has led to the cancellation of CCS pilot projects in Europe in the past. It is also of crucial importance that storage solutions be safe and long-lasting, as leaking CO_2 escaping towards the atmosphere would undermine the entire purpose of CCS. Second, the economic viability of CCS projects has to be improved, as the cost of capturing a tonne of CO_2 is currently estimated at about US$100 (Tavoni, 2015). Policies to increase the price of carbon (thereby making higher-cost CCS technologies economically viable) and policies to fund R&D could help achieve such a cost reduction (Tavoni, 2015).

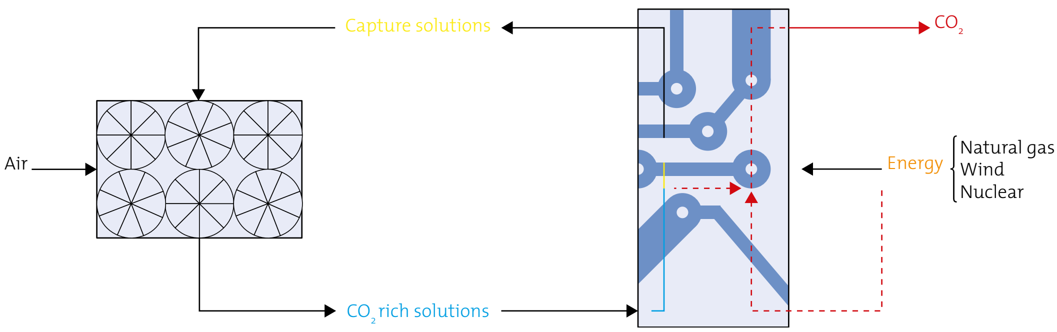
2.1.3 Policies to promote technological solutions aimed at removing carbon dioxide directly from the atmosphere

While Sections 2.1.1 and 2.1.2 discussed policy options to reduce the flow of emissions towards the atmosphere, this section discusses a policy instrument that aims to remove CO_2 directly from the atmosphere: carbon geoengineering.

Several technologies could remove CO_2 from the atmosphere. One of them, already briefly introduced in Section 2.1.2, is the application of CCS technologies to biomass. According to Barrett and Moreno-Cruz (2015), this approach could be useful but will be limited in scale by design. A second technology is industrial air capture, a carbon geoengineering technology that could be a viable alternative with the potential to be scaled up to any level (Barrett and Moreno-Cruz, 2015). Industrial air capture is a technology in which a capture solution (e.g. a chemical sorbent like alkaline liquid) is exposed to air, resulting in a chemical reaction removing CO_2 from the air. The CO_2 is subsequently filtered out of the CO_2-enriched capture solution and is stored in suitable storage sites while the chemical sorbent is recycled (Figure 40).

Figure 40

Direct industrial air capture system



Source: Carbon Engineering. Available at: *http://carbonengineering.com/air-capture.*

If industrial air capture is powered by renewable energy, the technology has the capacity to remove any amount of CO_2 from the atmosphere. If enough renewable energy is available to operate this technology on a sufficiently large scale, no other policies to stabilize CO_2 concentrations would be needed. As such, carbon geoengineering is considered to be the only true backstop technology to address climate change (Barrett and Moreno-Cruz, 2015). However, this technology can only be implemented provided it is further developed and available at an affordable cost.

Several studies reviewed in the survey by Barrett and Moreno-Cruz (2015) estimate the costs of removing a tonne of CO_2 through industrial air capture. These estimates range from US$30 per tonne up to US$600 per tonne. Barrett and Moreno-Cruz argue that if costs turn out to be as high as US$600 per tonne, the technology will not take off within a reasonable time frame. If, however, costs are as low as US$30 per tonne, the technology could revolutionize climate change policy and could even be implemented by a small coalition of countries. This coalition could unilaterally mitigate climate change (Barrett and Moreno-Cruz, 2015) by bypassing the collective action problem associated with conventional emission reductions, and emission capture and storage policies.

Because this technology is not yet on the table of climate change policy negotiations (see Section 4), and because there are still many unknowns about it, the first policy step should be to fund and coordinate R&D efforts to evaluate the costs and risks of industrial air capture technologies. Only if and when costs and risks are known can further policy instruments to promote carbon geoengineering be designed and implemented.

2.2 Policies to promote technological solutions aimed at increasing the amount of incoming solar radiation reflected back into space

Section 2.1 provided an overview of policy instruments to stabilize atmospheric GHG concentrations. Alternatively, however, humans could also try to offset the positive radiative forcing resulting from increasing GHG concentrations by reflecting more of the incoming solar radiation back into the space. This approach, known as solar geoengineering, is able to offset increases in mean temperature rather quickly. But it does not address certain other impacts of increased GHG concentrations such as ocean acidification (Barrett and Moreno-Cruz, 2015). For this reason, Barrett (2014) labels solar geoengineering a quick fix but not a true solution to climate change.

Solar geoengineering can be implemented in many ways. One option seems to be particularly promising in terms of costs: the injection of sulphate aerosols into the stratosphere. Barrett and Moreno-Cruz (2015) cite a study by McClellan *et al.* (2012) that provides an estimate of less than US$8 billion per year to offset the positive radiative forcing expected to occur over coming decades due to rising GHG concentrations. Unlike all other options, it seems that, in theory, even one willing country could implement such a solution single-handedly (Table 8).[78]

[78] This raises international governance questions, which today are far from settled. See Barrett and Moreno-Cruz (2015) for a short discussion on possible international governance frameworks.

Table 8

Comparison of policy options limiting climate change

Options	Objectives	Cost	Risks	Unknowns	Collective action
Substantial reduction of the flow of CO_2 emissions reaching the atmosphere	Reduce fossil fuel consumption and apply capture and storage technologies	High	Low	None	Difficult (see Module 3)
Carbon geoengineering	Reduce the concentration of CO_2 in the atmosphere	Very high	Moderate	Few	Coalition of the willing
Solar geoengineering	Limit solar radiation reaching the lower atmosphere	Low	High	Many	Easy, apart from governance

Source: Author's elaboration based on Barrett and Moreno-Cruz (2015).

However, as in the case of carbon geoengineering, many unknowns remain about solar geoengineering. Most importantly, the technology may entail severe environmental risks that are not yet (fully) understood (Barrett and Moreno-Cruz, 2015). Funding and coordinating R&D to assess the risks, feasibility, and efficiency of solar geoengineering is therefore needed before such technologies could be deployed.

Short summary

Section 2 reviewed the three fundamental policy options humans have to limit climate change: (1) substantial reduction of the flow of greenhouse gas emissions reaching the atmosphere, (2) direct removal of CO2 from the atmosphere by using carbon geoengineering, and (3) offsetting the positive radiative forcing resulting from increasing GHG concentrations by using solar geoengineering. These three options, including their expected costs, risks, unknowns, and the prospect of collective action, are summarized in Table 8. While policies to substantially reduce the flow of emissions (carbon pricing, promotion of renewables, conventional carbon capture and storage) are well known and entail only few risks, there are two main caveats regarding their implementation: associated costs are high and there are collective action problems. Despite this, actions to limit climate change have so far focused almost exclusively on these options, which have also been implemented by several developed countries and some developing countries. Carbon geoengineering could be an alternative to these policies because it could be implemented by only a handful of nations, thereby bypassing the collective action problem. However, the associated environmental risks and especially the costs are higher than those associated with policies to reduce the flow of emissions. Finally, solar geoengineering has the advantage of being easy to implement single-handedly by only one country and of having very low costs. At the same time, however, it does not address some impacts of climate change, and entails even higher environmental risks than carbon geoengineering.

3 Climate change adaptation policy options

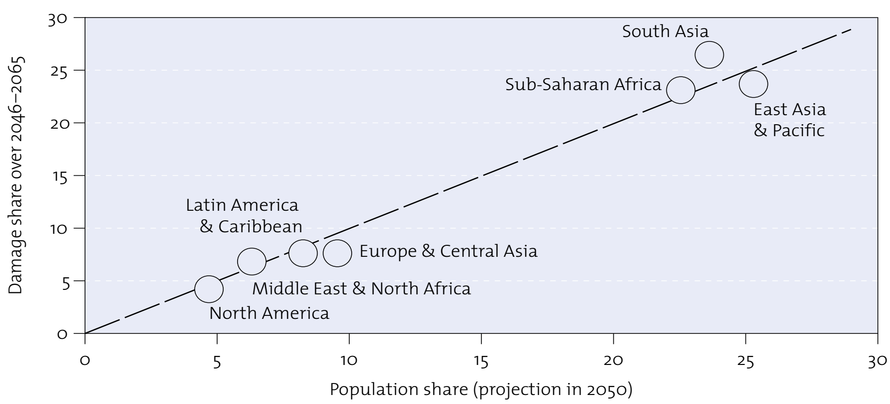
In addition to policies to limit climate change, humans can also try to reduce or even avoid the anticipated impacts of climate change by adapting to climate change. IPCC (2014c: 118) defines climate change adaptation as the "process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects."

Given that the anticipated impacts of climate change are expected to be largest in developing and least developed countries (see Module 2), adaptation policies are especially important for these countries. Drawing on Sauter *et al.* (2015, 2016), Figure 41 displays the projected population and damage shares of different regions.[79] Regions mostly composed of developing countries (especially South Asia, sub-Saharan Africa, and the Middle East and North Africa) are expected to have a higher share in world damages in proportion to their share in world population by 2050. In other words, these regions will most likely be over-proportionally affected by the impact of climate change. Regions mostly composed of developed countries (especially Europe and North America) are anticipated to have lower damage shares in proportion to their population shares. While these are only rough estimates, the numbers clearly indicate that adaptation policies are of crucial importance for developing countries.

[79] Sauter *et al.* (2015, 2016) used a rough proxy of potential damages based on predicted increases in extreme temperature events.

Figure 41

Potential climate change damage share in relation to population share by region in 2050 (per cent)



Source: Mekonnen (2015: 88), adapted from Sauter *et al.* (2015, 2016).

Humans have a long history of adapting to a changing climate. Throughout history, human beings have changed the locations or construction of their settlements, adapted their agricultural technologies, and changed entire economic processes in response to climate variations (Burton, 2006). Humans have been rather successful in doing so, but history also provides examples of local adaption failures that resulted in the collapse of entire societies (see Module 1). Adapting to human-induced climate change thus represents a new chapter in a long history of human adaptation to climatic conditions, but this time, the dimension of the challenge is global.

Climate change adaptation policies have gained increased attention recently. Since about 10 years ago, adaptation has figured more prominently on the international policy agenda as the failure of current policies to reduce emissions has become evident (Barrett and Moreno-Cruz, 2015). As will be shown in Section 4, these policies are currently one of the two main pillars of international climate change policy (the second pillar being policies to reduce the flow of emissions towards the atmosphere). Given that climate change impacts, risks, and vulnerabilities differ locally, different adaptation policies are needed in different places on the planet. The first step of any comprehensive adaptation policy therefore consists of assessing local risks and vulnerabilities in order to identify local needs (Noble *et al.*, 2014). Once local needs are known, the government can choose appropriate measures from a wide range of adaptation options. While a detailed discussion of all these options is out of the scope of this teaching material, we provide a schematic overview by using the IPCC's classification of adaptation measures.

Table 9 lists the three broad categories of adaptation options as classified in the fifth IPCC assessment report: structural and physical options, social options, and institutional options (Noble *et al.*, 2014).

Table 9

Categories and examples of adaptation options discussed in the fifth IPCC assessment report

Category		Examples of adaptation options
Structural and physical	Engineered and built environment	Seawalls and coastal protection structures; flood levees and culverts; water storage and pump storage; sewage works; improved drainage; beach nourishment; flood and cyclone shelters; building codes; storm and waste water management; transport and road infrastructure adaptation; floating houses; adjusting power plants and electricity grid
	Technological	New crop and animal varieties; genetic techniques; traditional technologies and methods; efficient irrigation; water-saving technologies, including rainwater harvesting; conservation agriculture; food storage and preservation facilities; hazard mapping and monitoring technology; early warning systems; building insulation; mechanical and passive cooling; renewable energy technologies; second-generation biofuels
	Ecosystem-based	Ecological restoration, including wetland and floodplain conservation and restoration; increasing biological diversity; afforestation and reforestation; conservation and replanting mangrove forest; bushfire reduction and prescribed fire; green infrastructure (e.g. shade trees, green roofs); controlling overfishing; fisheries co-management; assisted migration or managed translocation; ecological corridors; ex situ conservation and seed banks; community-based natural resource management; adaptive land use management
	Services	Social safety nets; food banks and distribution of food surplus; municipal services, including water and sanitation; vaccination programmes; essential public health services, including reproductive health services and enhanced emergency medical services; international trade
Social	Educational	Awareness raising; gender equity in education; extension services; sharing local and traditional knowledge, including integrating it into adaptation planning; participatory action research and social learning; community surveys; knowledge-sharing and learning platforms; international conferences and research networks; communication through media
	Informational	Hazard and vulnerability mapping; early warning and response systems, including health early warning systems; systematic monitoring and remote sensing; climate services, including improved forecasts; downscaling climate scenarios; longitudinal datasets; integrating indigenous climate observations; community-based adaptation plans, including community-driven slum upgrading and participatory scenario development
	Behavioural	Accommodation; household preparation and evacuation planning; retreat and migration, which has its own implications for human health and security; soil and water conservation; livelihood diversification; changing livestock and aquaculture practices; crop-switching; changing cropping practices, patterns, and planting dates; silvicultural options; reliance on social networks
Institutional	Economic	Financial incentives, including taxes and subsidies; insurance, including index-based weather insurance schemes; catastrophe bonds; revolving funds; payments for ecosystem services; water tariffs; savings groups; microfinance; disaster contingency funds; cash transfers
	Laws and regulations	Land zoning laws; building standards; easements; water regulations and agreements; laws to support disaster risk reduction; laws to encourage insurance purchasing; defining property rights and land tenure security; protected areas; marine protected areas; fishing quotas; patent pools and technology transfer
	Government policies and programs	National and regional adaptation plans; sub-national and local adaptation plans; urban upgrading programmes; municipal water management programmes; disaster planning and preparedness; city- and district-level plans and sector plans, which may include integrated water resource management, landscape and watershed management, integrated coastal zone management, adaptive management, ecosystem-based management, sustainable forest management, fisheries management, and community-based adaptation

Source: Noble *et al.* (2014: 845).

Structural and physical options include the use of engineering (e.g. building sea walls or coastal protection structures), the application of specific technologies (e.g. the use of new crop varieties resistant to local anticipated climate impacts or the implementation of early warning systems to prepare for the increased frequency of extreme weather events), the use of ecosystems and ecosystem services (e.g. assisted migration of threatened species or ecological restauration measures), and the delivery of specific services at various levels (e.g. the creation of food banks to counter anticipated food shortages or the implementation of vaccination programmes to limit expected health risks). Box 18 provides an example of a structural adaptation project in Bangladesh.

Box 18

Cyclone shelters and early warning systems in Bangladesh

Bangladesh has experienced a number of extreme weather and climate events over its history. According to the Intergovernmental Panel on Climate Change (IPCC), approximately 500,000 people died during a category 3 cyclone in 1970. In 1991, another category 3 cyclone killed 140,000 people.

As climate change increases, the likelihood of such extreme weather and climate events, including future cyclones, is probable. Bangladesh has therefore undertaken a collaborative process between local communities, government, and private organizations to implement adaptation measures. This collaboration has improved overall education about disasters (a social adaptation measure), deployed early warning systems based on high-technology information systems and measures such as training volunteers to distribute warning messages by bicycle (a structural and physical adaptation measure), and built a network of cyclone shelters (another structural and physical adaptation measure).

As a result of these adaptation efforts, Bangladesh was able to achieve a remarkable reduction in mortality: during the category 4 cyclone in 2007, 3,400 people died, considerably down from the 500,000 and 140,000 deaths recorded during the previously mentioned cyclones. The achievement is even more remarkable considering that the country experienced population growth of more than 30 million between the cyclone events.

Source: Author's elaboration based on Smith *et al.* (2014).

Social options aim to reduce local vulnerabilities of disadvantaged segments of the population and actively address social inequities (Noble et al., 2014). They include educational measures (e.g. awareness-raising and knowledge-sharing about adaptation planning), informational measures (e.g. the development and dissemination of improved climate forecasts to better identify risks), or behavioural measures (e.g. changing agricultural practices, switching crop varieties, or developing household evacuation plans). Table 9 outlined additional examples of social adaptation options. Box 19 provides an example of an adaptation project implemented in Bolivia that combines a behavioural measure with a structural measure.

Box 19

The *camellones* project in Bolivia

In Bolivia, the frequency of extreme weather events has increased in recent years and is expected to further increase in the future due to climate change. Increased frequency of floods particularly threatens the poor population living in remote rural areas of the country. Devastating floods in Beni in 2007 prompted people from locations around Trinidad to participate in a project known as *camellones* that was jointly implemented by the Kenneth Lee Foundation and Oxfam.

The project consists of a combination of behavioural adaptation – a change of an agricultural practice – and a structural adaptation – the building of the *camellones* platforms. The aim of the project was to avoid future agricultural losses due to increased occurrence of floods. Instead of using a conventional farming technique, the project implemented the *camellones* farming technique that is based on a traditional farming method. Several modern *camellones* were built in 2007 and have since been used for farming (see photo). These modern *camellones* are essentially earth platforms. Each platform measures roughly 500 m² and varies in height between 0.5 and 3 meters, depending on the predicted height of the local flooding and the area's capacity for water run-off (Oxfam, 2009). Because these platforms are above the flood levels, they protect the crops from the flood. The ditches surrounding the *camellones* become canals in the event of a flood and act as an irrigation and nutrient source during the dry season (Oxfam, 2009).

Box 19

The *camellones* project in Bolivia

***Camellones* in Bolivia**

Source: *http://valorandonaturaleza.org/noticias/manejo_precolombino_de_ecosistema_amaznico_*

As a result of the new agricultural practices, farmers did not lose their crops and seeds during floods in 2008. The system seems to be a sustainable solution to address increased flooding, and it also preserves water for times of drought, acts as a natural seed bank, and improves soil quality and ultimately food security (Oxfam, 2009).

Source: Author's elaboration based on Oxfam (2009).

Institutional options aim to increase the potential for adaptation (Noble et al., 2014) through a variety of economic measures (e.g. disaster contingency funds or financial incentives to implement adaptation options), legal and regulatory measures (e.g. mandatory building standards, or laws to encourage contracting and insurance), and governmental plans and programmes (e.g. national and regional adaptation plans to coordinate adaptation efforts). Table 9 listed additional institutional options. An example of an institutional adaptation policy is provided in Box 20.

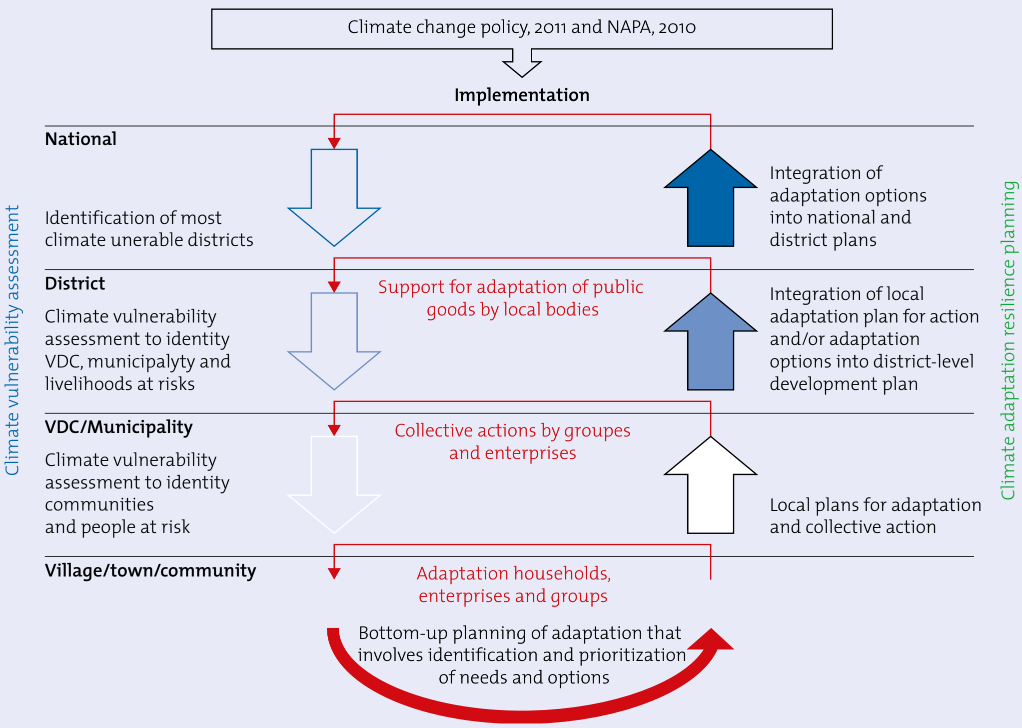
Box 20

Nepal's National Framework on Local Adaptation Plans for Action

In 2011, Nepal adopted the Nepal National Framework on Local Adaptation Plans for Action (LAPA). The LAPA framework aims to integrate climate adaptation into local and national development planning processes in a bottom-up, inclusive, responsive, and flexible manner (Government of Nepal, 2011). Figure 42 outlines schematically how climate adaptation actions are integrated into and harmonized with local and national planning. The LAPA framework foresees seven steps: (1) information gathering; (2) vulnerability and adaption assessment; (3) prioritization of adaptation options; (4) formulation of LAPAs; (5) integration of LAPAs into local planning processes; (6) implementation of LAPAs; and (7) assessment of the progress of LAPAs. These steps are followed by implementation of a village- or district-specific LAPA (Government of Nepal, 2011).

Figure 42

The local adaptation plans for action framework



Source: Government of Nepal (2011: 6).
Note: NAPA: National Adaptation Programme of Action; VDC: Village Development Committees.

By 2014, a total of 70 LAPAs had been prepared (69 at the village level and one at the municipality level) and implemented by the affected communities (Mimura *et al.*, 2014).

Source: Author's elaboration based on Government of Nepal (2011) and Mimura *et al.* (2014).

Identifying adaptation needs and implementing adaptation options is costly and requires funding. As risks and vulnerabilities and thus adaptation needs are unevenly distributed and are often highest in poor countries, local adaptation requires globally coordinated financing. As Section 4 will show, negotiations on adaptation financing are a central part of global climate change negotiations.

Short summary

Section 3 reviewed adaptation policies that aim to reduce or even avoid the anticipated impacts of climate change by adapting economies to climate change. Given that climate change impacts, risks, and vulnerabilities differ locally, different adaptation policies are needed in different places on the planet. The section explained that the first step of any comprehensive adaptation policy therefore consists of assessing local risks and vulnerabilities in order to identify local needs. Once local needs are known, the government can choose appropriate measures from a wide range of adaptation options. The section also highlighted that adaptation policies are especially important for developing and least developed countries, as the anticipated impacts of climate change are expected to be largest in these countries.

4 The international climate change policy architecture

Having discussed the different options for climate change limitation and adaptation policies, we now turn our attention towards the international climate change policy framework. Multilateral climate change negotiations to date have mainly focused on emission reduction policies and, more recently, have also started to integrate adaptation policies. We structure our discussion around three milestones in the development of the multilateral climate change policy framework: (a) the signature of the 1997 Kyoto Protocol, which was the first substantial international agreement to reduce GHG emissions by establishing country-specific, legally binding emission targets for developing countries; (b) the failure of the COP15 in Copenhagen that marked the end of the Kyoto Protocol approach; and (c) the successful conclusion of the COP21 in Paris, which marked the start of a new era of international climate policy architecture. Unlike what has happened over the past two decades, the Paris Agreement does not impose legally binding emission targets for developed countries, but rather is built on voluntary national contributions by all countries. As such, it represents a major change from the Kyoto Protocol approach, which had a more limited scope albeit high ambitions, to a regime based on broad participation, even if its ambitions are initially relatively modest.

4.1 From Rio to Paris – 25 years of climate change negotiations[80]

The 1992 Conference in Rio adopted the United Nations Framework Convention on Climate Change (UNFCCC), which required signatory countries to undertake national inventories of GHG emissions and develop action plans to reduce national emissions. Signatory countries of the UNFCCC then held yearly conferences (called Conferences of the Parties - COPs) starting in 1995. From the very beginning of the UNFCCC process, a key principle guiding the negotiations was that of common but differentiated responsibilities. This principle is enshrined in Principle 7 of the Rio Declaration on Environment and Development:

> “In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.”

In other words, the principle of common but differentiated responsibilities takes into account that the bulk of cumulative human-induced GHG emissions have been emitted by the current developed countries. For this reason, these countries should bear a greater responsibility in solving the climate change issue.

The Kyoto Protocol was the first substantial international agreement to reduce GHG emissions. Signed at the COP3 in Kyoto in 1997, it fully embraced the principle of common but differentiated responsibilities (Flannery, 2016). The protocol used the UNFCCC classification of countries into Annex I, Annex II, and Non-Annex I Parties. Annex I Parties encompassed industrialized member countries of the Organisation for Economic Co-operation and Development (OECD) as of 1992 and countries with economies in transition (EIT Parties), which included Russia, Central and Eastern European countries, and Baltic countries. Annex II Parties consisted of a subset of Annex I countries, namely those countries that were members of the OECD in 1992. Non-Annex I Parties were mostly developing countries.

Based on this country classification, the Kyoto Protocol imposed legally binding mitigation targets for Annex I Parties and established a market mechanism to facilitate reductions in GHG emissions. In accordance with the principle of common but differentiated responsibilities, it excluded all developing countries (Non-Annex I Parties) from any legally binding obligation to reduce emissions. Moreover, it imposed an obligation on Annex II parties to provide financial support to Non-Annex I Parties.

The Kyoto Protocol used the so-called top-down approach (Flannery, 2016): negotiations conducted at the international level focused essentially on determining country-specific, legally binding emission targets for Annex I countries. Each country then had to implement the required emission reductions using suitable policy instruments (many of which were described in Section 2.1). The overall goal of the protocol was to reduce emissions of all major greenhouse gases by 5 per cent by 2012 relative to 1990.

To enter into force, the Kyoto Protocol needed to be ratified by at least 55 countries, responsible for at least 55 per cent of 1990 CO_2 emissions. While it was signed in 1997, the required conditions for entering into force were only met in 2005. The first phase of the protocol thus started in 2005 and was set to end in 2012. The United States, at the time the country with the highest GHGs emissions worldwide, never ratified the protocol.

80 This section draws on Flannery (2016).

Its absence from the Kyoto Protocol illustrates the collective action problem (see Module 3) and has been one of the factors that considerably weakened the Kyoto process.

After 2005, efforts quickly concentrated on negotiating the roadmap for future developments to shape international climate change policy after the first commitment phase of Kyoto expired in 2012. During COP13 in Bali in 2007, a roadmap was agreed upon with two key points. The first was to prepare a second Kyoto commitment period with legally binding emission reductions for Annex I Parties for the COP15 to be held in Copenhagen. The second was to open negotiations for a new agreement involving all UNFCCC parties. According to Flannery (2016), it was this latter decision that signalled, for the first time, that the principle of common but differentiated responsibilities could evolve.

The COP15 in Copenhagen in 2009 resulted in an outcome that many observers qualified as a failure: the conference did not agree on a legally binding extension of the Kyoto Protocol. Flannery (2016: 72) states that by failing to reach such a legally binding extension, "Copenhagen dealt a deathblow to the top-down approach in which nations negotiated terms for one another's actions as the basis for agreement. Going forward, national pledges will be based on voluntary submissions that reflect national circumstances and priorities." Such an approach based on voluntary national contributions is generally called a bottom-up approach. In retrospective, Copenhagen indeed marked the end of top-down approaches in international climate change negotiations. Such an outcome could have been anticipated, however, as many heads of state (including those of the United States and the People's Republic of China) had announced earlier that they would not sign a legally binding agreement. After the Copenhagen failure, negotiations remained stalled for several years. It was only in 2012 at the COP18 in Doha that there was agreement on a second Kyoto commitment period (until 2020).

With regard to global GHG emissions, the top-down approach of the Kyoto Protocol can be considered a failure (Barrett *et al.*, 2015): the IPCC notes that while the group of Annex I countries indeed managed to collectively meet their Kyoto target by reducing their aggregate emissions more than 5.2 per cent below 1990 levels by 2012, these reductions were largely offset by emission growth in Non-Annex I countries (Stavins *et al.*, 2014).[81] Consequently, global GHG emissions, instead of being reduced, have been growing at an unprecedented rate over the past two decades.

In parallel with negotiations on a second Kyoto commitment period, negotiations were taking place to develop a post-2020 climate change policy framework. To this end, the COP17 in Durban established the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP) with a mandate to (a) increase the ambition of the climate change limitation policy for the pre-2020 period, and (b) negotiate a global agreement for the post-2020 period by 2015 (Flannery, 2016). Compared to the political landscape of the 1990s that led to adoption of the Kyoto Protocol, the situation has changed considerably. Besides the obvious failure of the top-down approach of the Kyoto Protocol, GHG emissions from developing countries have been growing rapidly. While the United States had been the largest emitter of CO_2 until the mid-2000s, the People's Republic of China has been the largest emitter since 2005. Other developing countries such as India are currently also among the top emitters worldwide. Following intense negotiations, the ADP's work ultimately led to the outcome of the COP21: the Paris Agreement.

4.2 The Paris Agreement

Negotiations for a post-2020 climate change framework initiated by the ADP concluded successfully in 2015 with the adoption at COP21 of the Paris Agreement. The agreement brings the 197 parties to the United Nations Framework Convention on Climate Change (all United Nations Member States, the State of Palestine, the Cook Islands, Niue and the European Union) under a common legal framework. This represents a change from the Kyoto Protocol, which had a more limited scope, albeit high ambitions, to a regime based on broad participation, even if ambitions initially are relatively more modest. This departure from the past two decades of a top-down climate policy, which suffered from limited coverage of only a small subset of countries required to cut emissions, towards a bottom-up framework, which involves all UNFCCC parties, is important given the paramount significance of long-term action by all countries to address climate change.

Together with the new architecture combining bottom-up Nationally Determined Contributions (NDCs) – i.e. national commitments to reduce GHG emissions, with top-down procedures for reporting and synthesis of NDCs by the UNFCCC Secretariat – the Paris Agreement represents significant progress towards a climate regime that could limit climate change. Prior to the Paris Conference, 186 parties had submitted Intended Nationally Determined Contributions (INDCs),[82] and

[81] This growth can be partially attributed to carbon leakages from developed countries.

[82] Note that INDCs became NDCs when the Paris Agreement was concluded.

two more did so during the conference, bringing the total to 188 INDCs. The Paris Agreement will take effect in 2020 when the Kyoto Protocol ends. In the interim, parties agreed to promote climate action, ramp up financing, and begin implementation of their climate plans. They will have an opportunity, as part of a collective review in 2018, to update these plans. Equally important is the fact that the private sector has been involved in a major way in contributing to climate action. Over 5,000 global companies in 90 countries covering all industrial sectors pledged actions to combat climate change.

It is important to note that the new policy architecture incorporates several elements that have been identified by game theory models (see Module 3) as being able to increase cooperation. NDCs can be viewed as national commitments to reduce emissions (to some extent) regardless of what other countries are doing. If they turn out to be credible commitments, they will be a key element fostering cooperation. The financial transfer mechanisms and the repeated follow-up procedures (see Section 4.2.2), as well as the prospect of linking development and climate change policy issues (see Section 4.2.3), are additional elements that strengthen cooperation under the Paris Agreement. So far, these elements seem to have positively affected the agreement's signature and ratification process. The Paris Agreement was opened for signature on 22 April 2016. By 29 June 2016, 179 countries had signed it. To date, 19 of the 179 signatories have also deposited their instruments of ratification, acceptance, or approval, accounting in total for 0.18 per cent of total global GHG emissions (UNFCCC, 2016). According to Article 21, §1, of the Paris Agreement, the agreement will enter into force 30 days after the date on which at least 55 parties to the convention, accounting in total for at least 55 per cent of total global GHG emissions, have deposited their instruments of ratification, acceptance, approval, or accession with the Depositary.[83]

Similar to the Kyoto Protocol, the Paris Agreement reflects the principle of common but differentiated responsibilities and thus takes on board the equity and fairness concerns of developing countries. The following sections review the content and the ambition of the agreement, explain the follow-up procedures, and discuss climate financing.

4.2.1 Objectives of the Paris Agreement

Parties to the agreement aim to limit "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (Article 2.1.a of the agreement). This formulation represents a win for small island developing states and other developing nations that argue that a temperature increase above 1.5°C would be devastating for them.

Parties also aim to "reach global peaking of GHG emissions as soon as possible," without specifying a date. They will "undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" (Article 4.1). This does not mean that emissions would go to zero, but that they would go low enough that they could be offset by natural processes or advanced technologies that are able to remove greenhouse gases from the air (see Sections 2.1.2 and 2.1.3).

Put simply, the Paris Agreement requires any country that ratifies it to act to stem its GHG emissions in the coming century, with the goal of peaking GHG emissions "as soon as possible" and continuing the reductions as the century progresses. Parties will aim to prevent global temperatures from rising more than 2°C by 2100 with an ideal target of keeping the temperature rise below 1.5°C.

4.2.2 Follow-up procedures and financing

The Paris Agreement calls on all countries to submit a new NDC every five years (Articles 3, 4, 7, 9, 10, 11, and 13) that should represent a "progression" over the prior one, and should reflect the country's "highest possible ambition" (Article 4.3). This process is crucial, because the commitments in current NDCs are not sufficient to limit warming to below 2°C, much less 1.5°C. The UNFCCC Secretariat's assessment of the collective impact of over 146 INDCs submitted by 1 October 2015 (i.e. prior to the Paris Conference) concluded that they will result in a fall in global emissions and keep the rise in global warming to around 2.7°C by 2100. While not enough to avert a dangerous warming of the earth, these commitments are important steps forward.

Implementation of the agreement will be assessed at "global stocktakes" every five years, with the first global stocktake scheduled for 2023 (Articles 14.1 and 14.2).

In addition to climate change mitigation, the agreement also stipulates that countries will "engage in adaptation planning processes" (Article

[83] Note that the agreement specified the Secretary-General of the United Nations as Depositary. He or she will be responsible for ensuring the proper execution of all treaty actions related to the agreement.

9) to ensure that they are ready to cope with the effects of climate change. For impacts to which countries cannot adapt, the agreement contains a "loss and damage" section, suggesting that these cases will be addressed through a variety of means including "risk insurance facilities, climate risk pooling and other insurance solutions" (Article 8.4.f). This provision is another key win for small island states and other vulnerable developing nations.

The agreement states that developed countries "shall provide financial resources to assist developing country parties with respect to both mitigation and adaptation" (Article 9.1) – i.e. to help them brace for impacts and shift to cleaner energy systems. The text suggests, however, that wealthier developing countries can also contribute such funds if they so choose. Several such countries have considered doing so (e.g. Brazil), and the People's Republic of China has already pledged to provide US$3.1 billion over a three-year period. Developed countries should report on their climate donations every two years (Article 9.5). Such financial assistance will to a large extent determine the level of implementation of NDCs by developing countries. The commitment of developing countries to address climate change is thus largely contingent on financial assistance from wealthier countries.

In this context, developed countries should continue their existing collective financing mobilization goal agreed upon in Cancún at COP16 through to 2025. That goal was to provide funds equal to US$100 billion per year by 2020. Prior to 2025, the parties to the Paris Agreement shall set a new collective quantified financing goal of at least US$100 billion per year, taking into account the needs and priorities of developing countries (Article 9, §3, Decision 54). To put this goal of US$100 billion per year into perspective, note that available climate financing in 2014 was estimated at US$62 billion (Mai *et al.*, 2016). As Figure 43 shows, roughly one-third of this amount came from multilateral sources, slightly more from bilateral sources, and the remaining part from private sources. Considerable efforts will thus have to be made to reach the US$100 billion per year target by 2020.

Figure 43

Estimated climate financing in 2014

Targets and (actual and potential) sources of climate finance		
Goals for 2020	Mobilize from advanced economies US$100 billion per year for climate mitigation and adapatation in developing countries by 2020	
Actual flows in 2014	US$23.1 bn	Bilateral (e.g Official development assistance)
	US$20.4 bn	Multilateral (moslty Multilateral development banks)
	US$16.7 bn	Private finance (leveraged from public sources
	US$1.6 bn	Export credits (mainly for renewable energy
	US$61.8 bn	Total flows
Potential extra revenues	US$25 bn	\$30/ton CO2 charge, advanced economy domestic fuels (7 per cent apportioned).
	US$25 bn	\$30/ton CO2 charge, international aviation/maritime fuels.[a]

Source: Mai *et al.* (2016: 28)
[a] Includes only revenues from developed countries.

Financial resources to support climate mitigation and adaptation actions in developing countries are managed by four funds: the Green Climate Fund, the Global Environment Facility, the Least Developed Countries Fund, and the Special Climate Change Fund (Decision 59). While raising the required US$100 billion per year is clearly the most pressing challenge, several other challenges remain on the spending side and still need to be addressed. Mai *et al.* (2016: 27) note that there "are concerns on the spending side about the balance between mitigation and adaptation (currently most is on the former), allocating funding across countries and projects accounting for efficiency and equity, and avoiding paying for projects that would have gone ahead without funding."

4.2.3 Paris Agreement and development

Compared to the previous climate change policy architecture, the Paris Agreement marks a change for developing countries: they are now also called upon to implement climate change limitation policies by submitting their own NDCs, which was not the case under the Kyoto Protocol. These countries have a strong interest in limiting climate change, as they are overproportionally exposed to the associated risks (see Module 2 and also Section 3 of this Module). However, they also have a strong interest in rapid economic growth that would allow them to eradicate poverty and increase standards of living (Collier, 2015).

To pursue these two objectives simultaneously, the transformation towards low-carbon and resource-efficient economies must proceed in a way that allows for decoupling economic growth and social development from climate change. UNCTAD (2015: 1) notes that for developing countries, "such a decoupling should facilitate, and not undermine, opening new trade and investment opportunities, generating jobs, growing national economies, widening access to basic necessities and essential services and reducing poverty." To be able to achieve these objectives while limiting climate change, developing countries thus firmly demanded the inclusion of the principle of common but differentiated responsibilities in the Paris Agreement.

Given that they succeeded and that the Paris Agreement is built upon this principle, developing countries can count on financial and technological support from developed countries to implement their NDCs. The financial transfer mechanisms aiming at transferring at least US$100 billion per year from developed to developing countries by 2020 is one of the two key factors expected to enable developing countries to implement their NDCs. Technology transfer from developed to developing countries in areas such as renewable energy and energy conservation technologies is the second key factor for successful implementation of developing countries' NDCs. Financial and technological transfers should jointly ensure that the implementation of NDCs does not hurt developing countries' growth prospects.

Several observers are confident that due to the finance and technology-transfer mechanisms developing countries might not only be able to contribute to limit global GHG emissions by implementing their NDCs, but could also benefit from important co-benefits of these policies. The African Development Bank (2015: 3) notes that the need to respond to climate change represents "an opportunity to drive the economic transformation that Africa needs: climate-resilient, low-carbon development that boosts growth, bridges the energy deficit and reduces poverty. Climate change gives greater urgency to sound, growth-stimulating policies irrespective of the climate threat." The African Development Bank (2015) identifies several important co-benefits in different sectors. The African energy sector could greatly benefit from a transformation towards renewable energies, which could tackle fundamental inefficiency in Africa's energy systems and generate important investment opportunities. A second set of major co-benefits relates to the agricultural sector. Implementation of climate-smart agriculture could increase Africa's annual agricultural output from the current US$280 billion to an estimated US$880 billion by 2030, which would offer the potential to increase food security and generate jobs (African Development Bank, 2015). The third major set of co-benefits lies in low-carbon and climate-resilient investments in African cities. Such investments could make cities less vulnerable to anticipated climate change impacts, and also improve economic productivity, security, air quality, and public health, as well as reduce poverty (African Development Bank, 2015). The combination of finance and technology-transfer mechanisms with policies that help mitigate climate change and also produce significant co-benefits stimulating growth is thus key for the successful transformation of developing economies into low-carbon economies.

Many developing countries were among the first parties to sign the Paris Agreement: 18 of the 19 countries that had ratified the agreement as of this writing are developing countries. Many developing countries have also already submitted detailed NDCs. Box 21 briefly illustrates the objectives and approaches of the NDC of one such developing country, Kenya.

Box 21

Kenya's Nationally Determined Contribution objectives and approaches

Kenya's experience is typical for a lower-income country that aspires to high growth but also wants to pursue climate change policies. According to Kaudia (2015), Kenya's GHG emissions were estimated to be 73 $MtCO_2$-eq in 2010, with roughly 75 per cent of them attributable to activities such as agriculture, forestry, and free-range rearing of livestock. Historically, Kenya's contribution to cumulative global GHG emissions has been very low, ranging around 0.1 per cent, with cumulative per capita emissions of less than 1.26 $MtCO_2$-eq (the global average is 7.58 $MtCO_2$-eq). Kaudia (2015) notes that the country plans to attain 10 per cent GDP growth by 2030, which would double its emissions if no additional climate change policies were implemented. The Intended Nationally Determined Contribution Kenya submitted before the COP21 in Paris foresees reducing the country's emissions by 30 per cent compared to their 2014 levels (see the low-carbon pathway in Figure 44). Kenya thus intends to pursue ambitious growth while simultaneously committing to an ambitious emission reduction goal.

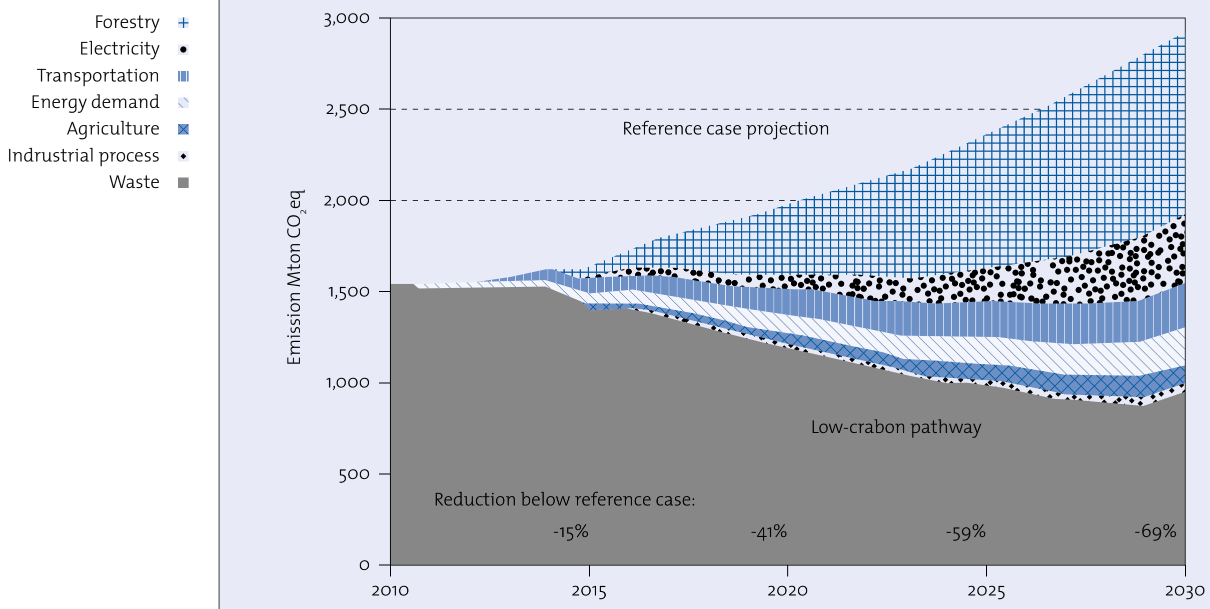
Box 21

Kenya's Nationally Determined Contribution objectives and approaches

To achieve this ambitious goal, Kenya has already implemented several policy measures to limit climate change. These include policies to indirectly price carbon dioxide by taxing older and hence fuel-inefficient vehicles and by limiting the age of vehicles that can be imported to a maximum of eight years. Kenya has also integrated climate change into its national planning process and established, in cooperation with the World Bank, what are called Climate Innovation Centers, which have had a positive impact through various climate-change-related investment projects (Kaudia, 2015).

Figure 44

Kenya's carbon dioxide abatement potential by sector



Source: Kaudia (2015) based on data from Government of Kenya (2012).

Kaudia (2015) reports that reducing the rate of deforestation by way of large-scale tree planting would be the least-cost solution to tackle climate change in Kenya and other low-income countries. As shown in Figure 44, Kenya's forestry sector clearly has the biggest CO2 abatement potential. This cost-effective solution would preserve or even increase natural carbon sinks and thus contribute to reducing the country's emissions. Kaudia (2015) therefore recommends that low-income countries that rely on natural capital to develop their green growth strategy should mainly focus on environmental and natural resource management policies

Source: Author's elaboration based on Kaudia (2015).

Short summary

Section 4 reviewed the international climate change policy architecture. It discussed the past 25 years of international climate change policy that started with the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The section showed that climate change policy has been shaped by the principle of common but differentiated responsibilities. It also showed that over past years, climate change policy shifted from a top-down approach – the Kyoto Protocol – towards a mixed approach upon which the Paris Agreement relies. This latter approach combines bottom-up nationally determined contributions – i.e. national commitments to reduce greenhouse gas emissions – with top-down procedures for reporting and synthesis of nationally determined contributions by the UNFCCC Secretariat.

5 Exercises and questions for discussion

1. Describe the two fundamental options available to limit climate change.

2. List policy instruments capable of reducing atmospheric greenhouse gas concentrations.

3. Compare carbon taxes to carbon cap and trade systems and discuss their relative advantages and disadvantages.

4. What are carbon capture and storage technologies?

5. Compare solar geoengineering to carbon geoengineering. What are the fundamental differences?

6. Discuss the objectives, costs, risks, unknowns, and collective action prospects of:

   - Substantial reductions of the flow of carbon dioxide emissions reaching the atmosphere
   - Carbon geoengineering
   - Solar geoengineering

7. Discuss the importance of climate change adaptation projects for your country. Find examples of planned or implemented climate change adaptation projects.

8. Identify the fundamental difference between the Paris Agreement and prior international climate change agreements.

9. Define the concept of common but differentiated responsibilities. Why is this concept of central importance to many developing countries?

10. Go to *http://unfccc.int/focus/indc_portal/items/8766.php* and download the INDC of your country. Discuss the objectives and approaches of your country's INDC.

11. What are the challenges and opportunities for climate change policies in developing countries?

ANNEX 1

Some useful databases		
Database	**Description**	**Link**
Organisation for Economic Co-operation and Development database on instruments used for environmental policy and natural resources management	This data catalogue contains information on climate change policies of different countries. The database can be searched by policy category (taxes/fees/charges, tradable permits, deposit-refund systems, environmental subsidies, and voluntary approaches), environmental domain, country, and sector.	*http://www2.oecd.org/ecoinst/queries/*
ECOLEX database	This data catalogue contains treaties, Conference of the Parties decisions, legislation, court decisions, and literature related to various environmental issues, including climate change.	*http://www.ecolex.org/*
World Trade Organization (WTO) environmental database	This data catalogue covers environment-related notifications submitted by World Trade Organization (WTO) members and environmental measures and policies mentioned in the Trade Policy Reviews of WTO members.	*https://www.wto.org/english/tratop_e/envir_e/envdb_e.htm*
United Nations Framework Convention on Climate Change Intended Nationally Determined Contributions (INDC) portal	This data catalogue contains submitted INDCs of different countries.	*http://unfccc.int/focus/indc_portal/items/8766.php*

ANNEX 2

Selected additional reading material
Barrett S, Carraro C, and de Melo J, eds. (2015). *Towards a Workable and Effective Climate Regime*. CEPR Press and Ferdi. London.
Stern S (2015). *Why Are We Waiting? The Logic, Urgency, and Promise of Tackling Climate Change*. MIT Press. Cambridge, MA.
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