07. Climate change

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Key messages

- Climate change is happening. Several climate variables, including global and European temperatures and sea level, have repeatedly broken long-term records in recent years. Climate change has substantially increased the occurrence of climate and weather extremes, including heat waves, heavy precipitation, floods and droughts, in many regions of Europe.

- Climate change is creating risks to, and in some cases opportunities for, the environment, the economy and people. The adverse impacts and risks are expected to intensify as the climate continues to change. Europe is also affected by indirect climate change impacts occurring outside Europe through various pathways, such as trade and migration. To limit the adverse effects of climate change, strong mitigation and adaptation measures are needed.

- EU greenhouse gas emissions have decreased by about 22 % in the past 27 years due to the combined result of policies and measures and economic factors. The carbon and energy intensity of the EU economy is lower now than it was in 1990 because of improvements in energy efficiency and the use of less carbon-intensive fuels, especially renewable energy sources. Transport remains one of the biggest challenges ahead to decarbonising the economy.

- Climate change adaptation is increasingly mainstreamed in EU policies, programmes, strategies and projects. Most EEA member countries now have a national adaptation strategy, and an increasing number of cities are adopting local adaptation strategies. The EU adaptation strategy adopted in 2013 has delivered on most of its objectives; however, its evaluation also identified areas where further action is needed.

- The EU is broadly on track towards meeting the target of spending at least 20 % of its budget for 2014-2020 on climate-related measures, but further efforts are needed. This target seems to have triggered a shift in climate-related spending in some policy areas (such as the European Regional Development Fund and the Cohesion Fund) but not in others (such as agriculture, rural development and fisheries).

- Looking ahead, a significant step-up in reductions is needed to achieve the EU's objective of an 80-95 % reduction in greenhouse gas emissions by 2050. While the EU is on track to achieve its 2020 targets on greenhouse gas emissions and renewable energy, progress on the energy efficiency target remains insufficient. Rising energy consumption trends and recent greenhouse gas projections from Member States indicate that the EU is not yet on track towards its 2030 climate and energy targets.

- The magnitude and pace of future climate change, and thus the long-term adaptation challenges, depend on the success of global mitigation efforts to keep the increase in global temperature to well below 2 °C compared with pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C, as stated in the Paris Agreement.

Thematic summary assessment

Theme	Past trends and outlook		Prospects of meeting policy objectives/targets		
	Past trends (10-15 years)	Outlook to 2030	2020	2030	2050
Greenhouse gas emissions and mitigation efforts	Improving trends dominate	Developments show a mixed picture	☑ Largely on track	☒ Largely not on track	☒ Largely not on track
Energy efficiency	Improving trends dominate	Developments show a mixed picture	☐ Partly on track	☒ Largely not on track	☒ Largely not on track
Renewable energy sources	Improving trends dominate	Developments show a mixed picture	☑ Largely on track	☒ Largely not on track	☒ Largely not on track
Climate change and impacts on ecosystems	Deteriorating trends dominate	Deteriorating developments dominate	☒ Largely not on track		
Climate change risks to society	Deteriorating trends dominate	Deteriorating developments dominate	☐ Partly on track		
Climate change adaptation strategies and plans	Improving trends dominate	Improving developments dominate	☐ Partly on track		

Note: For the methodology of the summary assessment table, see the introduction to Part 2. The justification for the colour coding is explained in Section 7.3, Key trends and outlooks (Tables 7.4, 7.5, 7.6, 7.7, 7.8 and 7.9).

07.
Climate change

7.1
Scope of the theme

Climate change is a key environmental, economic and social challenge globally and in Europe. On the one hand, most economic activities are contributing to climate change by emitting greenhouse gases or affecting carbon sinks (e.g. through land use change); on the other hand, all ecosystems, many economic activities and human health and well-being are sensitive to climate change.

This chapter gives an overview of the causes of climate change, of past and projected changes in the climate system and of selected impacts on the environment, the economy and people. Further information on climate change impacts is available in Chapters 3, 4, 5 and 6. This chapter also addresses the two fundamental policy areas to limit the adverse impacts of climate change: mitigation and adaptation. Both policies can be facilitated by targeted financing.

Mitigation of climate change means reducing the emissions of greenhouse gases and enhancing their sinks. Energy is also addressed in this chapter, as it is the key source of greenhouse gases. Climate change is a global problem, which requires global action. The global policy framework comprises the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement. The EU and all EEA member countries have ratified these international treaties, and they are jointly responsible for their implementation.

Adaptation to climate change involves making adjustments to minimise the adverse impacts of climate change or to exploit any opportunities that may arise. Adaptation comprises a wide range of measures, including 'grey adaptation' (e.g. building coastal protection infrastructure in response to rising sea levels), 'green and green-blue adaptation' (e.g. planting trees in cities to reduce the urban heat island effect) and 'soft adaptation' (e.g. improving emergency management to deal with natural disasters).

Mitigation and adaptation are both necessary to limit the risks related to climate change.

7.2
Policy context

Mitigation and adaptation are both necessary to limit the risks related to climate change. However, the measures and policies are rather different.

Mitigation of climate change has a quantitative target that was agreed at the global level and is delivered through a set of climate and energy policies with specific targets and objectives for 2020, 2030 and 2050. The central aim of the Paris Agreement is to keep the rise in global temperature well below 2 °C above pre-industrial levels and to pursue

TABLE 7.1 Overview of selected policy objectives and targets

Policy objectives and targets	Sources	Target year	Agreement
Climate change mitigation including energy			
Limit human-induced global temperature rise to well below 2 °C (and pursue efforts to limit the temperature increase to 1.5 °C) above pre-industrial levels — building on the UNFCCC Treaty's ultimate objective to stabilise GHG concentrations at a level that would prevent dangerous anthropogenic interference with the climate system	Paris Agreement (UN)	Permanent	Binding international treaty
20 % cut in GHG emissions (from 1990 levels) 20 % of EU energy from renewable sources 20 % improvement in energy efficiency **To achieve the 20 % target:** EU ETS sectors would have to cut emissions by 21 % (compared with 2005) Non-ETS sectors would need to cut emissions by 10 % (compared with 2005) — this is translated into individual binding targets for Member States	EU 2020 climate and energy package	2020	Binding GHG target
At least 40 % cuts in GHG emissions (from 1990 levels) At least 32% of EU energy from renewable sources At least 32.5 % improvement in energy efficiency **To achieve the target of at least 40 %:** EU ETS sectors would have to cut emissions by 43 % (compared with 2005) — to this end, the ETS has been reformed and strengthened for its next trading period (2021-2030) Non-ETS sectors would need to cut emissions by 30 % (compared with 2005) — individual binding targets for Member States were adopted in May 2018	EU 2030 climate and energy framework	2030	Binding GHG target
By 2050, the EU's objective, in the context of necessary reductions by developed countries as a group, according to the IPCC, is to reduce GHG emissions by 80-95 % below 1990 levels Milestones: 40 % cuts in emissions by 2030 and 60 % by 2040	EU 2050 low-carbon roadmap and European Council conclusions of 29/30 October 2009	2050	Non-binding commitment
A climate-neutral economy: net zero GHG emissions by 2050	European Commission strategy: A Clean Planet for All: a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy	2050	Non-binding commitment
Overarching objectives: secure, competitive and sustainable energy Specific objectives: expand security of energy supply; develop a connected EU energy market; reduce energy demand and improve energy efficiency; decarbonise the energy mix; and increase research and development	Energy Union	2030, 2050	EU strategy
Climate change adaptation			
Decisive progress in adapting to the impact of climate change	7th EAP (EU) (EU, 2013a)	2020	Non-binding commitment
Strengthen resilience and the capacity to adapt to climate-related hazards and natural disasters in all countries	SDG target 13.1 (UN); Paris Agreement (UN) (UN, 2015; UNFCCC, 2015b)	2030	Non-binding commitment
Integrate climate change measures into national policies, strategies and planning	SDG target 13.1 (UN); Paris Agreement (UN) (UN, 2015; UNFCCC, 2015b)	2030	Non-binding commitment

TABLE 7.1 Overview of selected policy objectives and targets (cont.)

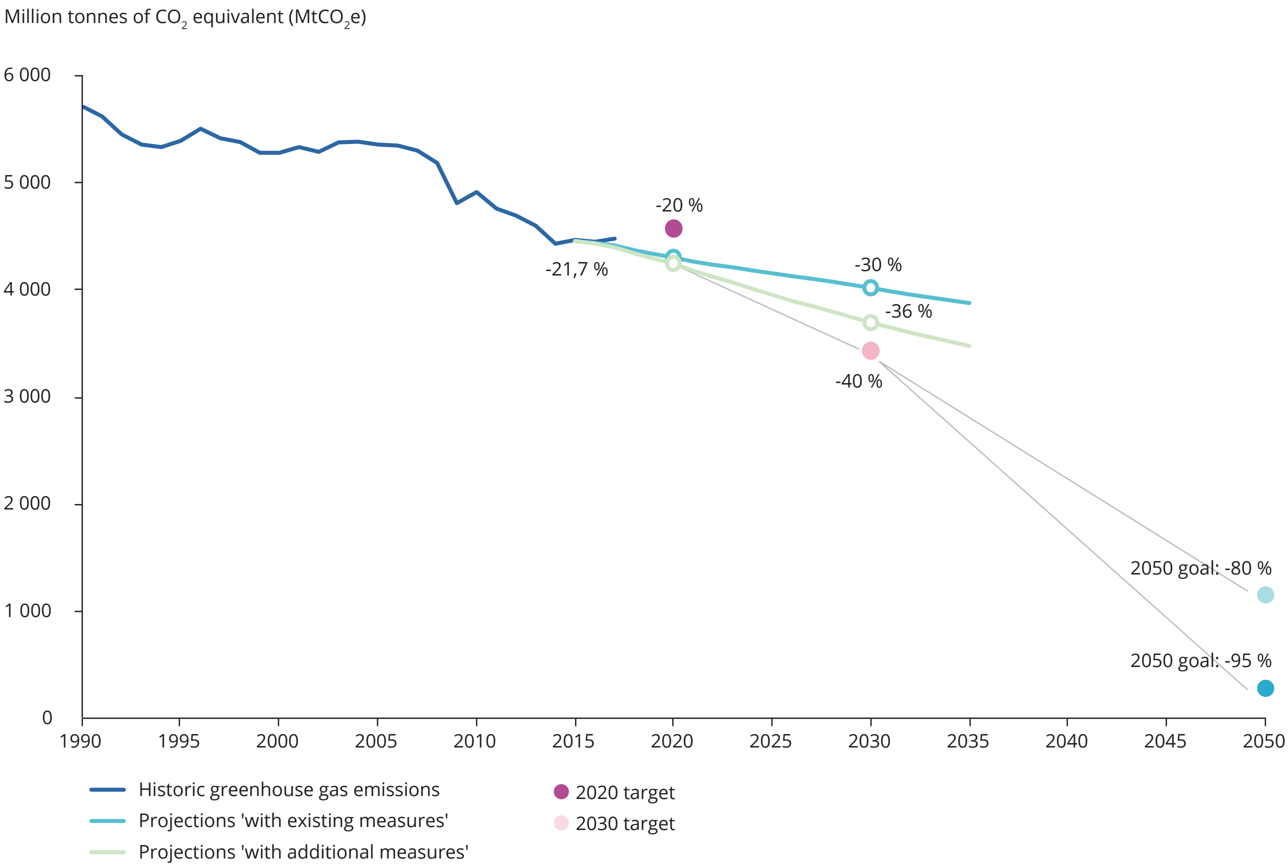
Policy objectives and targets	Sources	Target year	Agreement
Climate change adaptation			
All Member States are encouraged to adopt comprehensive adaptation strategies	EU strategy on adaptation to climate change (Commission Communication and Council Conclusions) (EC, 2013b; Council of the European Union, 2013)	2017	Non-binding commitment
Climate-proofing EU action: mainstream adaptation measures into EU policies and programmes	EU strategy on adaptation to climate change (Commission Communication and Council Conclusions) (EC, 2013b; Council of the European Union, 2013)	N/A	Non-binding commitment
Climate change finance			
Climate action objectives will represent al least 20 % of EU spending (in the period 2014-2020)	EU Multi-annual financial framework (Commission proposal, endorsed by Council and Parliament) (EC, 2011; European Council, 2013)	2014-2020	Non-binding commitment
Developed countries will jointly mobilise USD 100 billion annually to address the mitigation and adaptation needs of developing countries	Copenhagen Accord (UN), Paris Agreement (UN), SDG target 13.4 (UN) (UNFCCC, 2010, 2015b; UN, 2015)	2020	International treaty

Note: 7th EAP, Seventh Environment Action Programme; ETS, Emissions Trading System; GHG, greenhouse gas; IPCC, Intergovernmental Panel on Climate Change; SDG, Sustainable Development Goal; UN, United Nations; UNFCCC, United Nations Framework Convention on Climate Change; N/A, non-applicable.

efforts to limit the temperature increase to 1.5 °C. These global temperature targets correspond directly to remaining carbon budgets, i.e. to the amount of greenhouse gases that human activities can emit without exceeding a given level of warming. The EU has implemented many legislative acts aiming to reduce the emissions of the most important greenhouse gases and to enhance their sinks (see Table 7.1). One feature of the EU's domestic climate legislation is that it has the key objective of delivering on the international commitments agreed by heads of state. The other feature is the internal consistency between the quantified efforts required by Member States and the agreed international objectives binding the EU Member States and the EU as a whole. Specifically, with regard to the provision and use of energy, renewable energy and energy efficiency targets and objectives for 2020 and 2030 were included as headline targets in the Energy Union strategy (EC, 2015c), along with minimum targets for electricity interconnection (10 % by 2020 and 15 % by 2030), and flanked by objectives in other dimensions. The Energy Union and Climate Action Regulation of 2018 (EU, 2018b) sets out the legislative foundation that is meant to deliver a reliable, inclusive, cost-efficient, transparent and predictable governance of the Energy Union and climate action, for the purpose of ensuring that the 2030 and long-term objectives and targets of the Energy Union, in line with the 2015 Paris Agreement, are achieved.

In contrast, there is no single metric for measuring the success of adaptation to climate change. As a result, the policy targets for adaptation at the global and European levels are less quantifiable, and most monitoring activities so far focus on the adaptation process rather than on quantitative outcomes. In addition to the adaptation policies and targets mentioned explicitly in Table 7.1, climate change adaptation also requires 'mainstreaming' — or making part of everyday practice — in many other EU policies addressing climate-sensitive issues. Of particular relevance are policies for disaster risk reduction (e.g. EU Civil Protection Mechanism, EU action plan on the Sendai Framework for Disaster Risk Reduction), the common agricultural policy, the common fisheries policy, the Floods Directive, the Water Framework Directive, the forest policy, the nature directives, and policies related to public health. The effectiveness

FIGURE 7.1 **Greenhouse gas emission trends and projections in the EU-28, 1990-2050**



Note: The GHG emission trends, projections and target calculations include emissions from international aviation, and exclude emissions and removals from the LULUCF sector. The 'with existing measures' scenario reflects existing policies and measures, whereas the 'with additional measures' scenario considers the additional effects of planned measures reported by Member States.

Source: EEA, based on the final 2019 EU GHG inventory submission to the United Nations Framework Convention on Climate Change and projections reported by EU Member States under the EU Monitoring Mechanism Regulation.

of adaptation measures often can only be assessed after an extreme climate-related event. However, there is increasing evidence globally and in Europe that well-designed adaptation measures in response to extreme events have decreased the death toll caused by subsequent heat waves and the economic damage from subsequent river flooding (Fouillet et al., 2006; WMO and WHO, 2015; Thieken et al., 2016).

Mitigation and adaptation are facilitated by a suitable policy framework, earmarked financial resources, and targeted information and knowledge. There are quantified targets for climate change finance at the global and the European levels (see Table 7.1). Interestingly, none of these targets distinguishes between mitigation and adaptation. Further support for adaptation measures in Europe is provided by, among others, the Copernicus Climate Change Service (C3S) and dedicated research projects (e.g. under Horizon 2020 and JPI Climate).

7.3 Key trends and outlooks

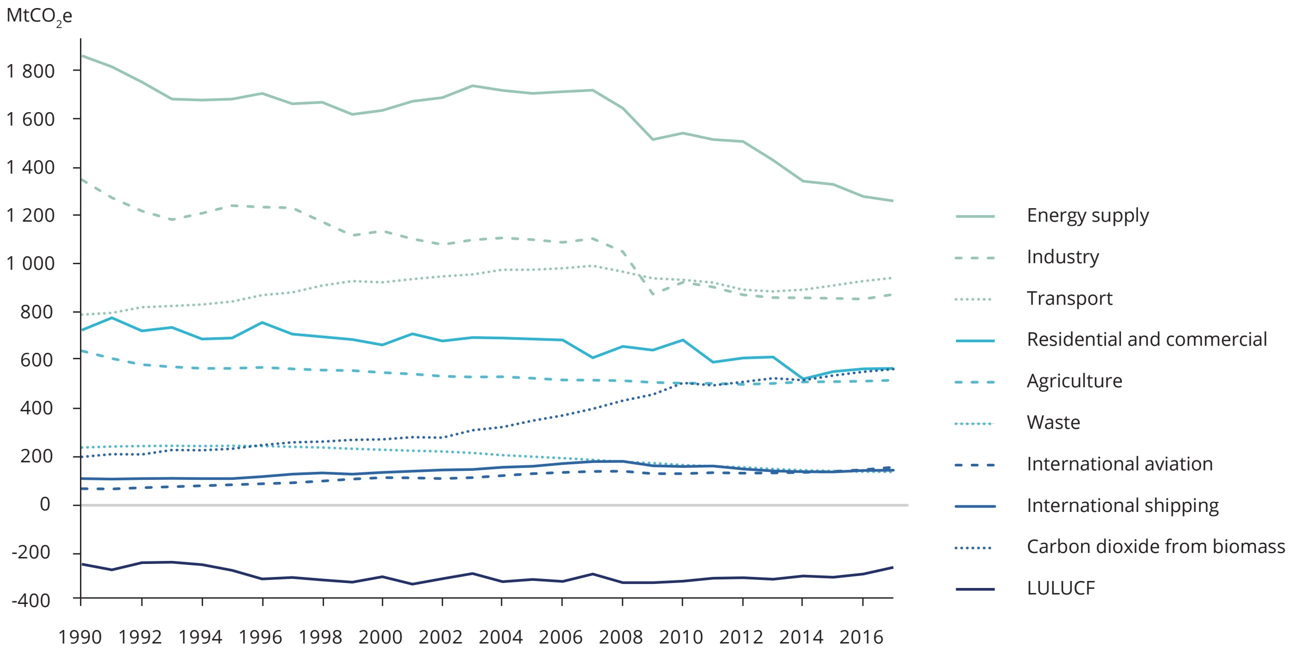
7.3.1 Emissions of greenhouse gases and climate change mitigation efforts

► See Table 7.4

Snapshot of the EU's greenhouse gas emission trends and projections

Figure 7.1 shows that the total greenhouse gas (GHG) emissions excluding land use, land use change

FIGURE 7.2 Greenhouse gas emissions by main sector in the EU-28, 1990-2017



Note: The sectoral aggregations are:
Energy supply CRF 1A1 (energy industries) + 1B (fugitives); industry CRF 1A2 (manufacturing industries and construction) + CRF 2 (industrial processes); transport CRF 1.A.3; residential and commercial CRF 1A4a (commercial) + CRF 1A4b (residential); agriculture CRF 1A4c (agriculture, forestry and fishing) + CRF 3 (agriculture); waste CRF 5 (waste); land use, land use change and forestry CRF 4 (LULUCF).
International aviation, international shipping and CO_2 biomass are memorandum items according to UNFCCC reporting guidelines and are not included in national GHG totals. International shipping is not included in any targets under the UNFCCC or the Kyoto Protocol. International aviation is included in the EU's 2020 and 2030 GHG targets. CO_2 from biomass is reported separately to avoid any double-counting of emissions from biomass loss in the LULUCF sector.

Source: EEA.

and forestry (LULUCF) and including international aviation declined by 1.2 billion tonnes of carbon dioxide equivalent (CO_2e) between 1990 and 2017. This represents a reduction of 22 % in the past 27 years.

The reduction in total GHG emissions since 1990 means that the EU remains on track to meet its 2020 target. However, according to the latest projections reported by Member States (EEA, forthcoming (a)), only the 2020 target is within reach. Significant efforts will therefore be needed to reach the 2030 target and, even more substantial efforts, to reach the 2050 objective (EEA, 2018j).

The EU is the sum of its Member States and most Member States have reduced emissions since 1990 (Table 7.3). About 50 % of the EU net-decrease was accounted for by Germany and the United Kingdom. The overall net GHG emission reductions achieved by most Member States were partly offset by higher GHG emissions in a few Member States.

On an aggregate level, Figure 7.2 shows that GHG emissions decreased in the majority of sectors between 1990 and 2017, with the notable exception of domestic and international transport. The largest decrease in emissions in absolute terms occurred in energy supply and industry, although agriculture, residential and commercial (i.e. buildings), and waste management have all contributed to the positive trend in GHG emissions since 1990. The figure also shows the strong increase in carbon dioxide (CO_2) emissions from

TABLE 7.2 Trends in EU emission-source categories between 1990 and 2017

Emission source category	$MtCO_2e$
Road transportation (CO_2 from 1.A.3.b)	170
Refrigeration and air conditioning (HFCs from 2.F.1)	93
Aluminium production (PFCs from 2.C.3)	-21
Agricultural soils: direct N_2O emissions from managed soils (N_2O from 3.D.1)	-22
Cement production (CO_2 from 2.A.1)	-26
Fluorochemical production (HFCs from 2.B.9)	-29
Fugitive emissions from natural gas (CH_4 from 1.B.2.b)	-37
Commercial/institutional (CO_2 from 1.A.4.a)	-38
Enteric fermentation: cattle (CH_4 from 3.A.1)	-43
Nitric acid production (N_2O from 2.B.2)	-46
Adipic acid production (N_2O from 2.B.3)	-56
Manufacture of solid fuels and other energy industries (CO_2 from 1.A.1.c)	-60
Coal mining and handling (CH_4 from 1.B.1.a)	-66
Managed waste disposal sites (CH_4 from 5.A.1)	-73
Residential: fuels (CO_2 from 1.A.4.b)	-115
Iron and steel production (CO_2 from 1.A.2.a +2.C.1)	-116
Manufacturing industries (excl. iron and steel) (energy-related CO_2 from 1.A.2 excl. 1.A.2.a)	-253
Public electricity and heat production (CO_2 from 1.A.1.a)	-433
Memo items:	
International aviation (CO_2 from 1.D.1.a)	89
International navigation (CO_2 from 1.D.1.b)	35
Total GHGs [excluding LULUCF, excluding international transport]	-1 327
Total GHGs [excluding LULUCF, including international aviation]	-1 237

Notes: The numbers in the table include the EU-28 and Iceland and show the change in emissions between 1990 and 2017. Only those emission sources that have increased or decreased by more than 20 million tonnes of CO_2 equivalent are shown in the table.

CH_4, methane; CO_2, carbon dioxide, N_2O, nitrous oxide.

Source: EEA, based on the final 2019 EU GHG inventory submission to the UNFCCC.

TABLE 7.3 **Country comparison — climate mitigation variables and indicators by country: trends and projections**

	Total GHG emissions in 2017 ($MtCO_2e$)	Change in total GHG emissions, 1990-2017 ($MtCO_2e$)	Change in total GHG emissions, 1990-2017 (%)	GHG emissions per GDP in 2017 (PPS, EU-28=100)	GHG emissions per capita in 2017, (tCO_2e per person)	Change in the carbon intensity of energy 1990-2017 (%)	Change in the total energy intensity of the economy 1990-2017 (%)
Austria	84.5	5.0	6.2	87	9.6	-20.0	-18.3
Belgium	119.4	-30.4	-20.3	103	10.5	-29.0	-27.1
Bulgaria	62.1	-40.5	-39.5	204	8.8	-6.1	-54.0
Croatia	25.5	-6.9	-21.3	114	6.2	-13.0	-20.5
Cyprus	10.0	3.6	55.7	156	11.6	2.7	-28.7
Czechia	130.5	-69.3	-34.7	157	12.3	-28.9	-48.4
Denmark	50.8	-21.3	-29.5	79	8.8	-32.9	-35.5
Estonia	21.1	-19.5	-48.0	232	16.0	-14.1	-64.8
Finland	57.5	-14.8	-20.5	109	10.4	-33.2	-24.5
France	482.0	-74.6	-13.4	79	7.2	-21.8	-25.5
Germany	936.0	-327.2	-25.9	105	11.3	-16.3	-40.1
Greece	98.9	-6.7	-6.4	156	9.2	-15.0	-13.0
Hungary	64.5	-29.7	-31.5	111	6.6	-25.5	-38.5
Ireland	63.8	7.3	12.9	84	13.3	-13.1	-66.1
Italy	439.0	-83.1	-15.9	86	7.3	-22.8	-10.8
Latvia	11.8	-14.8	-55.7	104	6.1	-31.4	-54.5
Lithuania	20.7	-27.9	-57.3	107	7.3	-23.6	-68.2
Luxembourg	11.9	-1.2	-9.2	90	20.0	-20.7	-51.0
Malta	2.6	0.3	12.2	65	5.5	-11.6	-63.3
Netherlands	205.8	-20.5	-9.1	107	12.0	-7.3	-34.2
Poland	416.3	-58.7	-12.4	178	11.0	-11.6	-61.7
Portugal	74.6	13.9	22.8	108	7.2	-8.0	-4.0
Romania	114.8	-134.1	-53.9	107	5.9	-18.1	-69.6
Slovakia	43.5	-29.9	-40.8	120	8.0	-35.2	-63.6
Slovenia	17.5	-1.2	-6.2	114	8.5	-19.0	-31.1
Spain	357.3	64.0	21.8	95	7.7	-14.6	-14.3
Sweden	55.5	-17.2	-23.7	52	5.5	-31.0	-39.8
United Kingdom	505.4	-304.4	-37.6	83	7.7	-24.7	-49.3
EU-28	**4 483.1**	**-1 239.8**	**-21.7**	**100**	**8.8**	**-20.5**	**-36.3**
Iceland	5.9	2.1	54.8	151	17.2	-40.3	13.4
Liechtenstein	0.2	0.0	-15.2	-	5.1	-	-
Norway	54.4	2.5	4.9	81	10.3	-10.0	-22.4
Switzerland	52.6	-4.1	-7.3	46	6.2	-	-
Turkey	537.4	317.6	144.5	116	6.7	-3.5	-12.8

Notes: The year 1990 is used as the reference year to show trends in GHG emissions on a comparable basis for all Member States and to assess progress towards the EU 2020 and 2030 targets. These data should not be used to assess the achievement of climate mitigation targets of individual Member States. GHG data are based on the final 2019 GHG inventory submissions to the UNFCCC (EEA, 2019c). GHG aggregates include international aviation and exclude the LULUCF sector. The source of GDP data is the European Commission's AMECO database (EC, 2019a). Where gaps were present, GDP was estimated based on trends in the data reported to the World Bank (Bulgaria, Croatia, Estonia, Hungary, Malta and Slovakia) (World Bank, 2019). Underpinning energy and population data are from Eurostat (Eurostat, 2019a, 2019b). For the Western Balkan countries, there is no requirement to report GHG inventories annually using the CRF Reporter as Annex I Parties to UNFCCC do. However, climate change information, including GHG inventories and mitigation actions, is available from the Parties' biennial update reports ([1]) to the UNFCCC and from European Commission projects such as the Environment and Climate Regional Accession Network (ECRAN ([2])).

Source: EEA.

([1]) https://unfccc.int/BURs
([2]) http://www.ecranetwork.org/Climate

biomass combustion, incentivised by the EU's policy on renewables and by the EU Emissions Trading Scheme (EU ETS) (EEA, 2019a). Although net removals from LULUCF increased over the period, the strong increase in CO_2 emissions from biomass combustion highlights the rapidly increasing importance of bioenergy in climate and energy responses across the EU. The pressures from these sectors are relevant not only to climate change but also to other environmental variables (Chapter 13).

On a more detailed level, Table 7.2 shows that the largest emission reductions ocurred in manufacturing industries and construction, electricity and heat production, and in residential combustion. The largest decrease in emissions in relative terms took place in waste management, due to reduced and better controlled landfilling. GHG emissions from hydrofluorocarbons (HFCs) and from road transportation increased substantially over the period 1990-2017.

This represents a challenge for Member States and for achieving the 2030 targets under the EU Effort Sharing Regulation, as transport accounts for about one third of emissions covered by the sectors in which national mitigation targets apply.

Currently, the EU's climate mitigation policy is based on a distinction between GHG emissions from large industrial sources, which are governed by the EU ETS (EC, 2019c), and emissions from sectors covered by the Effort Sharing Decision (EC, 2019b). For the ETS, there is an overall cap for the period 2013-2020, which puts a limit on emissions from installations by setting the maximum amount of emissions allowed during the 8-year period. For the sectors covered by the Effort Sharing Decision, there are binding annual GHG emission targets for Member States for the period 2013-2020.

Greenhouse gas emissions decreased in the majority of sectors between 1990 and 2017.

Between 2005 and 2017, emissions covered under the EU ETS decreased more rapidly than those from sectors not covered by the System. ETS emissions did increase faster than non-ETS emissions during the first phase of the EU ETS between 2005 and 2007, coinciding with a period of greater consumption of hard coal and lignite for power generation. Since then, however, ETS emissions have decreased at a faster rate than non-ETS emissions. In addition to the improvements observed in carbon intensity and energy efficiency in the heat and power sector, the economic recession that started in the second half of 2008 affected ETS sectors more than those outside the ETS (EEA, 2014b). The largest industrial installations are part of the EU ETS and the contraction in gross value added in industry appears to have led to a significant reduction in final energy demand and emissions in the sector. When emissions from energy supply were allocated to the end-user sectors, EEA figures showed that the largest emission reductions in the period following the economic recession were largely accounted for by industry as a whole (EEA, 2012).

Of the net EU reduction in total GHG emissions between 2005 and 2017, two thirds was accounted for by the ETS, and one third by the sectors not covered under the ETS. The sectors falling under the scope of the Effort Sharing Decision (soon to become the Effort Sharing Regulation) currently represent about 60 % of total greenhouse gas emissions in the EU, and they broadly include residential and commercial (buildings), transport, waste, agriculture and the part of industry not covered by the ETS. Of these sectors, improvements since 2005 have been more visible for buildings, non-ETS industry and waste management. For transport, emissions decreased between 2007 and 2013 but have increased consecutively in the last few years for both freight and passenger cars. For agriculture, emissions have increased in the past few years, both from livestock and from soils.

Analysis of key past and future trends and drivers

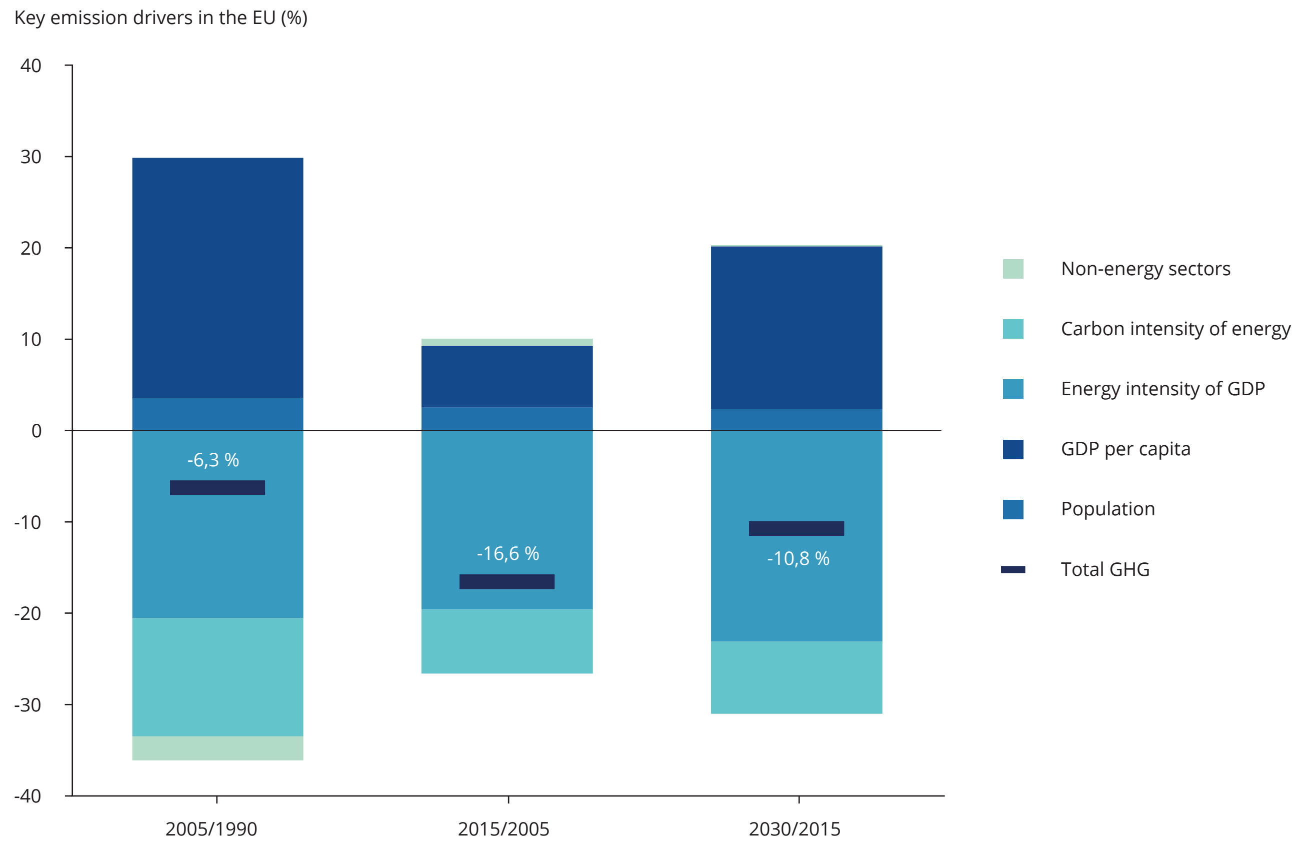
The speed of reduction in GHG emissions observed in the past will not be sufficient to meet the 2030 targets unless there are further improvements in both energy efficiency and carbon intensity (EEA, 2017a).

Figure 7.3 shows a comparison of key drivers underpinning GHG emissions in three different periods (1990-2005, 2005-2015 and 2015-2030), based on information reported by EU Member States.

Overall, the four main findings at EU level are:

1. Higher gross domestic product (GDP) would usually lead to higher GHG emissions, other factors being equal, because economic growth is still intrinsically linked to an energy system that remains heavily dependent on fossil fuels in most European countries (EEA, 2014b). Yet, the figure shows that emissions decreased and are expected to decrease further as GDP increases, confirming that attempts to mitigate climate change do not necessarily conflict with a growing economy.
In addition, the GHG intensities of Member States have both decreased since 1990 and converged (EEA, 2017a). One reason for this convergence is the strong growth in the use of renewable

FIGURE 7.3 Drivers of reductions in GHG emissions in the EU-28, 1990-2017



Note: Based on final GHG inventories to the UNFCCC and projections data reported under the EU Monitoring Mechanism Regulation by 29 May. The decomposition analysis is based on the logarithmic mean Divisia index (LMDI). The bar segments show the changes associated with each factor alone, holding the other factors constant. Projections at EU level have been aggregated based on Member States' submissions under EU reporting requirements. GHG emission projections in this figure refer to those in the 'with existing measures' scenario. The EU Reference Scenario 2016 from the European Commission (based on the PRIMES and GAINS models) was used to gap-fill incomplete reporting for specific Member States' parameters.

Source: EEA.

energy sources in most Member States and a clear move towards less carbon-intensive fuels. Due to this strong convergence, GHG emissions per capita and per GDP are more similar now across Member States than they were in 1990. Projections by Member States suggest a continued decoupling of GHG emissions alongside higher economic growth for the period 2015-2030. However, higher levels of renewables in the energy mix will be required to achieve complete decoupling between GHG emissions, energy and economic growth.

Fulfilling the 2030 targets requires further energy efficiency and carbon intensity improvements.

2. The lower carbon intensity of energy has been a key factor underpinning lower emissions, in spite of a decline in nuclear electricity production in recent years. This positive trend has been due both to the higher contribution from renewable energy sources in the fuel mix and to the switch from more carbon-intensive coal to less carbon-intensive gas.

The lower carbon intensity of energy (i.e. fewer emissions from producing and using energy) was, and is, expected to remain an important factor underpinning lower emissions in the future. According to Member States' projections, both an increase in renewable energy sources and a less carbon-intensive fossil fuel mix, with less coal than gas and lower oil consumption, are expected to drive reductions in emissions in the future.

3. The decrease in the energy intensity of GDP has been the largest contributing factor to lower GHG emissions from fossil fuel combustion in the past. The lower energy intensity of economic growth can be explained by improvements in energy efficiency (transformation and end use, including energy savings) and the strong uptake of renewables, as well as by changes in the structure of the economy and a higher share attributable to the services sector than to the more energy-intensive industrial sector (3). The decrease in the energy intensity of GDP is expected to remain a key factor in the transition to a low-carbon economy and, potentially, to carbon neutrality. This means continued improvements in energy efficiency — in both transformation and end use.

4. The largest emission reductions in the period 1990-2005 occurred in the non-energy sectors. In the period 2005-2015, energy-related emissions from both production and consumption decreased faster than non-energy emissions. Although the effects of the non-energy sectors shown in the decomposition analysis appear to be modest, the actual emission reductions observed in industrial processes, agriculture and waste management have been substantial since 1990. The largest emission reductions are projected to occur in the energy sector, although all sectors of the economy are expected to contribute to meeting climate mitigation objectives.

≈80 %

of all EU greenhouse gas emissions come from fossils fuels.

Overall, the same factors driving emission reductions in the past are also expected to play a key role in the future, although to a different degree. For the EU as whole, the projected overall estimates for reductions in GHG emissions by 2030 (with existing policies and measures), as reported by Member States, are consistent with a 30 % reduction compared with 1990 (excluding LULUCF and including international aviation). When additional measures are included, the gap closes to about a 36 % projected reduction compared with 1990. Whereas the EU is on track to achieve its 20 % GHG emission reduction target by 2020, more efforts to reduce GHG emissions will be needed to achieve its reduction target of at least 40 % by 2030 (EEA, 2018j) ([4]). These results suggest that efforts should, together with lower energy intensity and higher efficiency, concentrate on further improving the carbon intensity of energy production and consumption. The transport sector remains one of the key challenges to decarbonising the economy, although all sectors of the economy should contribute to the emission reductions that are required for the EU and Member States to meet their mitigation targets.

It is worth highlighting that, notwithstanding the different trends by country and region, warmer winters are another factor contributing to lower GHG emissions in Europe. In addition, there has also been lower fuel use due to the lower demand for space heating because of better insulation standards and retrofitting in buildings. There is a clear positive correlation between heating degree-days and fuel use and emissions from the residential sector. According to Eurostat data (Eurostat, 2019a), the current demand for heating in Europe is below its long-term average (defined as 1980-2004). An EEA analysis on heating and cooling showed that

([3]) There are various reasons for the lower share of industry in Europe's economy. Industry can close down, become more efficient and even relocate. Carbon footprint statistics (consumption-based approach) can be useful for assessing the impact of domestic economic activities abroad and for analysing emission trends. Yet, the assessment of progress towards GHG mitigation targets used here is consistent with how the targets have been defined and agreed both domestically and internationally (production-based approach). Also, while Europe may be indirectly generating some of the emissions elsewhere for final consumption in Europe — via imported products — a share of Europe's own emissions can also be linked to final consumption of European goods outside Europe — via EU exports.

([4]) In June 2019, the European Commission published its assessment of Member States' draft national energy and climate plans (NECPs) to implement the Energy Union objectives and the EU 2030 energy and climate targets. On aggregate, the projected emission reductions submitted in draft plans appear broadly consistent with the at least 40 % GHG reduction commitment under the Paris Agreement. The significant difference between the expected emission reductions in the draft NECPs and the 2019 projections reported by Member States under the EU Monitoring Mechanism Regulation can be explained by the different gap-filling methodologies that have been used when the 'with additional measures' (WAM) scenarios were not reported by Member States.

TABLE 7.4 Summary assessment — greenhouse gas emissions and mitigation efforts

Past trends and outlook		
Past trends (10-15 years)		The EU has reduced its GHG emissions by 22 % since 1990 primarily as a result of improved energy efficiency, higher shares of renewable energy and a less carbon-intensive fossil fuel mix. Other key factors, such as structural changes in the economy towards the services sector, the effects of the economic recession, and a lower demand for heat as a result of milder winter conditions and improved building insulation also played a role.
Outlook to 2030		The projected reductions in GHG emissions by 2030 (with existing policies and measures), as reported by Member States, are consistent with a 30 % reduction compared with 1990 (excluding LULUCF and including international aviation). When additional measures are included, the projected reductions would reach about 36 % relative to 1990.
Prospects of meeting policy objectives/targets		
2020	☑	The EU remains on track to achieve its 20 % 2020 targets compared with 1990.
2030	☒	Further mitigation efforts are required to meet the target to reduce GHG emissions by at least 40 % by 2030 compared with 1990.
2050	☒	Even faster rates of emissions reductions are required to meet the 2050 objective of a reduction in GHG emissions of 80-95 %.
Robustness		GHG historical data are based on GHG inventories reported to the UNFCCC and to the EU under the EU Monitoring Mechanism Regulation. Although there is uncertainty in emission estimates, GHG inventories undergo a thorough quality assurance/quality checking and review process on an annual basis. Outlooks are based on GHG projections data from Member States, as reported under the EU Monitoring Mechanism Regulation. The uncertainty in the projections is higher than that in GHG inventories, but the estimates for 2020 and 2030 at EU level are fully consistent with what Member States report to the EU.

heating degree-days have decreased by about 0.5 % per year between 1981 and 2014, and particularly in northern and north-western Europe. In parallel, cooling degree-days increased on average by almost 2 % per year during the same period, particularly in southern Europe (EEA, 2019g). Because temperatures in Europe are projected to increase, the trends towards fewer heating degree-days and more cooling degree-days are also expected to continue — if not to accelerate.

In summary, the EU has so far managed to reduce its GHG emissions since 1990 due to a combination of factors, including:

- the effects of a number of policies (both EU and country-specific), including key agricultural and environmental policies in the 1990s, and climate and energy policies in the 2000s;

- the growing use of energy from renewable sources;

- the use of less carbon-intensive fossil fuels (e.g. the switch from coal to gas);

- improvements in energy efficiency;

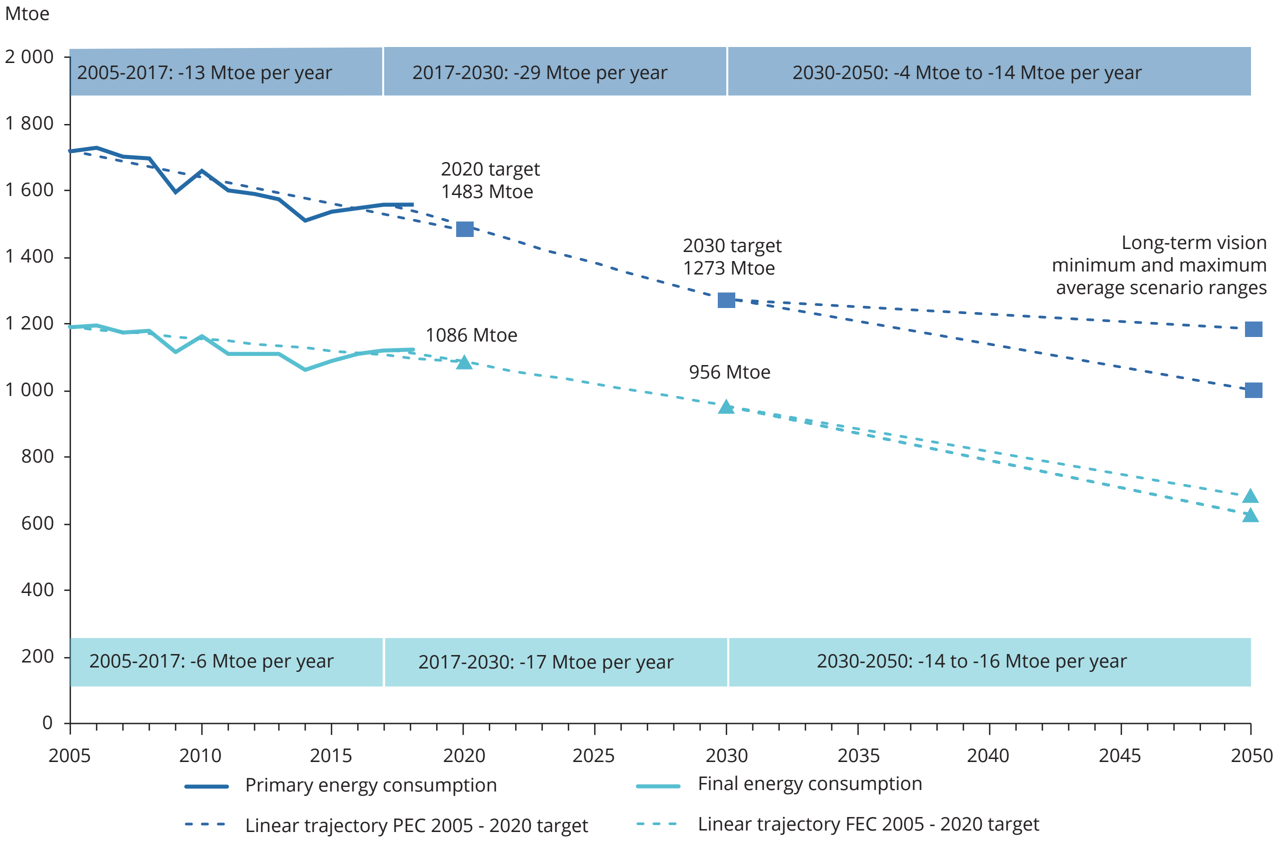
- structural changes in the economy, with a higher share of total GDP accounted for by services and a lower share by more energy-intensive industry;

- the effects of economic recession;

- the milder winters experienced in Europe on average since 1990, which has reduced the demand for energy to heat buildings.

Finally, in spite of good progress in reducing GHG emissions and in decarbonising the EU economy, fossil fuels are still the largest source of energy and emissions in the EU. They contribute to roughly 65 % of the EU's final energy and to almost 80 % of all EU GHG emissions. There cannot be a complete decoupling of emissions from economic growth in a fossil fuel-based economy. This is because energy demand, which to date is mostly fossil fuel driven, remains connected to economic growth. This also implies that the higher the contribution from renewables, the easier it will be to break the link between economic growth, energy demand and GHG emissions. Most importantly, the more the EU reduces its total energy consumption through energy efficiency improvements, the less renewables need to be stepped up to replace fossil fuels.

FIGURE 7.4 **Primary and final energy consumption in the EU, 2005-2017, 2020 and 2030 targets and 2050 scenario ranges for a climate neutral Europe according to the EU strategic long-term vision for 2050**



Note: The 2020 target represents energy savings of 20 % from levels projected for 2020 in the Commission's energy baseline scenario of 2008. The indicative energy efficiency target for 2030 represents an improved energy efficiency of at least 32.5 % compared with 2030 projections in the same energy baseline scenario. The 2050 values represent indicative ranges for primary and final energy consumption that, combined with very high shares of energy from renewable sources in the energy mix, would allow the EU to reach carbon neutrality by 2050. The 2050 values are drawn from the carbon neutrality scenarios '1.5 TECH' and '1.5 LIFE' in the in-depth analysis accompanying the Commission's recent strategic long-term vision for a climate-neutral economy by 2050.

PEC, primary energy consumption; FEC, final energy consumption.

Sources: EC (2008, 2018c, 2018e); EEA (forthcoming (b), forthcoming (c)); European Council (2014); Eurostat (2019a).

Overall, the EU is reducing its energy consumption, but this trend has reversed since 2014.

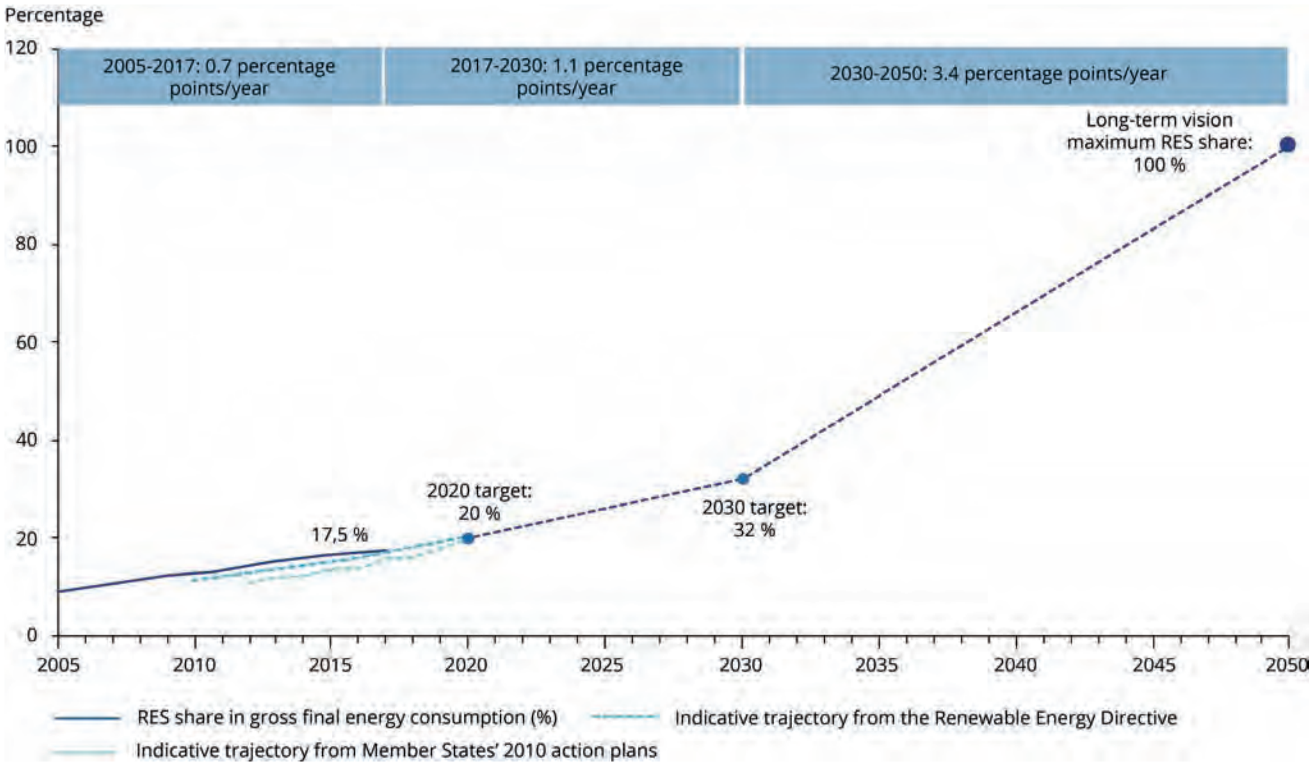
7.3.2
Energy efficiency and renewable energy sources

► *See Table 7.5 and Table 7.6*

Access to energy sustains the provision of key societal services, ranging from the temperature control and illumination of buildings to cooking, telecommunication, transport, agriculture, farming, mining and manufacturing of the goods we consume. However, supplying this energy at all times gives rise to many environmental risks and impacts, from global and long-term ones, such as climate change, to regional and local air pollution, the contamination of soils, surface waters and ground waters, and damage to sensitive ecosystems. The environment is showing signs of stress, as our energy consumption gives rise to approximately two thirds of all EU GHG emissions and as air quality declines to dangerous levels in certain areas, especially in regions that rely intensively on burning coal.

To make the provision and use of energy more sustainable and climate compatible, the EU and its Member

FIGURE 7.5 **Share of energy from renewable energy sources in the EU's gross final energy consumption, 2005-2050**



Note: Values for 2020 and 2030 represent legally binding targets for the minimum share of renewable energy sources in the EU's gross final energy use. The 2050 value represents the indicative share of renewable energy in the EU's gross final consumption that, combined with energy efficiency and other climate mitigation measures, would allow the EU to reach carbon neutrality by 2050. The 2050 value is consistent with the carbon neutrality scenarios '1.5 TECH' and '1.5 LIFE' in the in-depth analysis accompanying the Commission's recent strategic long-term vision for a climate-neutral economy by 2050. The renewable energy shares in the figure follow the accounting methodology put forward under Directive 2009/28/EC.

Sources: EC (2013a, 2013d, 2018c, 2018e); EEA (2018b); EU (2009); Eurostat (2019a).

States have agreed to progress towards the energy efficiency and renewable energy headline targets for 2020 and 2030 that were included in the Energy Union framework strategy, and to reform environmentally harmful subsidies, such as support for fossil fuels, limiting the exceptions to vulnerable social groups (EC, 2015c).

Energy efficiency

Overall, the EU is reducing its energy consumption, but this trend has reversed since 2014 (Figure 7.4). Compared with 2005, the EU's primary energy consumption in 2016 was 10 % lower as a result of decreases in final energy consumption, changes in the fuel mix used to produce electricity and heat (higher penetration of renewables and natural gas) and of improved efficiency in the conversion of primary energy sources (e.g. coal and gas) into final energy.

In 2017, final energy consumption in the EU was 6 % lower than in 2005 and 3 % higher than in 1990. The main drivers of the decrease since 2005 were the implementation of energy efficiency policies, structural changes in the economy towards less energy-intensive industrial sectors

Energy consumption gives rise to approximately 2/3 of EU greenhouse gas emissions.

TABLE 7.5 Summary assessment — energy efficiency

Past trends and outlook		
Past trends (10-15 years)		Overall, the EU has been reducing energy consumption and decoupling energy consumption from economic growth. However, this trend has reversed since 2014 and final energy consumption is increasing again, driven in part by economic growth (especially demand from the transport sector) and more energy use by households.
Outlook to 2030		Further improvements in energy efficiency are expected with implementation of current policies. However, the increasing trend in energy consumption since 2014 indicates that reversing this trend will require increased efforts and additional national policies and measures to address energy demand in all sectors, especially transport. Reducing energy consumption through efficiency improvements is cost-effective and has multiple health and environmental benefits. It supports meeting the EU's decarbonisation targets by lowering the demand for carbon-intensive fuels, making it easier for renewables to be substituted for them.
Prospects of meeting policy objectives/targets		
2020	☐	Despite past progress, the EU is at risk of not meeting the 20 % energy efficiency target for 2020 without new and renewed efforts. New measures to reduce energy consumption agreed under the recast of the Energy Efficiency Directive are expected to incentivise ambitious new reductions in the Member States. Without that, assuming that the current rate of progress continues, the EU is not on track to meet its minimum 32.5 % energy efficiency target for 2030 or to achieve its decarbonisation objectives for 2050.
2030	☒	Indicative EU energy efficiency targets beyond 2030 have not yet been defined. However, for the EU to achieve carbon neutrality by 2050, primary and final energy consumption across the EU would have to decrease by at least 31 % and 43 % by 2050 compared with 2005 levels, and possibly by as much as 42 % and 47 %, respectively, combined with very high shares of energy from renewable sources in the energy mix, in accordance with the in-depth analysis accompanying the Commission's recent strategic long-term vision for a climate-neural economy by 2050.
2050	☒	
Robustness		Energy indicators are robust, with energy production, consumption and import data being reported to Eurostat and to the European Commission. GHG and air pollutant emissions linked to energy production and consumption are well understood and quantified. Other environmental aspects related to energy efficiency (e.g. multiple social and health benefits) are less well captured. Outlook information is available and assumptions documented. The assessment of outlooks and the prospects of meeting policy targets also relies on expert judgement.

17.5 %

of the EU's energy came from renewable sources in 2017.

and the 2008 economic downturn. The biggest contributors to the decrease in final energy consumption were the industrial and household sectors (EEA, 2018g). Together these are responsible for approximately four fifths of the decrease since 2005.

Since 2014, levels of primary energy consumption increased again relative to the previous year. In 2017, primary energy consumption in the EU increased by 1 % compared with 2016, primarily due to increased energy demand in the transport sector and increases in the household and services sectors. As in 2016, in 2017 both primary energy consumption and final energy consumption were above the indicative trajectory towards 2020. This continued increase makes achieving the 2020 target increasingly uncertain. Increased efforts are needed from Member States to bring the EU back on track and reverse the trend towards increasing energy consumption.

Renewable energy sources

In 2016, the EU's share of energy from renewable sources (RES) was 17.0 %, increasing to 17.5 % in 2017. This gradual increase has occurred despite an increase in energy consumption from all sources, observed since 2014 across the EU. Steady progress in increasing the RES share indicates the EU has met its indicative trajectory for 2017-2018, as set out in the Renewable Energy Directive (Figure 7.5).

In absolute terms, the largest amount of renewable energy was consumed in the heating and cooling energy market sector, followed by

TABLE 7.6 Summary assessment — renewable energy sources

Past trends and outlook		
Past trends (10-15 years)		The EU has steadily increased the share of energy consumed from renewable sources. However, the annual increase has slowed down in recent years, especially due to increases in total final energy consumption.
Outlook to 2030		Further increases in the use of renewable energy sources are expected with the implementation of current policies. This requires further progress in energy efficiency and continuous further deployment of renewable energy sources along with an increase in their uptake in all sectors, especially in transport. Achieving this needs substantial investment across all sectors, including in industry, transport and the residential sector (also facilitating decentralised production and empowering renewable energy self-consumers and renewable energy communities).
Prospects of meeting policy objectives/targets		
2020	☑	The EU is overall on track to meet its 20 % renewable energy target in 2020. However, a continued increase in energy consumption poses risks for achieving the renewable energy target. The EU is not on track to meet the 10 % target for renewable energy use in transport by 2020. Achieving the minimum target of a 32 % share of gross final energy consumption from renewable sources by 2030 will require an increased pace of deploying renewables, together with efforts to tackle energy demand and increase investors' confidence. While renewable energy targets beyond 2030 have not yet been defined, achieving carbon neutrality by 2050 in accordance with the in-depth analysis accompanying the Commission's long-term vision for a climate-neutral economy would require significant improvements in energy efficiency and the transition to 100 % renewable energy sources in the energy mix (calculated according to the Renewable Energy Directive).
2030	☒	
2050	☒	
Robustness		Energy indicators are robust, with energy production, consumption and import data being reported to Eurostat and to the European Commission. These data allow tracking of energy flows from the production to the consumption side. GHG and air pollutant emissions linked to energy production and consumption are well understood. To some extent, they are quantified in relation to renewable energy sources. Outlook information is available and assumptions documented. The assessment of outlooks and prospects of meeting policy targets also rely on expert judgement.

the renewable electricity market sector (where the growth was mainly driven by wind power and solar photovoltaic systems). Insufficient progress has been achieved so far towards the EU's 10 % target for renewable energy consumption in the transport sector. In addition, average year-on-year RES growth across the EU has slowed since 2015, compared with the average annual pace of growth recorded between 2005 and 2014. With 2020 approaching, the trajectories needed to meet the national targets are becoming steeper. Increasing energy consumption, persistent legal/administrative constraints and further market barriers are hindering the uptake of an increased share of renewables in several Member States. These trends pose a risk for achieving the 2020 target.

7.3.3 Links between climate change mitigation and adaptation

The success of global efforts to reduce greenhouse gas emissions determines the magnitude and pace of climate change and consequently the need for adaptation to its impacts in the long term. Ambitious global mitigation measures are necessary to avoid the most dangerous impacts of climate change, because there are many limits and barriers to adaptation. At the same time, climate change is already occurring, and it will continue for many decades — and, in the case of sea level rise, many centuries — to come, even under the most stringent mitigation policies. Therefore, societies need to

18

of the 19 warmest years on record globally have occurred since 2000.

Since the 1950s, and in particular after 2000, Europe has increasingly experienced heat extremes and heat waves.

adapt to the unavoidable impacts of past and future climate change. In summary, the short-term adaptation challenges are largely independent of mitigation efforts, whereas the long-term climate challenge, and societies' ability to adapt to it, are strongly dependent on the success of global mitigation efforts.

There can be synergies as well as trade-offs between climate change mitigation and adaptation objectives. One strategy that often brings about mitigation as well as adaptation benefits is ecosystem-based adaptation. This is a nature-based solution that uses ecosystem services as part of an overall strategy to increase the resilience and reduce the vulnerability of communities to climate change (Secretariat of the Convention on Biological Diversity, 2009). Examples include natural water retention measures and green infrastructure (EC, 2013c; NWRM, 2019). Ecosystem-based adaptation can generate many environmental, social, economic and cultural benefits (EEA, 2017b; EC, 2018b). For further information, see the Climate-ADAPT platform [5]. Ecosystem-based adaptation can also contribute to climate change mitigation by reducing emissions caused by ecosystem degradation and/or by enhancing carbon stocks. An example of trade-offs between adaptation and mitigation is energy-intensive desalinisation or air conditioning based on fossil fuels.

7.3.4 Climate change and its impacts on ecosystems

► See Table 7.7

All ecosystems, many economic activities and human health and well-being are sensitive to climate variability and change. This section gives an overview of key changes in the climate system in the past and future, and of selected impacts on ecosystems. More detailed information on this topic is available in the EEA report *Climate change, impacts and vulnerability in Europe 2016 — an indicator based report* (EEA, 2017c). Specific information about the European climate in a particular year is available in the European state of the climate reports published annually by the C3S (C3S, 2018a).

Average temperature

Global average annual near-surface (land and ocean) temperature in the last decade (2009-2018) was about 0.91-0.96 °C warmer than the pre-industrial average (1850-1899) (Figure 7.6). The European land area has warmed by 1.6-1.7 °C over the same period, with significant regional and seasonal differences. Of the 19 warmest years on record globally, 18 have occurred since 2000 (EEA, 2019f).

All UNFCCC member countries have agreed on the long-term goal of keeping the increase in global average temperature to well below 2 °C compared with pre-industrial levels and have agreed to aim to limit the increase to 1.5 °C. About half of the maximum admissible warming under the Paris Agreement has already been realised. For the three highest of the four representative concentration pathways (RCPs, loosely known as emissions scenarios) considered by the Intergovernmental Panel on Climate Change (IPCC), the global mean temperature increase is projected to exceed 2 °C compared with pre-industrial levels during the 21st century, and most likely in the 2040s (IPCC, 2013; Vautard et al., 2014). 'Very deep and rapid global emissions reductions, requiring far-reaching transitions in all sectors of the economy, are necessary to keep the chance of limiting global mean temperature increase to 1.5 °C (IPCC, 2018).'

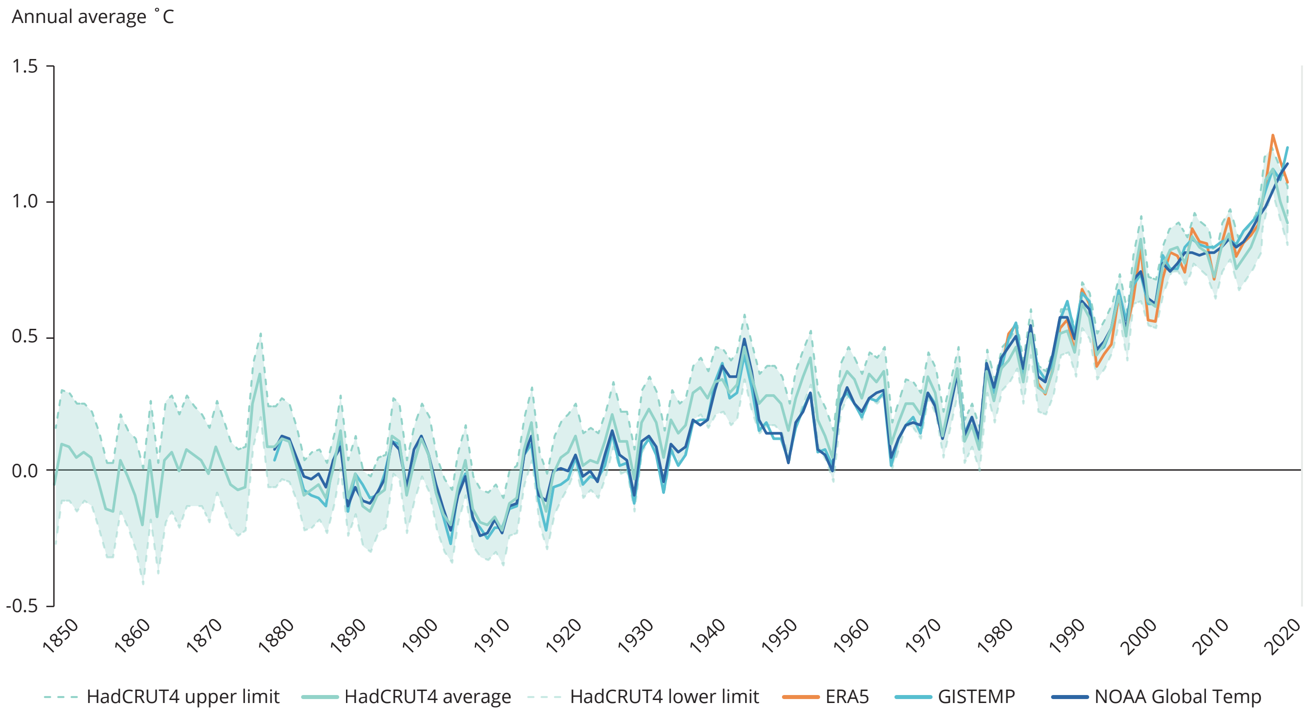
Heat extremes

Annually averaged land temperatures in Europe have increased considerably faster than global temperatures (see above), and daily maximum temperatures in Europe have increased much faster than annually averaged temperatures. This means that a given increase in global mean temperature is associated with a much larger increase in heat extremes in Europe.

Heat extremes and heat waves in Europe have increased considerably since the 1950s, and in particular after 2000. Since publication of the SOER 2015, all-time national temperature records were broken in eight EEA member countries (Poland in 2015, Spain in 2017 and Belgium, France, Germany, Luxembourg, the Netherlands and the United Kingdom in 2019), several of them with a large margin. In the same period, national records for the warmest night, which is particularly relevant from a human health perspective, were broken in nine countries (Austria in 2015, France and Slovenia in 2017, the Netherlands

(5) https://climate-adapt.eea.europa.eu/eu-adaptation-policy/sector-policies/ecosystem

FIGURE 7.6 Average global near-surface temperature since the pre-industrial period



Notes: HadCRUT4, Met Office Hadley Centre and Climatic Research Unit; GISTEMP, NASA Goddard Institute for Space Studies; NOAA Global Temp, National Centers for Environmental Information; ERA5, C3S by European Centre for Medium-Range Weather Forecasts. Light green area: 95 % confidence interval of HadCRUT4 data set. 'Pre-industrial period' refers to 1850-1899.

Source: EEA (2019f).

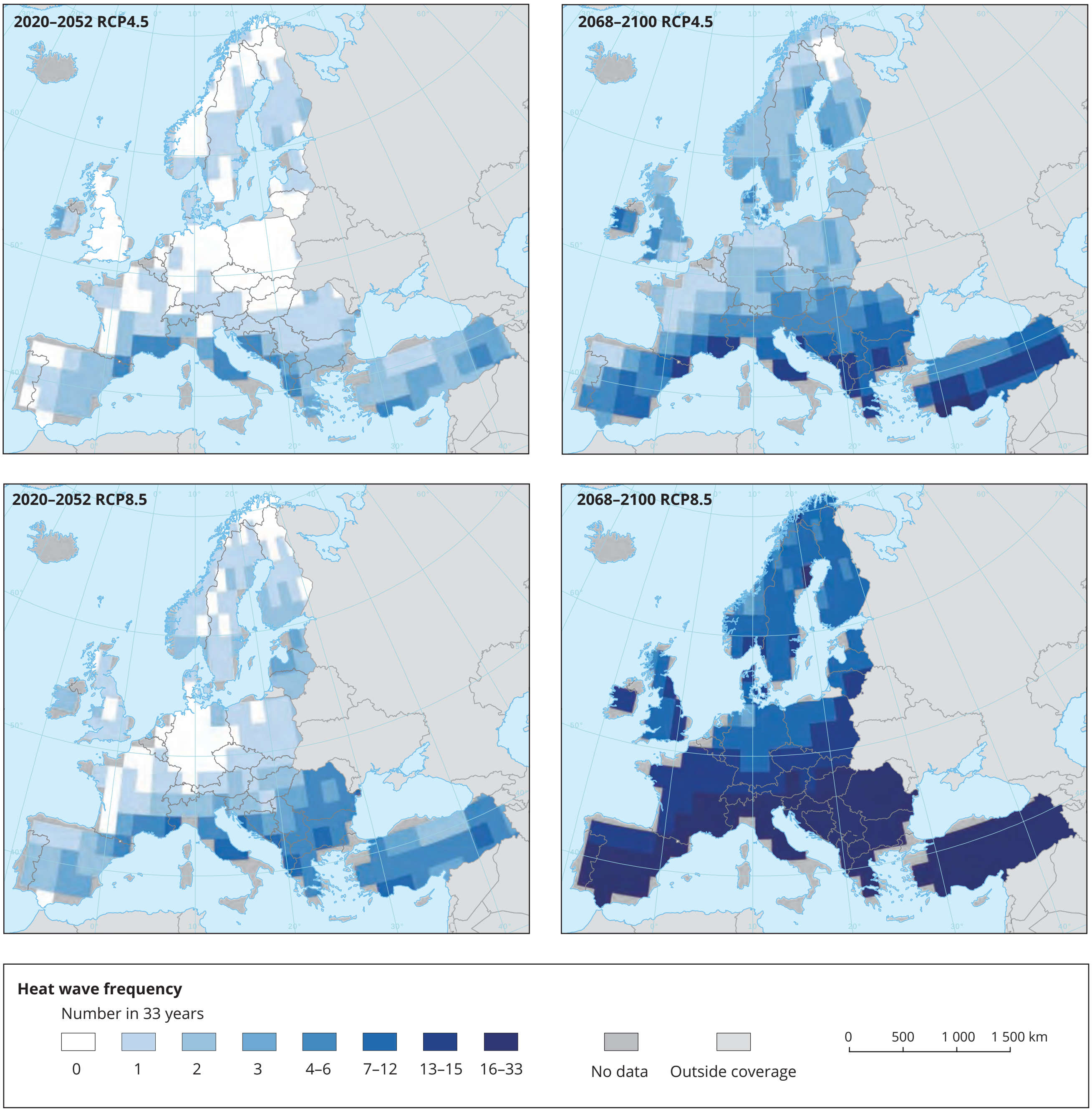
and Sweden in 2018 and Belgium, Luxembourg, Norway and the United Kingdom in 2019). Regional and/or monthly temperature records were broken in many more locations. Human-induced climate change made those unprecedented heat events in Europe, which already had considerable impacts on ecosystems, economic activities and human health, much more likely (typically around 10 to 100 times) than they would have been in an unchanged climate (EEA, 2019f; C3S, 2019; WMO, 2019; Vautard et al., 2019).

Heat waves are projected to become even more frequent and longer lasting in Europe. Under a high-emissions scenario, very extreme heat waves (more severe than the 2003 heat wave affecting southern and central Europe or the 2010 heat wave affecting eastern Europe) are projected to occur as often as every 2 years in the second half of the 21st century (Map 7.1). The projected frequency of heat waves is greatest in southern and south-eastern Europe (Russo et al., 2014). The most severe economic and health risks from heat waves are projected for low-altitude river basins in southern Europe and for the Mediterranean coasts, where many densely populated urban centres are located (Fischer and Schär, 2010). The effects of heat waves are exacerbated in large cities due to the urban heat island effect.

Total precipitation

Observed and projected changes in precipitation vary substantially

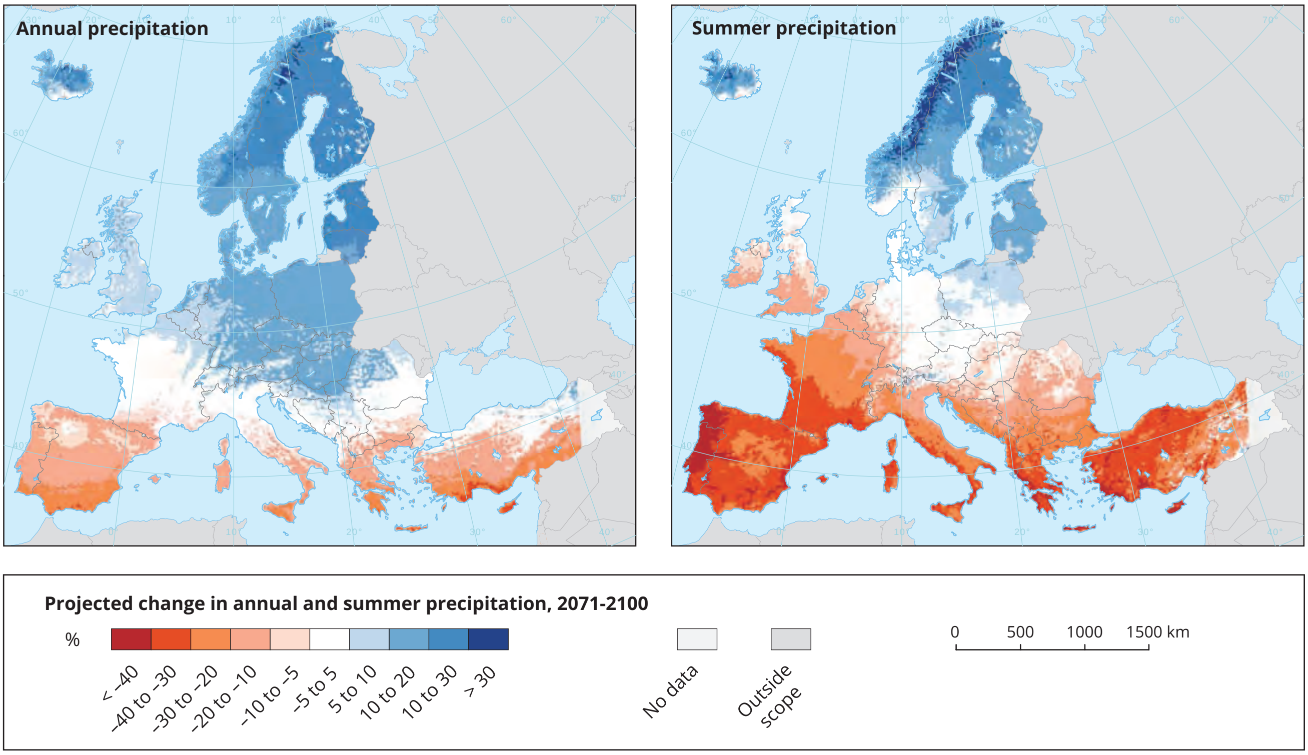
MAP 7.1 **Extreme heat waves in the future under two different forcing scenarios**



Note: RCP 4.5 corresponds to a medium-emissions scenario, whereas RCP 8.5 refers to a high-emissions scenario. Neither of these scenarios is compatible with the stabilisation target of the Paris Agreement.

Source: EEA (2019f), adapted from Russo et al. (2014).

MAP 7.2 **Projected changes in annual and summer precipitation**



Note: Projected changes in annual (left) and summer (right) precipitation (%) in the period 2071-2100 compared with the baseline period 1971-2000 for the forcing scenario RCP 8.5, which corresponds to a high-emissions scenario, based on the average of a multi-model ensemble of regional climate models.

Source: EEA (2017e), based on Euro-Cordex data.

across regions and seasons. Annual precipitation has increased in most parts of northern Europe and decreased in parts of southern Europe. These changes are projected to exacerbate in the future with continued climate change, and the projected decrease is greatest in southern Europe in the summer (Map 7.2) (EEA, 2017e).

Heavy precipitation and inland floods

The intensity of heavy precipitation events, which can cause floods, has increased in summer and winter in most parts of northern Europe. The largest increase has been observed for particularly strong precipitation events. Different indices show diverging trends for southern Europe. The intensity of heavy daily precipitation events is projected to increase over most of Europe, most strongly in north-eastern Europe (EEA, 2019h).

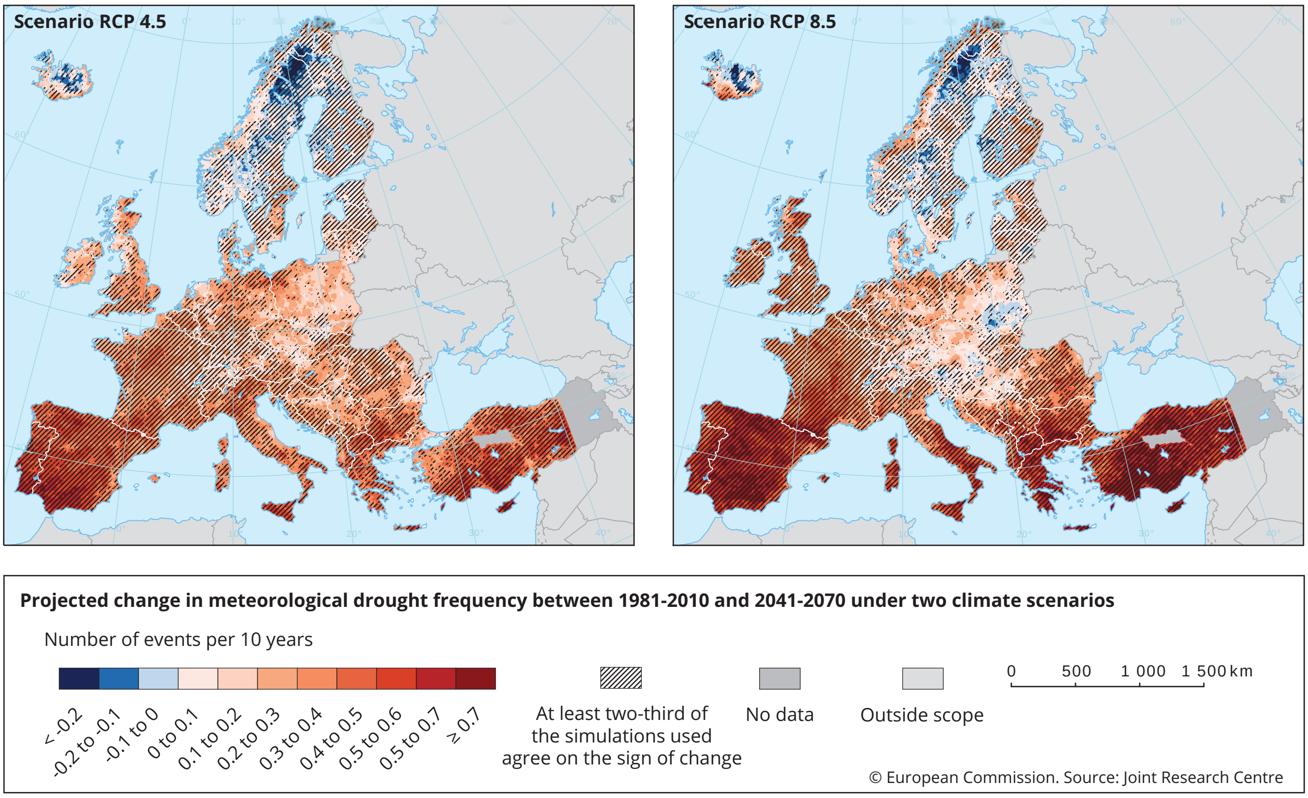
> Heatwaves are projected to become more frequent and to last longer across Europe.

The number of very severe flooding events in Europe has increased in recent decades, but there is large interannual variability. Various European-wide studies project river flooding to become more frequent in north-western and central-western parts of Europe, whereas the results diverge in other regions (Kundzewicz et al., 2016, 2018). Pluvial floods and flash floods, which are triggered by intense local precipitation events, are likely to become more frequent throughout Europe (EEA, 2017f).

Droughts

Drought conditions have generally increased in southern Europe and decreased in northern Europe, but

MAP 7.3 **Projected changes in the frequency of meteorological droughts**



Note: The maps show projected changes in drought frequency (number of events per decade) by mid-century (2041-2070 relative to 1981-2010) for two different emissions scenario: RCP 4.5 (left) and RCP 8.5 (right). For an explanation of these scenarios, see Map 7.1.

Source: Adapted from Spinoni et al. (2018). Open access under CC BY 4.0.

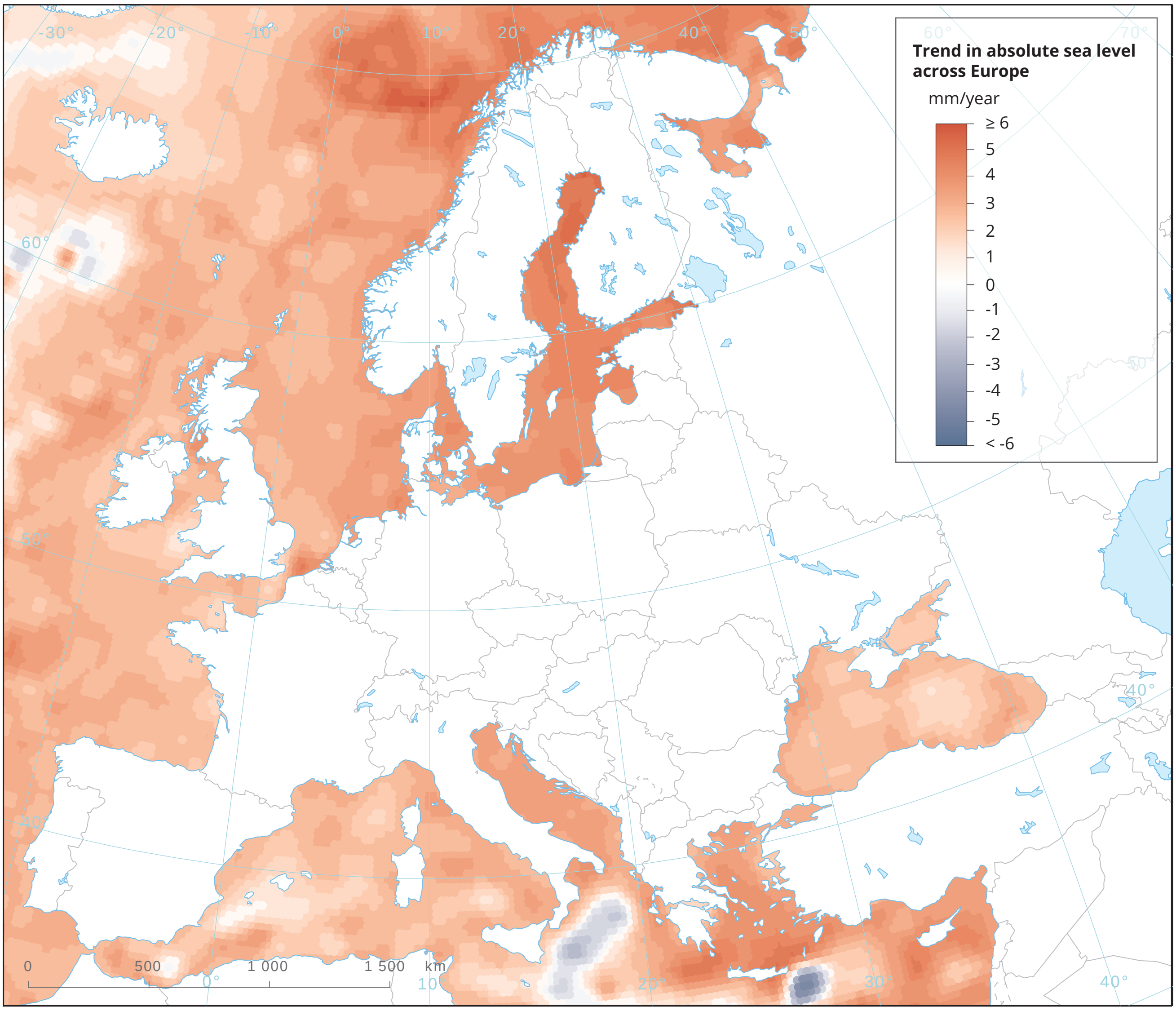
Severe floods have increased in recent decades in Europe, but with large interannual variability.

there are variations across seasons and some differences between various drought indicators. The increased droughts in southern Europe are driven by reductions in precipitation as well as by rising temperatures, which increases evapotranspiration. This pattern is projected to continue in the future (Map 7.3) (EEA, 2019i). Drought frequency is projected to increase everywhere in Europe in spring and summer, especially over southern Europe, and less intensely in autumn; winter shows a decrease in drought frequency over northern Europe (Spinoni et al., 2018). The observed and projected increase in drought conditions in southern Europe is increasing competition between different water users, such as agriculture, industry, tourism and households. For further information on freshwater systems affected by climate change, see Chapter 4.

Global and European sea level

Global mean sea level has increased by about 20 cm since 1900. The rise in global sea level has accelerated in recent decades as a result of human-induced climate change. The model simulations used in the IPCC Fifth assessment report (AR5) projected a rise in global sea level over the 21st century that is likely to be in the range of 28-98 cm (depending on the emissions scenario), but substantially higher increases in sea level were not ruled out. This range will be revised in the IPCC special report, The ocean and cryosphere in a changing climate, which is due to be published in September 2019. Several

MAP 7.4 **Trend in absolute mean sea level across Europe**



Note: Observed altimeter sea level trends (mm/year) from January 1993 to May 2017. The data have not been adjusted for glacial isostatic adjustment.

Source: CS3 (2018b).

recent model-based studies, expert assessments and national assessments have suggested an upper bound for 21st century global mean sea level rise in the range of 1.5-2.5 m. Further increases by several metres by 2300, and by many metres by 2500, are possible if the stabilisation goal of the Paris Agreement is not met (EEA, 2019e).

All coastal regions in Europe have experienced an increase in absolute sea level but with significant regional variation (Map 7.4). Extreme high coastal water levels have increased at most locations along the European coastline. The rise in sea level relative to land along most European coasts is projected to be similar to the global average, with the exception of the northern Baltic Sea and the northern Atlantic coast, which are experiencing considerable land rise as a consequence of post-glacial rebound. The increase in sea level and coastal flood levels is threatening coastal ecosystems, water resources, settlements, infrastructure and human

TABLE 7.7 Summary assessment — climate change and impacts on ecosystems

Past trends and outlook		
Past trends (10-15 years)		Anthropogenic climate change is ongoing and has led to increasing impacts on species and ecosystems. In some cases, such as sea level rise, changes have been accelerating.
Outlook to 2030		Climate change will continue in the coming decades, with increasingly severe impacts on species and ecosystems projected.
Prospects of meeting policy objectives/targets		
2020	☒	While there are no specific targets related to climate change and its impacts on species, habitats and ecosystems in Europe, the Seventh Environment Action Programme requires the mainstreaming of climate change adaptation into key policy initiatives and sectors in order to protect, conserve and enhance natural capital. Continuing climate change makes it more difficult to achieve other policy targets related to biodiversity protection, ecosystems and water quality.
Robustness		The qualitative and aggregated assessment presented here is based on a multitude of direct observations and quantitative modelling. It is considered robust, although there are considerable uncertainties for climate change and its impacts on specific ecosystems at the regional level.

lives (Chapter 6). Available studies project that the economic damage from coastal flooding in Europe would increase many fold in the absence of adaptation (Ciscar et al., 2018).

Further changes in the climate system

Climate change is also evident through melting glaciers (EEA, 2016e), decreasing sea ice (EEA, 2018c) and warming oceans (EEA, 2016h). Furthermore, the CO_2 emissions driving global climate change are making the oceans more acidic, which inhibits the growth of calcifying organisms (EEA, 2016f) (Chapter 6).

Climate change impacts on forests and other ecosystems

Climate change has caused widespread changes in the distribution of plant and animal species in Europe, both on land and in the sea. The migration has generally been northwards and, for and-based species, upwards to higher altitudes. The migration of many land-based species is lagging behind the changes in climate, which may lead to a progressive decline in European biodiversity (EEA, 2016b, 2016c). Climate change is also leading to changes in the seasonality of biological events, such as flowering of plants or hatching of birds (EEA, 2016g). Because these changes are not uniform across species, some animals no longer find sufficient food when they need it. Overall, these changes make it more difficult to achieve policy objectives related to preserving terrestrial and marine biodiversity in Europe (Chapters 3 and 6).

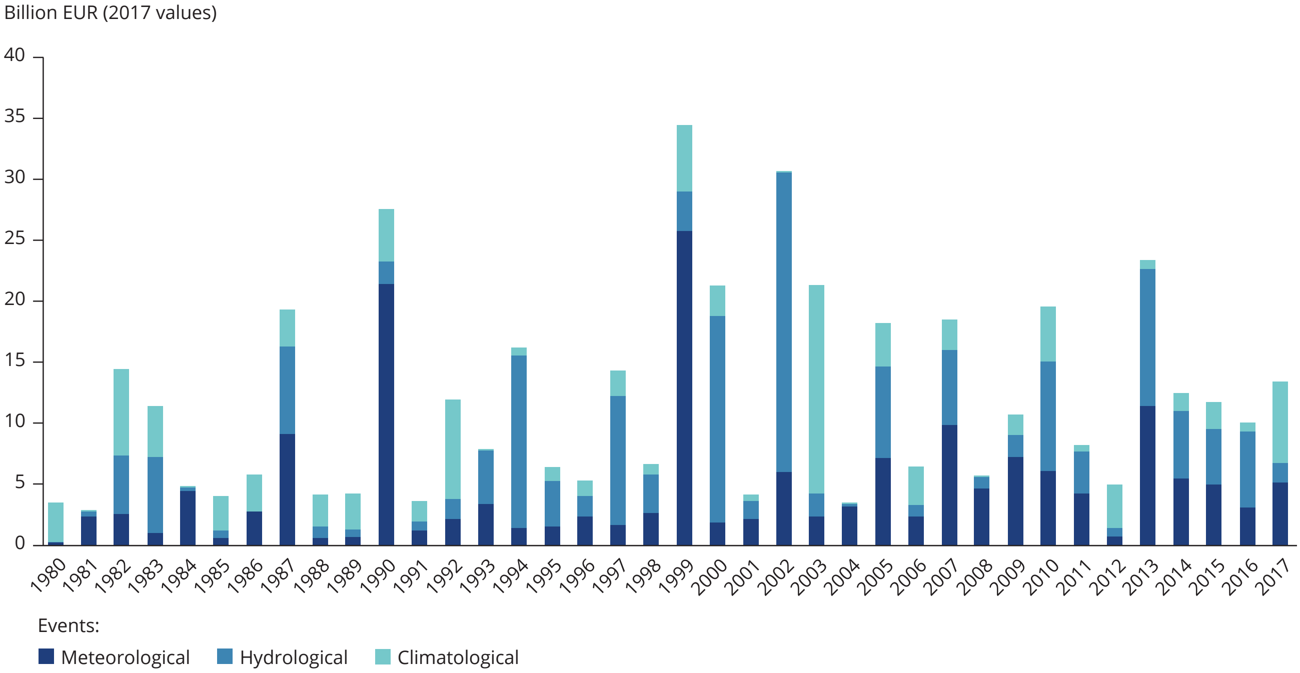
Forest growth is generally projected to increase in northern Europe and to decrease in southern Europe, but with substantial regional variation. At the same time, forest tree species are shifting towards higher altitudes and latitudes as a result of climate change (EEA, 2017d). More severe forest fire weather and, as a consequence, an expansion of the fire-prone area and longer fire seasons are projected across Europe in a warmer climate (EEA, 2019d). The impact of fire events is particularly strong in southern Europe, as exemplified by the extreme fires in Portugal in 2017 and in Spain and Greece in 2018. However, northern Europe can also be affected. For example, Sweden experienced unprecedented forest fires during extreme heat waves combined with droughts in 2014 and again in 2018. Climate change is also affecting the regional and spatial occurrence of forest pests and diseases. Forest insect pests are projected to increase in most regions of Europe (EEA, 2017c, Section 4.4.7). These combined impacts considerably affect forest structure and the functioning of forest ecosystems and their services (Chapter 13).

7.3.5 Climate change risks to society

► *See Table 7.8*

Climate change is affecting human health and well-being as well as many economic activities. This section gives an overview of selected climate change impacts on society. More detailed information on this topic is available in a 2017 EEA report (EEA, 2017c).

FIGURE 7.7 Economic damage caused by climate-related extreme events in EEA member countries



Note: Meteorological events: storms; hydrological events: floods and mass movement; climatological events: cold waves, heat waves, droughts, forest fires.

Source: Adapted from EEA (2019b), NatCatSERVICE provided by Munich Re.

Health impacts of climate change

Heat waves are the most deadly climate extremes in Europe. The 2003 summer heat wave alone is estimated to have caused around 70 000 premature deaths in Europe (Robine et al., 2008). The projected substantial increase in the frequency and magnitude of heat waves will lead to a large increase in mortality over the next few decades, especially in vulnerable population groups (the elderly, children, those in poor health), unless adaptation measures are taken. Urban areas are particularly affected due to the combined effects of higher temperatures as a result of the urban heat island effect, the frequent combination of heat with air pollution, including ground-level ozone, and high population density (EEA, 2016d). Different population groups are affected differently, depending on their age, general health and socio-economic status (EEA, 2019j).

Climate change is also affecting human health and well-being directly through floods and indirectly by changing the magnitude, frequency, seasonality and/or regional distribution of vector-, water- and food-borne diseases, pollen allergens and air pollution incidents. For example, extremely warm water temperatures in the Baltic and North Seas during recent heat waves were associated with unprecedented peaks in *Vibrio* infections in humans (EEA, 2017c, Section 5.2).

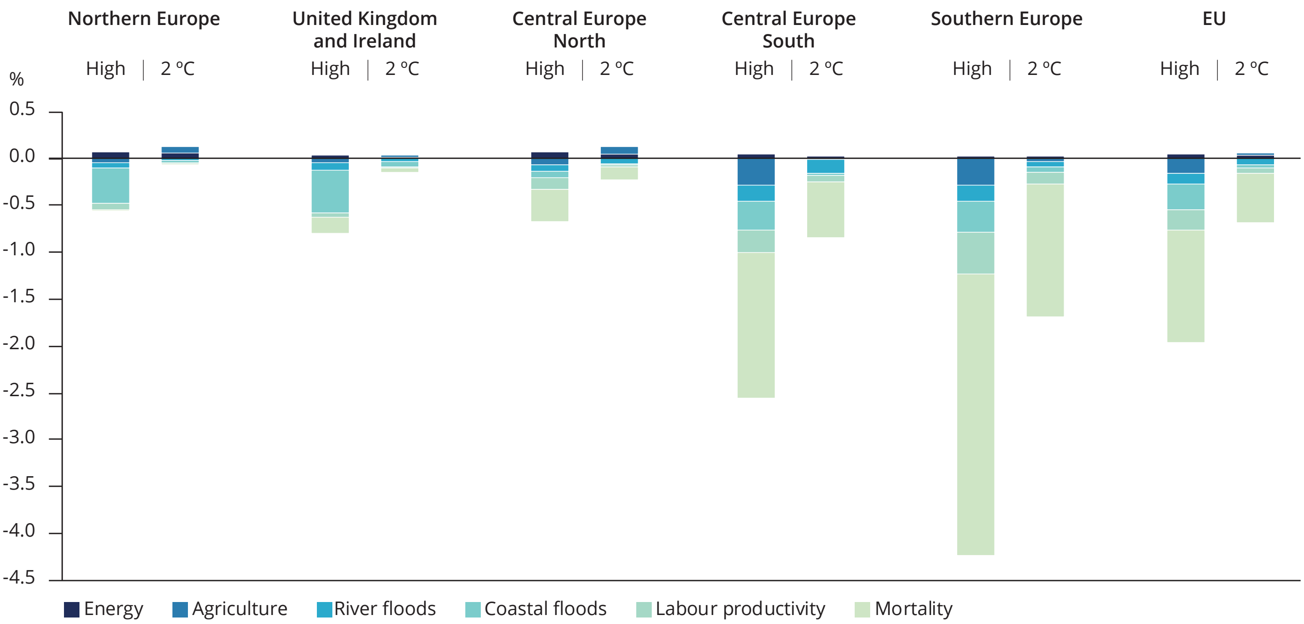
Economic losses from climate-related extremes

The direct economic losses caused by weather- and climate-related extremes in the EEA member countries amounted to approximately EUR 453 billion (in 2017 euro values) over the period 1980-2017 (Figure 7.7). The analysis of historical trends is difficult, because most of the losses were caused by a small number of very severe events (EEA, 2019b). Model simulations performed by the Joint Research Centre project large increases in most climate hazards in Europe and considerable economic damage. For example, in a hypothetical scenario without additional adaptation, impacts on critical infrastructure could rise 10-fold during the 21st century due to climate change alone (Forzieri et al., 2016, 2018).

Other economic impacts of climate change

A changing climate is affecting a wide range of economic sectors and human activities, including agriculture, forestry, fisheries, water management,

FIGURE 7.8 **Projected welfare impacts of climate change for different EU regions and sectors for two warming scenarios**

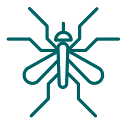


Note: The country grouping is as follows. Northern Europe: Denmark, Estonia, Finland, Latvia, Lithuania and Sweden. UK & Ireland: Ireland and United Kingdom. Central Europe North: Belgium, Germany, Luxembourg, Netherlands and Poland. Central Europe South: Austria, Czechia, France, Hungary, Romania and Slovakia. Southern Europe: Bulgaria, Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia and Spain.

Source: Ciscar et al. (2018).

coastal and flood protection, energy, transport, tourism, construction, and human health and wellbeing. Various research projects have assessed the multi-sectoral social and economic impacts of climate change across Europe or for specific European regions. The specific estimates depend strongly on the underlying climate scenarios; the sectors considered, including cross-border impacts; the assumptions regarding demographic and socio-economic developments, including adaptation; the treatment of uncertainties; and the economic valuation of non-market impacts and of impacts further in the future (EEA, 2017c, Section 6.3).

The Peseta III study by the Joint Research Centre has estimated the net welfare loss from climate change in the EU by the late 21st century at 1.9 % of GDP under a high warming scenario (RCP 8.5) and at 0.7 % under a 2 °C scenario (Figure 7.8). Southern and central-southern Europe are projected to suffer by far the highest losses as a percentage of GDP. Welfare losses in southern and central Europe are dominated by health-related impacts, in particular increased mortality from heat waves, but also reduced labour productivity. In contrast, welfare losses in northern and north-western Europe are dominated by coastal floods. The only sector with (small) positive net welfare impacts in the EU is the energy sector because of the reduced need for heating in a warming climate (Ciscar et al., 2018).



An increase in heat-related mortality and vector-and waterborne diseases has been observed across Europe.

The Peseta III estimates are based on a limited number of sectors and climate change impacts. Other studies using different modelling frameworks and assumptions have arrived at both higher and lower estimates. Many impacts can be significantly reduced

TABLE 7.8 Summary assessment — climate change risks to society

Past trends and outlook		
Past trends (10-15 years)		Premature deaths due to heat waves and an increase in the incidence of several vector- and water-borne diseases have been observed in Europe. Forest fires facilitated by extreme heat and drought have led to considerable death tolls in recent years. There are no clear trends in the economic losses from extreme weather events.
Outlook to 2030		The past trends related to health impacts are projected to continue with ongoing climate change. The overall economic impacts of climate change on Europe are primarily negative, but there is substantial variation across regions and economic activities.
Prospects of meeting policy objectives/targets		
2020	☐	There are no specific targets for climate-related health risks, but the Seventh Environment Action Programme requires decisive progress to be made in adapting to climate change to safeguard from environment-related pressures and risks to health. There is some evidence that repeated climatic extremes affecting the same region (e.g. heat waves) lead to reduced health impacts because of adaptation.
Robustness		Data on past climate-sensitive health impacts originate from different sources, including mandatory reporting, official statistics and attribution analyses. The identification of trends is difficult because the most significant events are very rare. An overall assessment of the impacts of climate change on health is hampered by the lack of reliable estimates for cold-related health impacts. Data on economic losses from climate-related events are derived from insurance data, including estimates of uninsured losses. Attribution of trends is difficult because of the sparsity of the most costly events as well as concurrent developments in hazards, exposure and vulnerability.

by appropriate adaptation measures. However, adaptation generally comes at a cost, there may be trade-offs with other policy objectives, and residual impacts remain (EEA, 2017c, Section 6.3; EC, 2018b, Annex XIII).

Europe's vulnerability to climate change impacts occurring outside Europe

European societies are also affected by the indirect impacts of climate change occurring outside Europe through various pathways, such as international trade and migration (Figure 7.9). These 'cross-border impacts' can be triggered by a single extreme weather event (e.g. a temporary disruption of global supply chains due to damaged production or transport infrastructure following a flood), by prolonged periods of extreme weather (e.g. an extreme drought that increases world market prices of agricultural products) or by gradual climate change (e.g. flooding of densely populated coastal areas that triggers internal or international migration). The strongest evidence for Europe's sensitivity to cross-border impacts are the economic effects of global price volatilities, disruptions to transport networks and changes in the Arctic environment. European vulnerability to cross-border impacts of climate change is expected to increase in the coming decades, but quantitative projections are not yet available (EEA, 2017c, Section 6.4; Ciscar et al., 2018). Cross-border effects of climate change can be addressed by a combination of domestic and international policies.

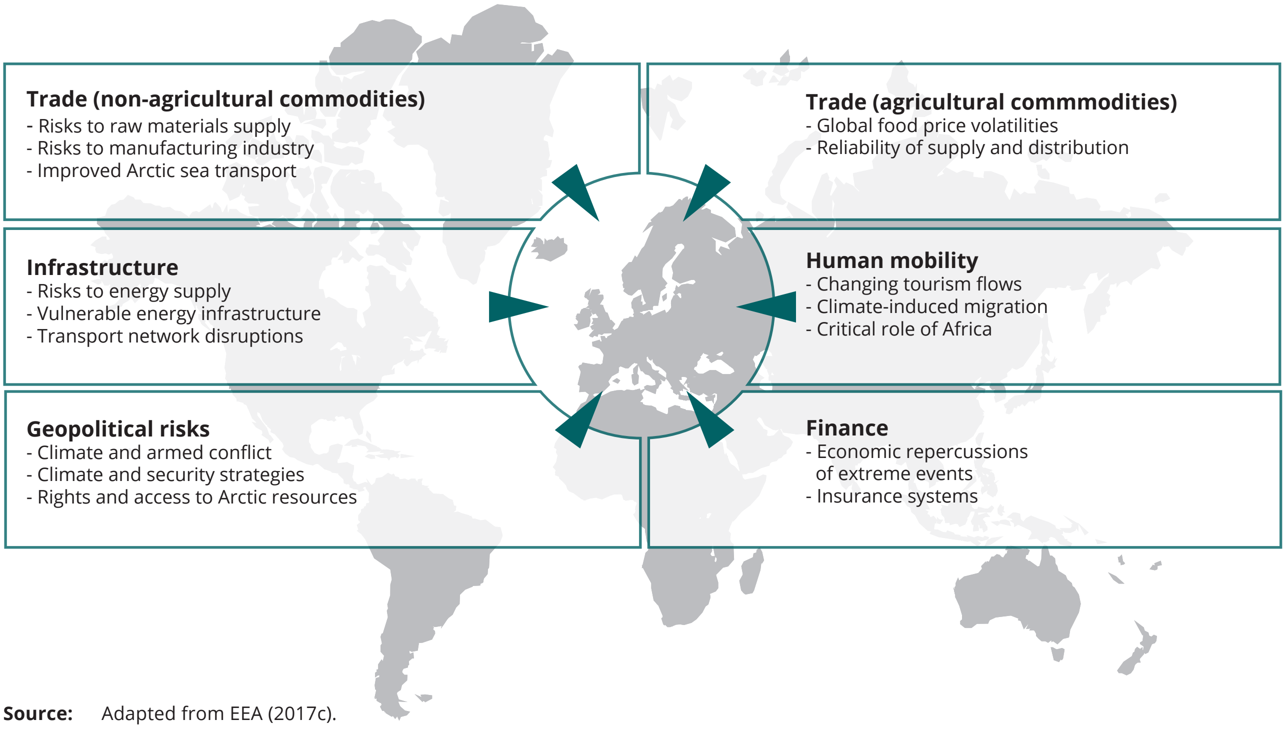
7.4 Responses and prospects of meeting agreed targets and objectives

7.4.1 Climate change mitigation

A number of policies have played an important role in reducing GHG emissions over the past 27 years (EEA, 2018e). In addition to the expected mitigation effects of climate policies, there have been positive indirect effects from other policies that were not aimed at reducing GHG emissions.

For instance, key EU polices such as the Nitrates Directive, the market reform of the common agricultural policy and the Landfill Directive have had a positive

FIGURE 7.9 Overview of major pathways of indirect climate change impacts for Europe



Source: Adapted from EEA (2017c).

impact on reducing greenhouse gas emissions from methane (CH_4) and nitrous oxide (N_2O). The Montreal Protocol on ozone-depleting substances has been one of the most successful multilateral environmental (and indirectly climatic) agreements to date, contributing to substantial reductions in GHG emissions in Europe and worldwide. This was because many of the substances addressed in the Montreal Protocol such as chlorofluorocarbons (CFCs) are also potent GHGs (Velders et al., 2007). The banning of CFCs, however, led to an increase in the consumption of substitute gases such as HFCs. In 2016, the Montreal Protocol was thus amended in Kigali, where countries committed to cutting the production and consumption of HFCs by over 80 % over the next 30 years.

Considerable co-benefits exist for air pollution and climate policies, not only at national but also at local level, although there are some trade-offs as well (Chapter 8). For instance, to

Considerable co-benefits exist for air pollution and climate policies.

stimulate the transition towards a more environmentally friendly future, the European Commission adopted the circular economy action plan (EC, 2015a). It includes measures covering the entire cycle from production and consumption to waste management. These actions should encourage greater recycling and reuse, and bring benefits for the environment, the economy and the climate (Chapter 9).

Moreover, the EU's Large Combustion Plant Directive has encouraged efficiency improvements and fuel switching from solid fuels to cleaner fuels and thus helped reduce emissions, not only of air pollutants but also of greenhouse gases (EEA, 2011, 2019a). Indeed, the EU has been able to reduce GHG emissions and air pollution, improve energy efficiency and achieve higher shares of energy from renewable sources and, at the same time, increase economic growth. Nevertheless, much remains to be done, and considering the co-benefits and trade-offs between climate policies and other policies, including environmental policies, in the design of new legislation would achieve maximum benefits.

In relation to direct effects, and the effectiveness of climate and energy policies, EEA analysis (EEA, 2016a) has shown that there is statistical evidence of a long-term relationship between GHG emissions, economic growth and use of energy from fossil fuels, and that GHG emissions can be predicted in the short term based on these two variables, with some variations due to, for example, particularly cold or warm years. A later analysis (EEA, 2017a) also showed that, based on projections reported by Member States, this long-term relationship becomes weaker as the years go by. This would suggest that climate change mitigation policies and measures, as a package if not individually, are gradually working and are expected to have a stronger effect over time both in Member States and at EU level.

Indeed, the increased use of energy from renewable sources since 2005 allowed the EU to cut its demand for fossil fuels by over one tenth in 2016 (EEA, 2018h). This is comparable to the fossil fuel consumption of the United Kingdom in that year, with coal being the fossil fuel most substituted across Europe (38 % of all avoided fossil fuels), followed by natural gas (at 36 %). The growth in the consumption of renewable energy after 2005 also helped the EU achieve an estimated gross reduction in CO_2 emissions of 9 % in 2016, compared with a scenario in which RES consumption stayed at the 2005 level (EEA, 2018h). This almost corresponds to the annual GHG emissions of France in that year. Most of these changes took place in energy-intensive industrial sectors under the EU ETS, as the increase in renewable electricity decreased the reliance on fossil fuels and made up roughly three quarters of the estimated total EU reductions.

Despite this recent progress, to meet the EU's 2030 and 2050 objectives there is a need to further improve energy efficiency and step up the use of renewables to reduce carbon intensity and completely decouple GHG emissions from energy use and economic growth.

Concerning energy, decarbonisation of the EU supply is possible. With full implementation of current energy efficiency solutions and the upscaling of low-carbon energy technologies, emissions of GHGs from the EU power sector can be reduced by 98 % or more (EC, 2018c). To make this possible, significant new investments in cost-efficient solutions, beyond diverting former fossil fuel investments to energy efficiency and renewables, are needed.

Meeting EU RES targets requires better RES deployment and more uptake, notably in transport.

Efforts to decommission conventional thermal generation (especially coal) also need to be intensified, because these technologies are by far the largest sources of climate and environmental pressures. Under such conditions, clean electricity can increasingly also foster low-carbon transitions within other sectors, such as industry, transport and buildings. Yet, to be successful, this transition also needs to be socially fair and inclusive. Not all new technological developments may ease pressures on the environment and challenges linked to deploying and upscaling new infrastructures need to be duly anticipated and addressed.

For the EU to remain on track towards its energy efficiency objectives, further implementation of energy efficiency measures across specific Member States is needed. To stay on track towards its RES targets, the EU needs to safeguard further RES deployment and to increase the pace of RES uptake in the transport sector.

A broad range of policies affect energy choices and planning and, as a result, environmental outcomes. These include energy security (subsidiarity element), finance and taxation, climate and energy policy at EU and national levels, and science and technology policies. Competencies are dispersed across EU, national, regional and municipal levels. Greater policy integration would improve the rate of progress: this includes continuing the mainstreaming of environmental objectives into key EU spending programmes in the energy area.

Taking a global perspective, although there have been strategies and various policies aimed at reducing GHG emissions in the EU since 2005, at the planetary scale the effect of such policies has been relatively modest. This is because the EU represents 8 % of global GHG emissions (EEA, 2017a). The 2020 EU climate and energy framework was partly designed to help the EU achieve its international 20 % reduction targets by 2020 under the UNFCCC as well as its 20 % emission reduction target under the Kyoto Protocol. The Paris Agreement, signed in 2015, raised the bar for everyone, with all UNFCCC member countries agreeing to keep the increase in global average temperature to well below 2 °C compared with pre-industrial levels and aiming to limit the increase to 1.5 °C (UNFCCC, 2015b).

In 2014, the European Council adopted the 2030 climate and energy framework (European Council, 2014), and the related legislation was adopted by the European Council and the European Parliament in 2018. The headline target of at least a 40 % reduction in GHG emissions by 2030 is consistent with the EU's nationally determined contribution (NDC) under the Paris Agreement. It is also consistent with the EU's longer term objective of the Roadmap for moving to a competitive low-carbon economy in 2050, agreed by the European Council in October 2009, in the context of the necessary reductions to be made by developed countries as a group, according to the IPCC, and re-affirmed thereafter, of reducing its GHG emissions by 80-95 % by 2050 compared with 1990, with milestones of 40 % by 2030 and 60 % by 2040. The EU ETS has been reformed and strengthened for the period 2021-2030 and will ensure that emissions in the sectors covered by the system are reduced by 43 % compared with 2005. For the sectors covered under the Effort Sharing Regulation, emissions would have to be reduced by 30 % compared with 2005, with individual binding targets for Member States. The climate change mitigation objectives are also part of the Energy Union framework strategy, which includes the strategic objectives of reducing energy demand, improving energy efficiency and decarbonising the economy. Finally, the European Commission published its strategic long-term vision for reductions of EU GHG emissions in November 2018, which embraces the target of net zero GHG emissions by 2050 and outlines feasible pathways for achieving this target with current technologies.

EU domestic legislation is in place to meet the Paris Agreement's objectives. It is, however, rather clear that the current NDCs by all signatories to the Paris Agreement are, to date, not consistent with the overall UNFCCC objective of avoiding dangerous anthropogenic interference with the climate system (UNFCCC, 1992), unless the current emissions gap is closed by 2030. According to the 2018 *Emissions gap report* by UN Environment (UNEP, 2018), pathways reflecting current NDCs imply global warming of about 3 °C by 2100. To close the gap, the level of global ambition should increase by 2030. The Paris Agreement requires each Party to prepare, communicate and maintain successive NDCs that it intends to achieve and to pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions. The EU submitted its first NDC in 2015 (UNFCCC, 2015a). New or updated NDCs have to be submitted by all Parties by 2020. The Talanoa Dialogue and the Global Stocktake in 2023 are the mechanisms to ensure that the global community delivers on its objectives to curb emissions to a level consistent with the 2 °C and 1.5 °C targets.

The Paris Agreement also recognises the role of local and regional stakeholders in climate change mitigation. The Covenant of Mayors for Climate and Energy brings together local and regional authorities to implement the EU's climate and energy objectives on a voluntary basis (Covenant of Mayors, 2019b). In Europe, over 7 000 cities have already committed to this goal. Indeed, to address the big challenge and prevent the worst impacts from climate change, mitigation measures can and should be implemented at any level of government.

Climate adaptation is increasingly integrated into EU policies, programmes and strategies.

The challenge is big. Three out of four representative concentration pathways (the global emission scenarios used in the latest IPCC report) exceed 2 °C of global warming during the 21st century and most likely into the 2040s (IPCC, 2013; Vautard et al., 2014). Very rapid global reductions in emissions, and possibly the large-scale application of bioenergy combined with carbon capture and storage technologies, are necessary to keep the chance of limiting global mean temperature increase to 1.5 °C (IPCC, 2018).

7.4.2
Climate change adaptation

► *See Table 7.9*

A number of United Nations (UN) multilateral frameworks with relevance for climate change adaptation have been adopted since 2015. Apart from the Paris Agreement on climate change (UNFCCC, 2015b), these are the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR; UNISDR, 2015), and the 2030 Sustainable Development Agenda, including the Sustainable Development Goals (SDGs; UN, 2017). All these agreements have strong links to climate change adaptation. The Paris Agreement established the global goal on adaptation of 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the global temperature goal' (UNFCCC, 2015b, Art. 7) and thus linking adaptation and sustainable development. The SFDRR and SDGs also consider adaptation as crucial, pointing to possible synergies at the national level where these frameworks need to be implemented. Adaptation monitoring and evaluation is recognised as an important step in the process of adapting to climate change.

EU adaptation efforts

The EU strategy on adaptation to climate change (EC, 2013b) aims to contribute to a more climate-resilient Europe by enhancing the preparedness and capacity to respond to the impacts of climate change from a local to a European level. In November 2018, the European Commission published an evaluation of the EU adaptation strategy (EC, 2018a, 2018b, 2018g) based on the REFIT criteria (EC, 2012a) of the Commission's regulatory fitness and performance programme. In the absence of a specific monitoring and evaluation framework, the eight different actions defined in the strategy have been evaluated in their own right.

The evaluation of the EU adaptation strategy shows that each of the actions made progress between 2013 and 2018 and that they added value to national and sub-national measures. For example, climate change adaptation is increasingly mainstreamed into EU policies, programmes and strategies; the EU has co-funded many adaptation-related projects across Europe through LIFE and other programmes; most EEA member countries now have a national adaptation strategy; an increasing number of cities are adopting local adaptation strategies; and the Climate-ADAPT platform facilitates the exchange of knowledge relevant to adaptation across Europe. While the adaptation strategy promoted adaptation action plans, it was less effective in implementing, monitoring and evaluating those plans. Reflecting on lessons learned, the evaluation emphasises the needs for the following:

- applying the knowledge available for decision-making under uncertainty, e.g. through science-policy dialogues;
- improving the climate resilience of long-term infrastructure; better integration of the strategy's actions with each other and with the international dimension of adaptation;
- better monitoring of the implementation and effectiveness of national adaptation strategies and plans;
- encouraging the establishment of local adaptation strategies in all Member States;
- improving the analysis of the distributional effects of climate change impacts and adaptation measures.

Areas for improvement include, among others, exploiting synergies between climate change adaptation, climate change mitigation and disaster risk reduction; facilitating ecosystem-based adaptation; better mainstreaming into the EU maritime and fisheries policy; reinforcing the links between public health and adaptation; and better adaptation support to investors and insurers, including private investors (EC, 2018g).

Climate-proofing of EU action mainly includes mainstreaming adaptation into key vulnerable sectors. The adaptation strategy explicitly refers to the common agricultural policy, the cohesion policy and the common fisheries policy, but progress has also been made in mainstreaming into disaster risk reduction, water, and urban and development cooperation policies (for a full list of EU policy initiatives where adaptation is mainstreamed, or is being mainstreamed, see EC, 2018b, Annex XI). Adaptation is also mainstreamed in the Energy Union and Climate Action Regulation, which was adopted in December 2018. This Regulation ensures that the national energy and climate plans to be submitted by the Member States in the future include climate adaptation components where applicable (EU, 2018b). A recent report by the European Court of Auditors found that the EU Floods Directive had positive effects overall but that the implementation of flood prevention measures suffers from weaknesses in allocating funding and that much fuller integration of climate change into flood risk management is needed (ECA, 2018).

> Adaptation action plans need to be effectively implemented, monitored and evaluated.

Another objective of the EU adaptation strategy is 'better informed decision-making', with a central role for Climate-ADAPT ([6]). This is a web portal that aims to provide a common European knowledge base related to adaptation. In April 2019, it contained 2 191 database items and 90 case studies and had 3 715 subscribers to its newsletter across Europe. With a growing number of countries implementing adaptation action plans, the information provided by Climate-ADAPT is shifting to knowledge on the implementation and monitoring of adaptation and the development of appropriate indicator sets, e.g. by improving the Adaptation Support Tool ([7]). Climate-ADAPT is branded as a 'first-stop shop' for adaptation information in Europe, complementary to the national adaptation portals (EEA, 2018i).

C3S ([8]) makes an increasing amount of data on past and projected climate change freely available to scientists, policymakers and stakeholders. Of particular relevance for adaptation decision-makers is the C3S Sectoral Information System, which is currently under development.

Adaptation efforts of EEA member countries

The effectiveness and efficiency of many national adaptation policies can be assessed only in the long term, and even then an exact assessment is impossible due to the lack of a counterfactual situation. Consequently, there are no legally binding quantitative objectives and targets regarding adaptation at the European level. Apart from the requirements for the national communications to the UNFCCC, the only mandatory reporting for EU Member States on adaptation comes from the Monitoring Mechanism Regulation (EU, 2013b, Art. 15). From 2021 onwards, as mainstreamed in the Energy Union and Climate Action Regulation, integrated reporting on adaptation actions will be submitted every 2 years instead of every 4 years, in accordance with the requirements agreed upon under the UNFCCC and the Paris Agreement, including the Paris rulebook, adopted in December 2018 as part of the Katowice

([6]) https://climate-adapt.eea.europa.eu
([7]) https://climate-adapt.eea.europa.eu/knowledge/tools/adaptation-support-tool
([8]) https://climate.copernicus.eu

climate package (UNFCCC, 2015b, 2019; EU, 2018b).

Since 2013, there has been a steady increase in the number of national adaptation strategies (NASs) and national adaptation action plans (NAPs) being adopted by countries, and several countries have adopted a revised NAS. To date, 25 EU Member States and four other EEA member countries have adopted a NAS; 17 EU Member States and two other EEA member countries have also developed a NAP (EEA, 2018f; updated based on Eionet, 2019) (Map 7.5). Almost all of these NASs and NAPs are underpinned by climate change vulnerability and risk assessments (EEA, 2018d). Progress is expected to continue as the EU Member States currently lacking a NAS (Bulgaria, Croatia and Latvia) are in the process of drafting one. It is also expected that additional countries will adopt NAPs and that they will implement more specific adaptation policies and actions in line with their strategies and plans (EC, 2018b, Annex IX).

In the Western Balkans, Bosnia and Herzegovina adopted a climate change adaptation and low-emission development strategy in 2013 (Radusin et al., 2017) and is now starting work on a NAP (UNDP, 2018). Serbia is developing a national plan for adaptation (Ministry of Environmental Protection, 2017). In addition, a detailed list of proposed priority adaptation measures across sectors is available for North Macedonia (Zdraveva et al., 2014).

In the EU countries, most vulnerability assessments are made and adaptation options are identified for agriculture, health, biodiversity, forestry and energy. The main sectors in which national policy instruments promote adaptation are water, agriculture, biodiversity and forestry, whereas health and energy are lagging behind. Almost all EU Member States include transboundary cooperation on adaptation issues in the water sector, as required by the Water Framework Directive (EU, 2000) and the Floods Directive (EU, 2007), and highlighted in the Blueprint to safeguard Europe's water resources (EC, 2012b). For all other sectors, this is limited to one or a few countries only (EC, 2018b, Annex IX).

Over 1 900

local authorities in the EEA-39 countries have committed to take action to adapt to climate change.

A limited number of countries have started to monitor and/or evaluate adaptation policies and actions at national level, using mainly 'process-based' indicators. Some countries also use 'output-based' or 'outcome-based' approaches to assess if and how vulnerability has decreased and/or resilience has increased (e.g. Austria, Finland, Germany and the United Kingdom), but such approaches use complex methodologies and are resource intensive (EEA, 2014a; Mäkinen et al., 2018; EC, 2018b, Annex IX). It will not be possible to determine with any certainty whether or not decisive progress in increased resilience at EU level has been achieved by 2020.

Adaptation efforts in transnational regions

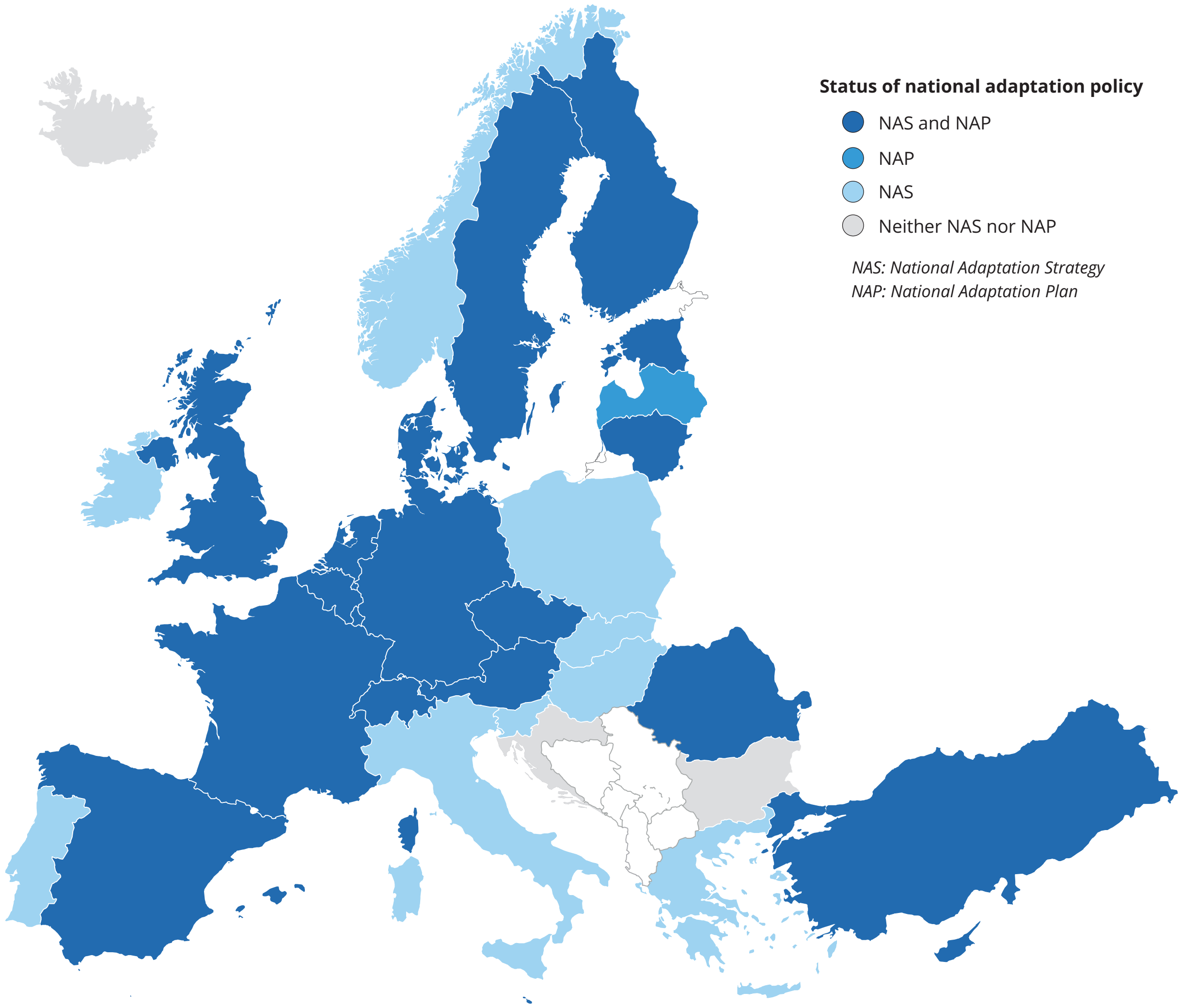
All European transnational regions are vulnerable to climate change to various degrees. Some of them, such as the Northern Periphery and Arctic, South West Europe and Mediterranean regions (which include large parts of the Adriatic-Ionian and Balkan-Mediterranean areas), as well as the mountainous part of the Alpine Space, have been identified as 'hot spots' (Ramieri et al., 2018; EEA, 2018a). Regions with geographically similar conditions address similar challenges, and the existence of shared resources typically requires common approaches (Rafaelsen et al., 2017; EEA, 2017c, 2018a).

Strategic objectives and actions related to adaptation are included in all four EU macro-regional strategies: for the Baltic Sea, the Danube, the Adriatic and Ionian, and the Alpine regions (EC, 2010, 2012c, 2014, 2015b). Common specific transnational adaptation strategies or action plans have also been developed in the North Sea, Northern Periphery and Arctic, Baltic Sea, Danube, Alpine Space and Mediterranean regions, but they have different levels of implementation. (Ramieri et al., 2018; EEA, 2018a).

Adaptation efforts in cities

Although the European and national levels provide the political, legislative and financial framework for adaptation, local adaptation actions address the specific situation of particular locations. The development of local adaptation strategies is increasing throughout Europe (Aguiar et al., 2018). As of April 2019, over 1 900 local authorities in the EEA member and collaborating countries have made commitments related to adaptation within the Covenant of Mayors for Climate and Energy. Among those signatories, 240 adaptation action plans have been submitted, and over 100 adaptation plans are at the monitoring stage (Covenant of Mayors, 2019a). Local authorities in Europe also join global initiatives relevant to adaptation, such as Making Cities Resilient (UN Office for Disaster Risk Reduction; over 650 participating local authorities in EEA member and collaborating countries), 100 Resilient Cities (Rockefeller Foundation; 14 European cities)

MAP 7.5 **Country comparison — overview of national adaptation policies**



Note: NAS, national adaptation strategy; NAP, national adaptation plan.

Sources: Adapted from EC (2018b) and EEA (2018f).

or C40 cities (8 European cities) (EEA, 2018k) ([9]). Involvement of cities in these initiatives may lead to longer-term commitment and action. Moreover, events and information platforms associated with the initiatives facilitate the exchange of knowledge through sharing of examples and lessons learnt (EEA, 2018k; Covenant of Mayors, 2019a). Many cities are already putting adaptation measures in practice. Frontrunner cities, such as Copenhagen or Rotterdam, are exemplars of how urban areas can be transformed to meet the adaptation challenge (Chapter 17). Others, such as Helsinki, are exploring how adaptation can be monitored (EEA, 2016i). In the absence of national strategies, cities can take the lead on adaptation within countries, as in the case of Belgrade (Ministry of Environmental Protection, 2017). Conversely, national leadership can ensure that adaptation planning follows the same standards in dozens of cities, as in the case of the 44MPA project in Poland (Ministry of the Environment, 2018).

([9]) The cities participating in these initiatives are mapped in the Urban vulnerability map viewer within the Climate-ADAPT platform (https://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation).

TABLE 7.9 Summary assessment — climate change adaptation strategies and plans

Past trends and outlook		
Past trends (10-15 years)		The consideration of climate change adaptation at the EU level, the national level and in cities has increased in recent years. Most EEA member countries now have national adaptation strategies and/or action plans.
Outlook to 2030		Further action on climate change adaptation is ongoing or planned at European, national and subnational levels.
Prospects of meeting policy objectives/targets		
2020	☐	Most, but not all, EU Member States currently have a national adaptation strategy. Implementation of adaptation is still in its early stages in many countries because of a lack of funding or other barriers. Some countries have started to monitor the implementation of adaptation activities.
Robustness		Process-based information on the planning of adaptation at the national level is available from countries reporting to the EEA. Information on the implementation of adaptation at different levels is patchy at best. The assessment of outlooks relies primarily on expert judgement.

7.4.3 Climate change finance

Most measures for mitigating or adapting to climate change require financing, either initially or permanently. This section briefly reviews two financial targets related to EU domestic spending and to international spending.

EU budget targets and further EU activities

With the intention of mainstreaming climate action into the EU budget, the EU has agreed that at least 20 % of its budget for 2014-2020 should be spent on climate-related action (EC, 2011; European Council, 2013). Analyses by the Commission indicate that the EU is broadly on track towards the 20 % target, but further efforts are needed (EC, 2016). A report by the European Court of Auditors (ECA) acknowledged that ambitious work was under way and that the target has led to more, and better focused, climate action in the European Regional Development Fund and the Cohesion Fund. At the same time, the report highlighted a serious risk that the 20 % target will not be met and that there has been no significant shift towards climate action in the areas of agriculture, rural development and fisheries. The report also emphasised methodological weaknesses of the current tracking method, including the failure of tracking mitigation and adaptation spending separately. The ECA report also includes a detailed reply from the Commission addressing the ECA's observations and suggestions (ECA, 2016). Broadly similar conclusions have been reached, and various suggestions for improved climate mainstreaming in the next EU multiannual financial framework (2021-2027) were made in a recent study for the Commission (Forster et al., 2017).

The revised EU ETS Directive established new low-carbon funding mechanisms, in particular the Innovation Fund and the Modernisation Fund (EU, 2018a; EC, 2018f). The Commission action plan on sustainable finance intends to reorient capital flows towards sustainable investment in order to achieve sustainable and inclusive growth, manage financial risks stemming from climate change, environmental degradation and social issues, and foster transparency and long-termism in financial and economic activity (EC, 2018d).

International climate change finance

In the Copenhagen Accord under the UNFCCC, developed countries made the collective commitment to jointly mobilise USD 100 billion annually by 2020 to address the mitigation and adaptation needs of developing countries (UNFCCC, 2010). This commitment was reconfirmed and extended in the Paris Agreement (UNFCCC, 2015b). The Organisation for Economic Co-operation and Development (OECD) has reported that public climate finance from developed to developing countries increased from USD 37.9 billion in 2013 to USD 54.5 billion in 2017 (OECD, 2016). A submission by developed countries and the EU to the UNFCCC based on an earlier OECD study projected that aggregated funding levels for climate action in developing countries would reach more than USD 100 billion in 2020 (OECD, 2016; UNFCCC, 2016). These estimates and the underlying methodology have been criticised for their ambiguity in definitions and lack of transparency in reporting (AdaptationWatch, 2016).