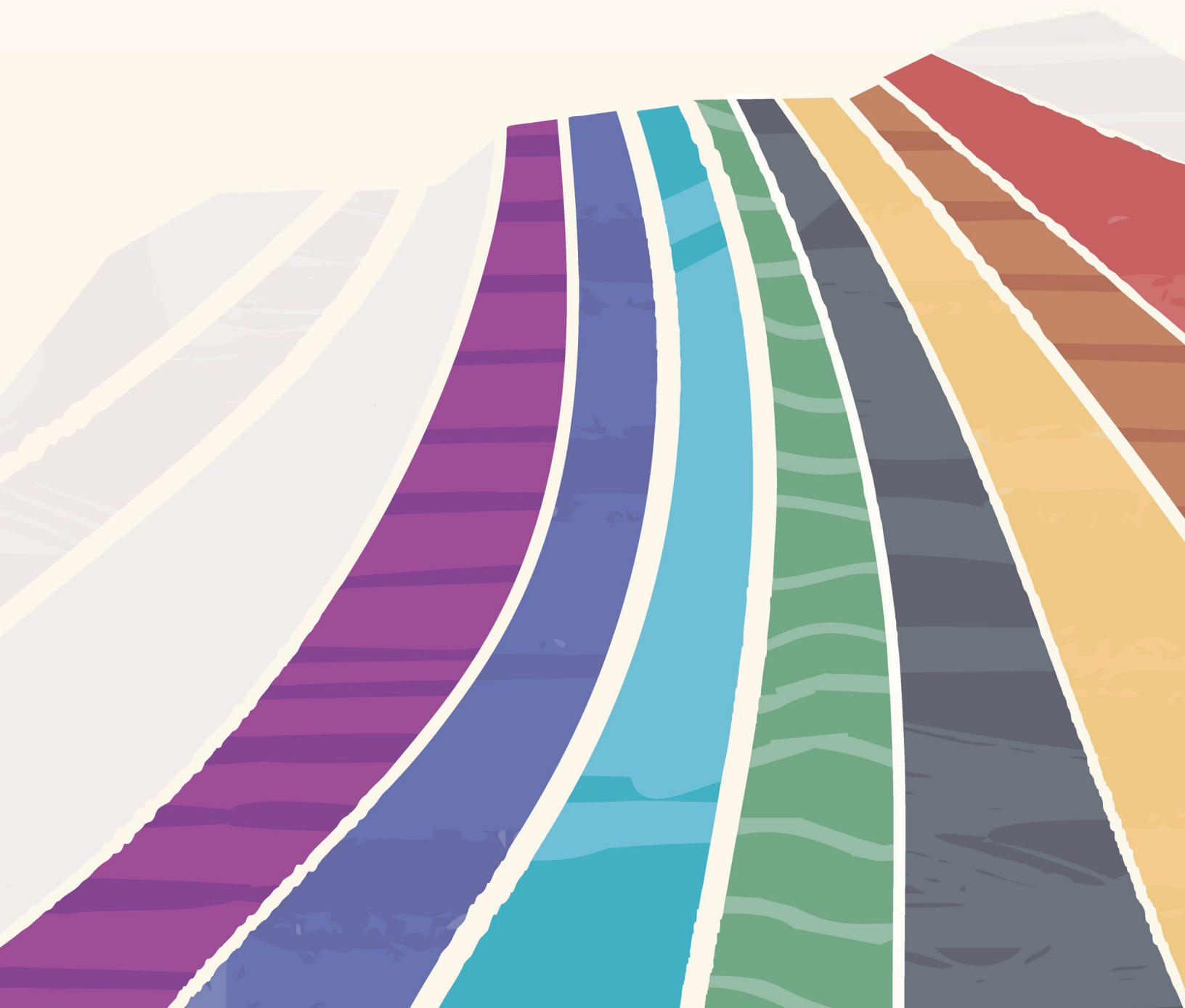


Second Austrian Assessment Report on Climate Change | AAR2

Summary for Policymakers



Second Austrian Assessment Report on Climate Change | AAR2

Summary for Policymakers (SPM)

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Introduction and framing

Impacts of climate change can already be observed in Austria. Recent changes in extreme events, such as extended dry periods, heatwaves and floods, are consistent with global trends driven by climate change. Global warming is caused by emissions from human activity over the last century. Accounting for current policies, global mean temperature will increase by 2.7°C (2.2–3.4°C) compared to the pre-industrial period (1850–1900). We will pass the threshold of an average global warming level of 1.5°C (GWL 1.5°C) within the next decade.

Greenhouse gas emissions in Austria have decreased in recent years, but national emissions remain high in global per-capita comparisons. There is a growing awareness that both ambitious emission reduction and substantial investments in adaptation and climate-resilience are required to safeguard society against adverse climate impacts. Nevertheless, the speed, scope and scale of measures is not sufficient to meet long-term policy targets.

This *Summary for Policymakers* (SPM) presents key findings of the *Second Austrian Assessment Report on Climate Change* (AAR2). The AAR2 provides a comprehensive, interdisciplinary assessment of the current scientific knowledge on climate change and related risks for Austria. It illustrates the range of climate impacts under different global warming levels and identifies potential mitigation strategies, adaptation measures and transformation pathways. The report closely follows the structure and processes of the *Intergovernmental Panel on Climate Change* (IPCC).

This *Summary for Policymakers* is structured along five policy-relevant guiding questions:

- A. Is Austria on track to climate neutrality?
- B. What are the impacts of climate change in Austria?
- C. Which mitigation options are available?
- D. How can Austria meet climate targets?
- E. Which policies can support effective and equitable climate governance?

More than 200 researchers and scientists collaborated to produce this report, and more than 100 external reviewers participated in the multi-stage scientific peer review process. The assessment builds on the first Austrian Assessment Report on Climate Change published in 2014 and a series of subsequent Special Reports coordinated by the *Austrian Panel on Climate Change* (APCC) and the *Climate Change Centre Austria* (CCCA).

The scientific evidence for each key message in this *Summary for Policymakers* is drawn from the eight chapters of the AAR2. Following the calibrated language of the IPCC, a confidence statement is assigned to each key message to indicate the strength of the scientific evidence and level of agreement in the literature.

In line with IPCC conventions, this assessment does not prescribe any specific policy measures or interventions. Instead, the report discusses alternative options for mitigation of greenhouse gas emissions and measures for adaptation to the impacts of climate change, highlighting synergies and trade-offs of specific climate actions with other societal priorities such as reaching the *Sustainable Development Goals* (SDGs). The AAR2 is conscious of the links and dependencies between climate change mitigation, adaptation, human well-being and sustainable development, as well as their trade-offs.

The ambition of this report is to provide relevant input to the broader discussion on an effective transition to a climate-resilient society, facilitating evidence-based decision-making and a well-informed public debate.

Understanding confidence statements in the AAR2

Science is a continuous process of discovery and uncertainty is an essential part of that process. Rather than being a weakness, it helps define the state-of-the-art of our understanding and highlights areas that require further research. This is highly relevant for climate science because future conditions depend on multiple factors including human decisions, natural variability, and complex interactions of climate processes and feedbacks.

The *Second Austrian Assessment Report on Climate Change* (AAR2) presents a comprehensive analysis and assessment of the scientific knowledge and understanding of climate change in Austria. To ensure clarity and transparency, it follows internationally recognized methods to communicate the robustness of scientific findings based on the approach developed by the *Intergovernmental Panel on Climate Change* (IPCC). These methods evaluate the strength of evidence and the level of agreement in the scientific literature to determine confidence levels in the conclusions.

Why do confidence levels matter?

To assess the level of confidence of all key messages and scientific statements, the report examines two dimensions: **Evidence** describes the amount and quality of scientific literature supporting a conclusion or a scientific finding. This includes information from observations, experiments, models, and expert analysis. **Agreement** describes the extent to which the scientific literature interprets the evidence in the same way. High agreement indicates that the evidence points towards a similar conclusion, while low agreement indicates alternative plausible interpretations. If the level of evidence and agreement align, the statement is simplified to a **Confidence** assessment.

By considering both evidence and agreement, the report determines the overall confidence in its findings, helping readers understand both well-established conclusions and areas needing further research. The AAR2 focuses exclusively on Austria, ensuring region-specific insights. When regional data is limited, findings from other regions are considered if they are relevant and transferable.

How are confidence levels expressed?

The following table illustrates how evidence and agreement are combined to confidence statements:

Agreement of scientific evidence ↑	limited evidence high agreement	medium evidence high agreement	high confidence
	limited evidence medium agreement	medium confidence	robust evidence medium agreement
	low confidence	medium evidence low agreement	robust evidence low agreement
Amount of scientific evidence (type, amount, quality, consistency) →			

If evidence and agreement align, the statement is labeled as low, medium, or high confidence. If they do not align, they are reported separately (e.g., robust evidence, medium agreement).

Why does this matter for you?

Understanding confidence levels helps **policymakers, organizations and individuals** make informed decisions about climate policy and it clarifies **which findings are well-supported by science** and **where further research is needed**. This approach ensures that climate policy and strategies are based on the best available knowledge while remaining transparent about uncertainties.

A guide to reading key messages of the AAR2

B.8 The impact of anthropogenic climate change on precipitation in Austria shows regional and seasonal variations and differs for aggregation levels (e.g., seasonal or annual sums) and individual precipitation events (robust evidence, medium agreement). Seasonal mean precipitation is projected to increase in winter (high confidence) and to decrease in summer (robust evidence, medium agreement). Daily maximum precipitation (10-year event) will increase compared to the current climate by 10 % at GWL 2.0°C and up to 23 % at GWL 4.0°C (medium confidence). {1.2.2, 1.4, Figure SPM.3}

Each key message starts with a bold statement showing the highlight of the scientific assessment.

Additional context and details are provided in the second part of the key message.

References to figures or chapter sections at the end of each key message refer the reader to figures and the relevant parts of the report from which the statement is drawn.

The confidence statements indicate the certainty that the authors have about the key message. Every key message has a confidence statement at the end of the bold part. If different sentences of the key message have different confidence assessments, these statements are added at the relevant places.

A. Is Austria on track for climate neutrality?

Current and future greenhouse gas emissions

This section outlines Austria's greenhouse gas emission trends, sectoral contributions, and policy measures. Austria has achieved notable reductions in greenhouse gas emissions in recent years, supported by measures like renewable energy investment, public transport incentives and CO₂ pricing. However, current policies and governance structures remain insufficient to meet EU targets and Austria's contribution to the Paris Agreement, with significant challenges posed by fragmented governance, structural barriers such as suburban sprawl, and high dependency on imported fossil fuels supported by climate-counterproductive subsidies.

Recent emission reductions and policy outlook

A.1 Greenhouse gas emissions in Austria have declined in 2022 and 2023. This development is largely due to climate policy measures and the increasing energy prices in preparation for and during the Russian invasion of Ukraine (*medium evidence, high agreement*). The implemented measures include increased deployment of renewables, incentives to phase out fossil-fueled heating systems, the extension and increased appeal of public transport (e.g., by introducing an annual public transport pass called 'KlimaTicket') and the implementation of an eco-social tax reform including CO₂ pricing for sectors that are not covered by the EU Emissions Trading System (ETS). Relatively warm winters have been a comparatively minor factor in emission reduction in recent years. {4.1, 6.3}

A.2 The EU targets for emission reduction by 2030 can be achieved with a set of measures in addition to currently implemented emission reduction policies. However, these measures are politically controversial. Their effective and timely implementation is uncertain (*medium evidence, high agreement*). The EU Effort Sharing Regulation (ESR) requires Austria to reduce greenhouse gas emissions by 48 % relative to 2005 across all sectors not covered by the EU Emissions Trading System (ETS). This applies in particular to emissions from energy use in transportation and buildings. The 'National Energy and Climate Plan' (NECP, BMK, 2024) shows that the 'with additional measures' scenario (WAM, Umweltbundesamt 2024a) can reach that target in combination with a package of policies. In contrast, the 'with existing measures' scenario (WEM, Umweltbundesamt 2024a) does not meet EU targets. It assumes a continuation of only those policies that are already implemented. This scenario shows a gap in greenhouse gas emission reductions of 10.4 MtCO₂-eq in 2030 compared to the national emissions target agreed under the Effort Sharing Regulation. {6.3, Figure SPM.1}

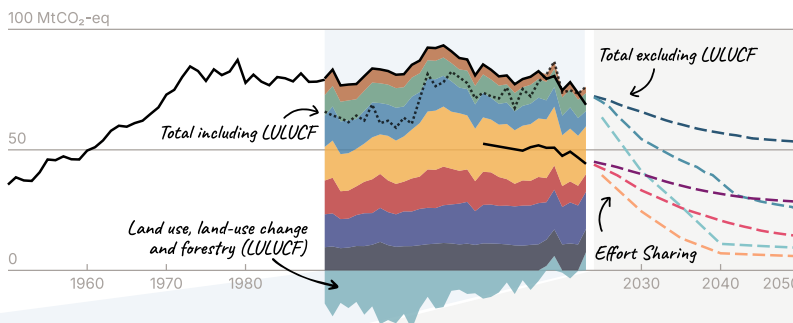
A.3 Climate governance in Austria includes a large variety of instruments to foster effective mitigation, but measures that are currently being implemented, planned for legislation, or proposed are not sufficient to achieve greenhouse gas emission reductions by the middle of the century consistent with Austria's contribution to the Paris Agreement (*high confidence*). Given diverging political and socio-economic interests – and respective power resources and relations – the effectiveness of climate governance is in many respects limited. Implemented instruments do not alter existing power relations, material growth logics, and the dominant mode of production and living based on high material throughput. This is reflected in a bias toward subsidies in market-based, economic instruments and a lack of sufficiency-oriented policy instruments capable of significantly reducing demand for energy, materials, and land. {6.2, 6.3, 6.4, 6.5, 8.4, 8.6, Figure SPM.1}

A.4 There are currently no legally binding, sector-specific reduction targets at the national level beyond the EU's 2030 targets. The Austrian federal government, several federal states and the three largest cities (Vienna, Graz, and Linz) have set themselves the goal of achieving greenhouse gas neutrality by 2040, but these targets are not supported by sufficient policy measures. The emission reduction targets defined in the national Climate Protection Act ('Klimaschutzgesetz', KSG) expired in 2020. An update was planned in the government agreement of the ÖVP-Green coalition (2020–2025) but has not been adopted. Effective climate legislation in Austria is largely induced by EU legislation. For the long term, the European Climate Law (Regulation (EU) 2021/1119) sets the binding target of achieving greenhouse gas neutrality at EU level by 2050. {6.3, 6.5, 8.4}

Historical emissions and key policy scenarios in Austria

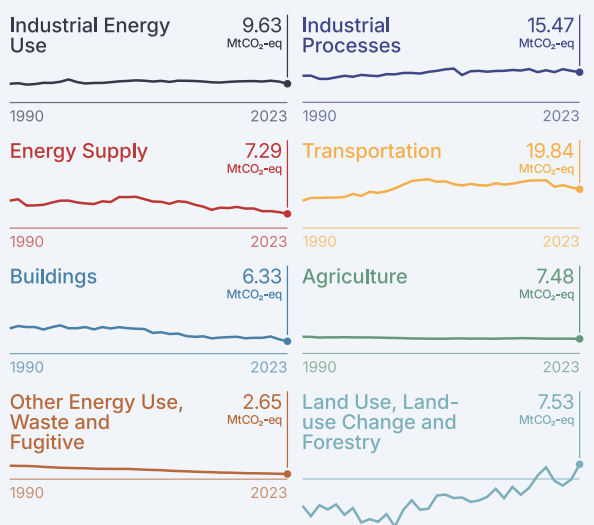
Greenhouse gas emissions in Austria remained stable for 50 years but have recently declined. Policy scenarios suggest pathways ranging from moderate to ambitious reductions.

(a) Overview of Austrian greenhouse gas emissions



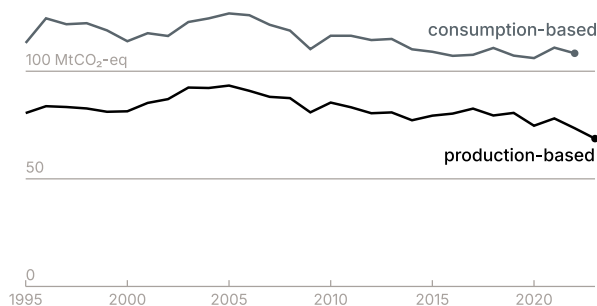
1990-2023: Historical emissions

(b) Historical emissions by sector: Industrial processes, energy use in industry and transportation are the largest emitters in Austria. Land use, land-use change and forestry turned from a carbon sink to a net source in recent years.



(c) Consumption- vs. production-based emissions:

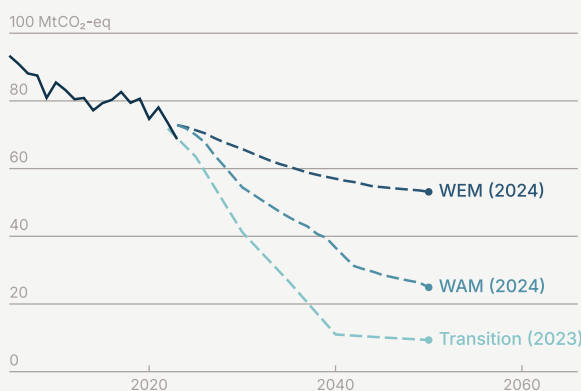
Austrian "consumption-based emissions", which include greenhouse gases from the entire value chain of goods and services, are about 40% higher than national "production-based emissions".



2024-2050: Emissions scenarios

(d) Total greenhouse gas emissions excl. LULUCF:

The "With Existing Measures" scenario (WEM) assumes a continuation of current policies, leading to modest reductions in the next decades. The "With Additional Measures" scenario (WAM) assumes implementation of currently discussed climate policy measures. The "Transition" scenario is the most ambitious model-based scenario towards climate neutrality.



(e) Emissions covered by Effort Sharing Regulation (ESR):

Under the ESR, Austria must reduce greenhouse gas emissions by 48% relative to 2005 across all sectors not covered by the EU Emissions Trading System (ETS). The "With Existing Measures" (WEM) scenario shows a gap in reductions of 10.4 MtCO₂-eq in 2030.

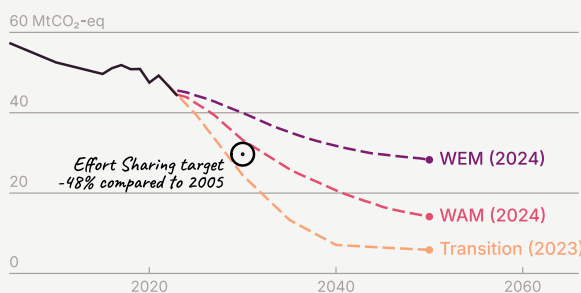


Figure SPM.1 | Historical greenhouse gas emissions and key policy scenarios. Left part of panel (a): Historical greenhouse gas emissions excluding land use, land-use change and forestry (LULUCF) from 1950 until 1990 (Gütschow et al., 2016, 2024). Central part of panel (a) and panel (b): Historical emissions by sector from 1990 until 2023 (Umweltbundesamt, 2025). Right part of panel (a) and panels (d) and (e): Aggregate greenhouse gas emissions excluding LULUCF and emissions covered under the Effort Sharing Regulation (ESR) in key policy scenarios (Umweltbundesamt, 2024a, 2024b). Panel (c): Production- vs. consumption-based accounting of emissions excluding sources and sinks from LULUCF (Dorninger et al., 2025).

A.5 Austria's remaining carbon budget aligned with global temperature targets of 1.5 or well below 2°C is close to being depleted or already exceeded, especially when considering different concepts of historical responsibility or capability (*medium evidence, high agreement*). To fulfill its international obligations and stay within such limits, it is imperative to phase out oil, gas and coal across the economy and implement all necessary measures to achieve net-zero greenhouse gas emissions as soon as possible. {8.2, 8.4, Figure 8.18}

Sectoral overview of emissions

A.6 The Austrian energy system is mainly based on fossil fuels and therefore a large greenhouse gas emitter (*high confidence*). In 2023, energy use was responsible for 70 % (44.5 MtCO₂-eq) of all greenhouse gas emissions and fossil fuels had a share of 62 % of gross domestic energy consumption. A major share of fossil energy is imported (96 %). This implies a high import dependency, low security of supply, and vulnerability to global price shocks. {4.5.1}

A.7 The industry and manufacturing sector is particularly emission-intensive, contributing 16 % to GDP and 39 % (25.1 MtCO₂-eq) to greenhouse gas emissions in 2023 through energy use and process emissions (*high confidence*). Emissions are highly concentrated in the iron and steel, chemicals, pulp and paper, and non-metallic minerals industries, which account for 82 % (21 MtCO₂-eq) of the sector's emissions and 29 % of national emissions (data for 2020). From 2014 to 2020, emissions fell by 1 % per year, while value added (i.e., the contribution to GDP) has grown by a rate of 2 % per year. {4.4.1}

A.8 Greenhouse gas emissions from the transport sector are currently 42 % higher compared to 1990, accounting for 29 % (19.8 MtCO₂-eq) of the national greenhouse gas emissions in 2023. The share of freight in transport emissions increased from 30 % in 1990 to 35 % in 2023 (*high confidence*). The rising share of freight transport is also driven by high levels of fuels (primarily diesel) purchased in Austria due to the diesel price gap compared to neighboring countries, primarily by trucks ('cross-border shopping of fuels', 'Tanktourismus'). Notable reductions in emissions have been observed only during years marked by specific external factors that led to a short-term decrease in demand for freight and passenger transport, in particular the financial crisis in 2008, the COVID-19 pandemic, and the Russian invasion of Ukraine and related fossil energy price increases. The long-term trend of increasing demand for freight and passenger transport presents a substantial barrier to achieving decarbonization of the transport sector and indeed of the whole provisioning system of all goods and services within the next two decades. {3.4}

A.9 Direct energy use in buildings was responsible for 36 % of Austria's energy consumption in 2023, accounting for 9 % of the total greenhouse gas emissions (*high confidence*). The latter share would be even higher if the greenhouse gas emissions associated with electricity and district heating were included. These indirect emissions related to buildings were responsible for 3.4 % of national greenhouse gas emissions in 2022 (data for 2023 not yet available). {3.3.3}

A.10 Greenhouse gas emissions from land use, land-use change, and forestry (LULUCF) were 1.8 MtCO₂-eq/year on average over the latest five-year period where data is available (2019–2023), ranging from a sink of -3.4 MtCO₂-eq/year to a source of 7.5 MtCO₂-eq/year (*high confidence*). This traditional sink – but recently acting as source – corresponds to 2.5 % of net greenhouse gas emissions (excluding LULUCF) over the period 2019–2023. Forests have historically acted as a carbon sink and have shown large year-to-year variations, with an average annual removal of 9.2 MtCO₂-eq/year over the period 2005 until 2015, ranging from 15.2 MtCO₂-eq/year to 4.1 MtCO₂-eq/year. The long-term trend shows a notable decrease in this sink since the early 2000s, turning into a source in recent years. Emissions from agriculture show a slightly decreasing trend from 8.0 MtCO₂-eq/year in 2000 to 7.6 MtCO₂-eq/year in 2023. {2.1.1, Figure SPM.1}

A.11 Greenhouse gas emissions induced by Austrian final demand of goods and services but occurring anywhere in the world along the production value chains of the respective goods – known as 'consumption-based emissions' – are around 40 % higher than greenhouse gases emitted on Austrian territory and reported within the UN climate framework as

national ‘production-based emissions’ (*medium evidence, high agreement*). The order of magnitude of this difference has remained stable since 1995, ranging from 30 % to 50 %. Austrian policymakers have instruments at their disposal that can address both types of emissions – the high production-based emissions and the significantly larger consumption-based emissions. Regulations like standards for embodied emissions of construction materials also affect the carbon-intensity of imports and are thus a useful instrument to reduce consumption-based emissions. {4.1, Figure SPM.1}

A.12 Targeting both production-based and consumption-based emissions prevents the undesired potential climate policy implication of carbon leakage (*high confidence*). Leakage occurs when a policy measure relocates polluting production outside of Austrian (or European) borders. This can result in consumption of more imported emission-intensive products without reducing the overall carbon footprint, such that neither environmental nor economic benefits are realized. There is a rich set of policy instruments at the national and EU level avoiding such detrimental implications, such as the EU’s Carbon Border Adjustment Mechanism (CBAM). {4.1}

Barriers to effective climate policy

A.13 Achieving net-zero greenhouse gas emissions in Austria is challenging given the existing settlement structure, transport infrastructure, and economic activity (*high confidence*). Current structures are characterized by a high amount of soil sealing and suburban sprawl, leading to car dependency and a large footprint of resources and emissions. The tax system includes climate-counterproductive subsidies in the range of EUR₂₀₁₉ 4.1–5.7 billion per year (estimates from 2020), allocating public expenditure to maintain economic activities and behavior that generate a net social harm for society (*limited evidence, medium agreement*). {3.2, 3.4, 6.2, 6.4, 8.4, 8.6}

A.14 Under the Austrian constitution, responsibilities for climate change mitigation and adaptation are divided between the national government, the federal states, and cities and municipalities. The necessity for a two-thirds majority in parliament to enact climate change legislation in many domains has sometimes resulted in political obstruction. This concerns, for example, spatial planning competences, which thwart the expansion of renewable energy and sustain high rates of soil sealing and urban sprawl, all undermining climate ambitions. A revision was considered in 2008 but has not been followed up in political decision-making. {6.3.3}

A.15 The fragmented structure in Austrian governance and its respective agencies constitutes a barrier to ambitious climate policy. In particular, Austrian federalism is more of an obstacle than an enabler for the formulation and realization of such policies (*high confidence*). Conflicting interests between the federal and the provincial levels either favor agreements with unambitious targets, unclear responsibilities, and a lack of sanction mechanisms, or lead to no agreement at all. The construction guideline (‘Gebäuerichtlinie’) is an example for such misaligned responsibility: While execution is the responsibility of the provincial administration, consequences for missing climate targets are borne at the federal level. {6.4.1}

A.16 Austria has set a renewable energy expansion target to satisfy domestic electricity demand from renewable power generation by 2030, but current investment in wind power plants is insufficient to reach that target (*medium evidence, high agreement*). Capacity growth in solar photovoltaics (PV) is exceeding the targets of the renewable expansion law (‘Erneuerbaren-Ausbau-Gesetz’, EAG) but is unlikely to contribute sufficiently to compensate for the shortfall in wind power expansion. {4.5}

A.17 Adaptation efforts in Austria remain insufficient in scale, scope, and speed to address increasing climate risks (*high confidence*). Austria has developed a National Adaptation Strategy (in 2012, updated in 2024), which prioritizes 14 fields of activity and has made progress in developing adaptation measures and specific sectoral efforts. Incremental measures, such as awareness campaigns and capacity-building, dominate, but transformative actions remain limited. There are gaps in legal enforceability, resource allocation, and long-term planning. Comprehensive and transformative adaptation, supported by stronger governance frameworks, is essential to close these gaps and enhance resilience across all sectors. {6.5.2, 7.5, 8.5.5}

A.18 Austria shows a high Sustainable Development Goals (SDG) score within the country, but a low score for its global contribution (*high confidence*). Currently, Austria has an SDG score of 82.3 (out of 100) for SDG achievement within Austria but only 59.9 when it comes to its SDG spillover score that assesses Austria's contribution to SDG attainment globally. Historical developments of the economic system yield a high score for many of the socio-economically related SDGs within Austria but a low score for environmental aspects. In recent years, there has been no discernible improvement in Austria's SDG score, neither within the country nor for global SDG spillover. {8.3.1, 8.4}

B. What are the impacts of climate change in Austria?

Physical manifestation, risks, and adaptation strategies

This section assesses current and future impacts and climate-related risks including changes to the risk components of hazard, exposure, and vulnerability. Austria is experiencing accelerated warming, with the mean annual surface air temperature in 2024 being 3.1°C above pre-industrial levels, leading to more frequent and severe heat extremes, reduced snow cover, and glacier retreat. Future climate projections indicate increasing risks of droughts, floods, and biodiversity loss. This leads to challenges for infrastructure, energy systems, agriculture, forestry, and tourism. Comprehensive risk assessments and implementation of adaptation strategies are essential for reducing long-term consequences by integrating nature-based solutions, resilient infrastructure, and strengthened governance.

Manifestation of anthropogenic climate change

B.1 An increase both in mean and extreme temperatures is detectable in Austria. This change has accelerated particularly since the 1980s (*high confidence*). In Austria, the mean annual surface air temperature in 2024 was about 3.1°C higher than during pre-industrial times (1850–1900). From the 1980s on, warming was particularly strong (+0.5°C per decade) in Austria and other parts of Europe. {1.2.1, Figure SPM.2}

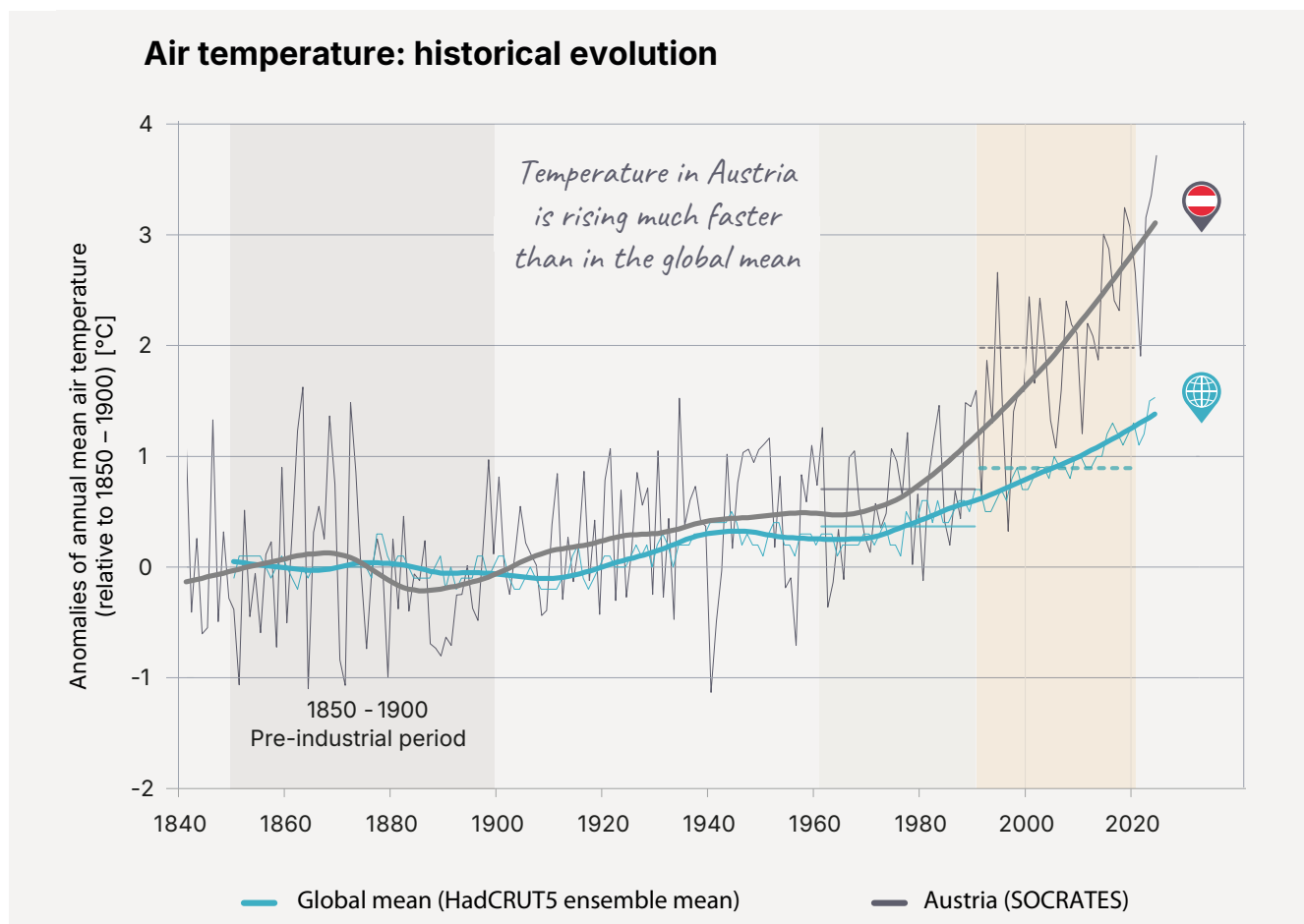


Figure SPM.2 | Annual mean air temperature deviations from the pre-industrial mean. Time series of air temperature deviations for the global mean (Morice et al., 2021) and Austria (Auer et al., 2007; Chimani et al., 2024) for the period 1841–2024. Thick lines are smoothed with a 42-year LOESS (locally estimated scatterplot smoothing) filter. Horizontal lines show the mean values of the 30-year climate normals (1961–1990, solid; 1991–2020, dashed). Note that the global datasets only start in 1850 and that the thin lines show annual mean values.

B.2 Temperature extremes such as hot days ($\geq 30^{\circ}\text{C}$) or tropical nights (nights when temperatures do not fall below 20°C) and the associated heat stress have markedly increased in the months April–September (1991–2020 vs. 1961–1990). This increase is especially strong in urban environments due to the ‘urban heat island’ effect (*high confidence*). In many Austrian cities, heatwaves are now 50 % more frequent and they last 1 to 4 days longer compared to the climate period 1961–1990 (*high confidence*). The number of hot days in very hot years (with a statistical return period of 10 years) has increased on average by a factor of 3 when comparing the climate period 1961–1990 to the recent past (1991–2020) in Austria. {1.2.1, 3.2.1, 3.2.3}

B.3 All available climate projections show a further increase in the global and regional mean temperature at least until the middle of the 21st century. This leads to a stronger mean temperature increase in Austria compared to the global mean, mainly because land surfaces heat up more quickly than oceans. Heat extremes will become more severe, and high temperatures will occur more frequently (*high confidence*). Even if the goals of the Paris Agreement are met, which corresponds to stabilization at ‘global warming level 2.0°C ’ (GWL 2.0°C), a very hot year occurring once in 10 years in the past (climate period 1961–1990) will occur 4.3 times in 10 years. If temperatures continue to increase, a global warming level of 4.0°C (GWL 4.0°C) implies 8.1 very hot years in 10 years and the average temperatures during heatwaves will increase by 6.6°C . {1.1, 1.2.2, Figure SPM.3}

B.4 With progressing climate change, long-term dry periods and droughts are becoming more severe (higher evaporation due to higher temperatures) and will further intensify (*robust evidence, medium agreement*). Long-term dry periods (3 months) during the summer half of the year (April until September), related to agricultural and ecological droughts, have intensified from the reference period 1961–1990 until today. For GWL 4.0°C , the severity roughly doubles compared to the current ‘Standardized Precipitation Evapotranspiration Index’ (SPEI) of -0.58. {1.2.1, 1.2.2, Figure SPM.3}

B.5 Changes in evaporation and increased lake surface water temperature are directly linked to observed and future temperature changes in Austria (*robust evidence, medium agreement*) and impact hydrological conditions (*high confidence*). Average evaporation has increased by about 110 mm/year in total (equals ~ 5 % increase per decade) over the past 35 years and will continue to increase with further warming (*high confidence*). Increased evaporation highly contributes to low flow conditions in rivers and water level changes of Lake Neusiedl (*robust evidence, medium agreement*). The surface temperature of selected lakes in Austria increased concurrent to warming air temperature on average between 1.5°C (past 40 years) and 2.5°C (past 15 years) (*high confidence*) and lake surface water temperature is expected to rise in the future. Higher lake water temperatures cause higher lake metabolism, which results in higher respiration (*high confidence*) and thus higher emissions of greenhouse gases, such as CO_2 and possibly nitrous oxide (N_2O) and methane (CH_4). {1.4.1, 1.4.2}

B.6 Observed and future temperature changes in Austria have far-reaching impacts on snow-related climatological variables and the cryosphere characteristics of the Alpine landscape (*robust evidence, medium agreement*). Snow cover duration (SCD) has a strong elevation dependency and ranges from ~ 40 days per year in the lowlands up to more than 200 days above 2000 m above sea level. The SCD has decreased at all elevations by 5 to 10 days per decade in Austria. Up to the year 2050, the SCD in Austria will continue to decline by at least 5 days per decade on average (*high confidence*), whereas at GWL 4.0°C , there will be an overall reduction of 60–80 snow-cover days (*robust evidence, medium agreement*). {1.3.1, 7.4.1}

B.7 All glaciers in Austria have been losing mass and are shrinking at an accelerating rate in recent years (*high confidence*) {1.2.1}. Many glaciers will vanish in the next few decades and virtually all Austrian glaciers will disappear before the end of the century (*medium confidence*). Permafrost temperature has increased by $+0.1^{\circ}\text{C}/\text{year}$ at 3 m depth since 2016 and further temperature increases will lead to widespread permafrost degradation (*low confidence*). {1.2.1, 7.4.1}

B.8 The impact of anthropogenic climate change on precipitation in Austria shows regional and seasonal variations and differs for aggregation levels (e.g., seasonal or annual sums) and individual precipitation events (*robust evidence, medium agreement*). Seasonal mean precipitation is projected to increase in winter (*high confidence*) and to decrease in summer (*robust evidence, medium agreement*). Daily maximum precipitation (10-year event) will increase compared to the current climate by 10 % at GWL 2.0°C and up to 23 % at GWL 4.0°C (*medium confidence*). {1.2.2, 1.4, Figure SPM.3}

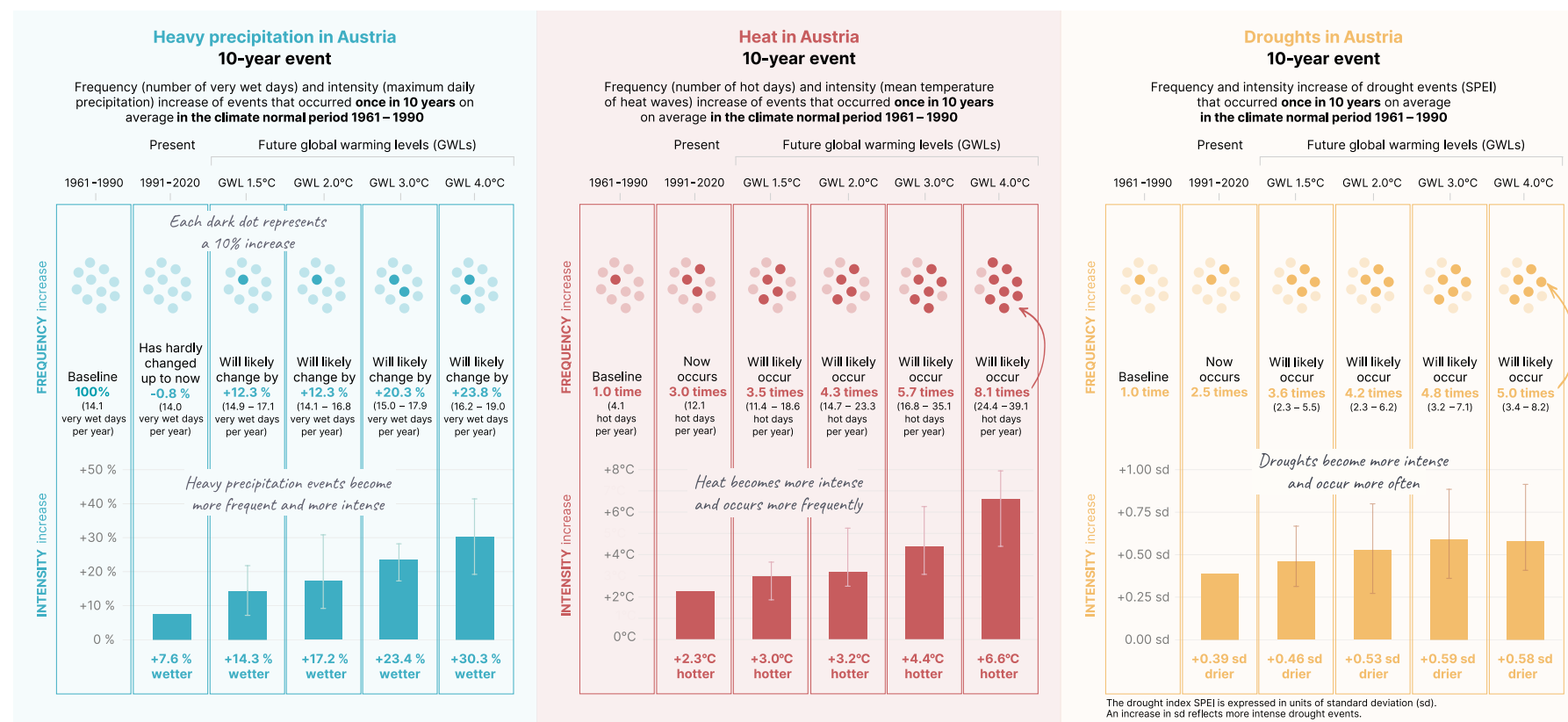


Figure SPM.3 | Current manifestation and projected changes in the intensity and frequency of extreme precipitation, heat and drought in Austria. The extremes are defined as 10-year extreme events. Projected changes are shown at global warming levels (GWLs) of 1.5°C, 2.0°C, 3.0°C and 4.0°C (Becsi and Formayer, 2024) and are calculated relative to the Austrian climate for 1961–1990. Heavy precipitation frequency is defined as the number of days per year exceeding 20 mm precipitation. Heavy precipitation intensity is defined as the annual maximum daily precipitation. Heat frequency is defined as the number of days per year with daily maximum temperature $\geq 30^\circ\text{C}$. Heat intensity is defined as climatological mean of the annual maximum of the 5-day running mean of daily maximum temperature. The frequency of droughts is defined as the average number of years in which the drought index SPEI (Standardized Precipitation Evaporation Index) falls below a defined threshold value during the summer half-year (April to September) in the respective periods. This threshold value is the 10-year event of the driest summer month in the respective region during the reference period. The intensity of the droughts is assessed by the change in the SPEI value of a 10-year event in the respective comparison periods relative to the reference period. Note that the basis of the drought assessment is the SPEI, which takes into account both precipitation and evaporation conditions. The SPEI is standardized and can therefore be compared across different climate zones and time periods. Calculations for the observational periods are based on GeoSphere Austria (2020), while calculations for projections are based on the Austrian climate scenarios (ÖKS15, Chimani et al., 2016).

B.9 There is a west-east gradient with generally higher groundwater recharge in the western part of Austria compared to the eastern or south-eastern part (*high confidence*). Seasonal changes in groundwater recharge are expected in the future, with the magnitude depending strongly on the scenario (*limited evidence, medium agreement*). Available groundwater resources may decrease by up to 23 % by 2050, or even 30 % regionally (*medium confidence*). {1.4.3}

B.10 River and pluvial floods have increased in parts of Austrian catchments (*medium confidence*). For river (fluvial) floods, the trend is more pronounced in smaller catchments than in larger ones. A clear seasonal shift from winter and spring fluvial floods to summer floods is detectable, meaning that summer is now the dominant flood season in the eastern half of Austria {1.4.1}. In Alpine areas, floods caused by heavy snowmelt are increasingly shifting from spring to winter (*high confidence*). {7.4.1}

B.11 Climate projections indicate a potential increase in flood occurrences in Austria, particularly summer floods in small catchments driven by extreme precipitation (*robust evidence, medium agreement*). Future climate scenarios suggest a notable shift in the seasonal pattern of floods, with an increased frequency of summer floods due to more intense and localized extreme precipitation events, especially in the Alps and smaller river basins. This shift is accompanied by a decline in spring floods, primarily linked to reduced snowmelt runoff. Despite these changes, natural variability in flood magnitude and frequency remains dominant, meaning that anthropogenic climate change is unlikely to exceed the existing variability in the near term. {1.4.1, 7.4.1}

B.12 Climate change is changing species composition in ecosystems by driving species ranges upslope in elevation, by replacing cold-adapted species with warm-adapted species and by increasing the impact of other stressors (e.g., agricultural intensification) in sensitive ecosystems such as wetlands, grasslands, and forests (*high confidence*). These changes lead to turnover in species composition – despite relatively stable average species richness – in recent decades with a general trend toward homogenization through the replacement of specialist species by generalist species. Neobiota native to regions with warmer climates, as well as some agricultural and forest pests, may benefit. In forests, the amount of timber volume damaged by spruce bark beetles has increased significantly. Due to high damage caused by disturbances (storms, bark beetles) and reduced increment, timber removals have sometimes exceeded growth. {1.6.1, 1.6.2, 1.6.3, 1.6.4}

Impacts and key risks

B.13 Observed losses and damages related to climate change and extreme weather events in Austria are currently EUR₂₀₁₉ 2 billion on average per year and are projected to rise to EUR₂₀₁₉ 2.5–5.2 billion per year by 2030 and to EUR₂₀₁₉ 4.3–10.8 billion per year by 2050 (estimates from 2020) (*limited evidence, medium agreement*). Austria is already affected by climate-related losses and damages, and future climate change along with socio-economic development will intensify these effects. Quantitative evidence from Austrian studies is limited, necessitating standardized documentation of losses and damages and more research for robust assessments. {6.7.2}

B.14 Under current climatic conditions, Austria has already observed moderate climate-induced risks, which are projected to intensify and expand spatially with rising temperatures (*high confidence*). The ‘burning embers’ diagram (see [SPM Method Box 1](#), [Figure SPM.5](#)) identifies growing levels of risk severity across human and ecological systems as global temperature levels increase, with most key risks reaching high levels around GWL 3.0°C. Without enhanced adaptation, very high risks, such as those affecting mortality, ecosystems, and water supply, could become unavoidable. The economic sectors could face very high risks relating to crop and forestry yields and ski tourism, given current levels of adaptation. Increasing risks highlight the urgent need for mitigation and adaptation actions. {Cross-Chapter Box 2, [Figure SPM.5](#)}

Method Box 1: Risk

The AAR2 emphasizes risk as a critical framework for assessing climate change impacts in Austria. Based on the IPCC framework, **risk** – defined as the potential for adverse consequences – results from the interaction of the climate-related hazard and its likelihood of occurrence, the exposure of elements at risk over time, and the vulnerability of the affected system (see Figure SPM.4). The AAR2 assesses risks by analyzing changes in hazard, exposure, and vulnerability, considering their uncertainties and variability. Dynamic interactions among these components affect overall risk over time. These risks are then evaluated for **severity and urgency to identify key risks**, which will become severe due to climate change impacts and associated changes in hazards, exposure, vulnerabilities (e.g., magnitude and likelihood of adverse consequences: pervasiveness of the consequences, degree of change, irreversibility of consequences, potential for impact thresholds or tipping points, potential for cascading effects beyond system boundaries), or mitigation/adaptation responses. **Adaptation and risk management are crucial but face limits**, either due to soft limits (options are currently not available due to socio-economic or cultural reasons to avoid intolerable risks through adaptive action) or hard limits (no adaptive actions are possible to avoid intolerable risks), impacting losses and damages. The key risks need to be prioritized for action based on societal risk tolerance and adaptation limits. {Figure SPM.4}

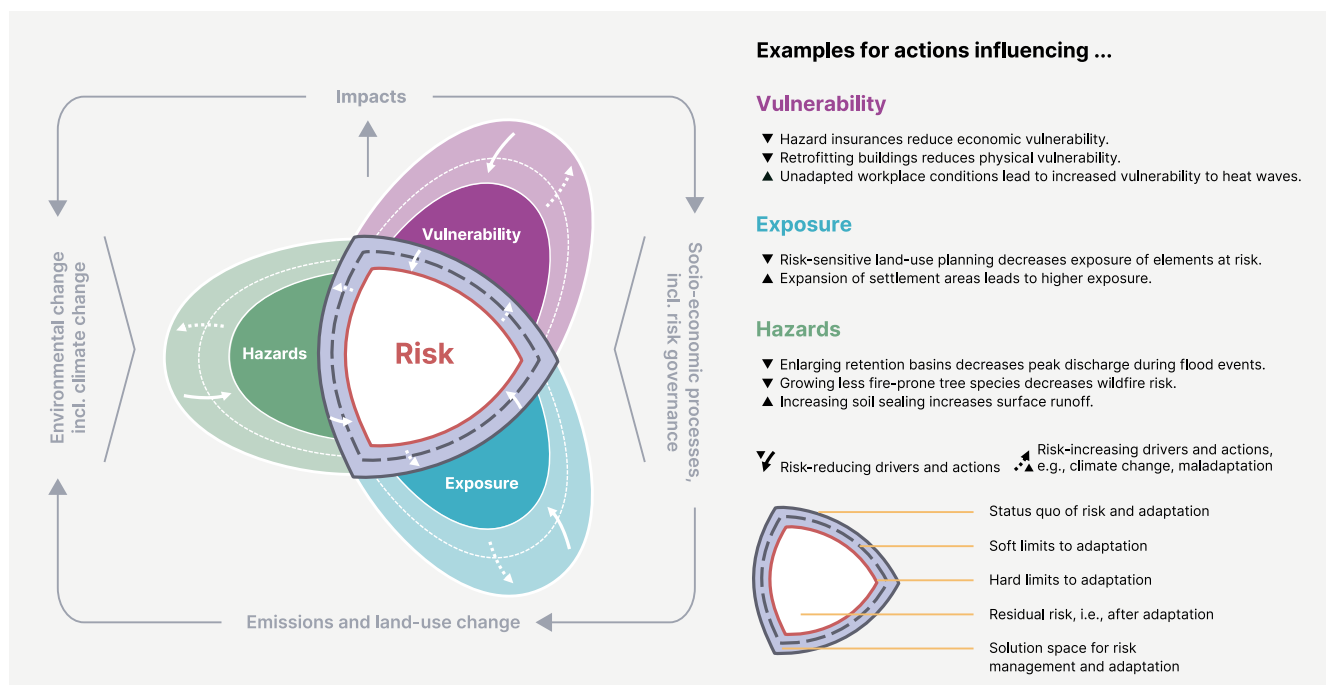


Figure SPM.4 | Core components of risk and related terms (see definition in SPM Method Box 1, Cross-Chapter Box 1 Figure 1). The figure is based on the initial IPCC risk figure (Garschagen et al., 2019) but has been slightly adapted for the AAR2 (Fuchs et al., 2024). The white arrows illustrate actions influencing hazard, exposure, and vulnerability, which shape risks over time (increase, decrease). The red line in the center illustrates hard limits to adaptation, while the dark gray solid line illustrates the status quo of risk. The dark gray dashed line illustrates the soft limits of adaptation. The area in between the red and the dark gray (light purple) is therefore the solution space. The remaining residual risk is the inner core of the risk figure (white), defined by the red line. Illustrative examples for risk management actions addressing each of the three risk components are provided.

Method Box 2: Burning Embers

The climate risk visualization tool called **burning embers** has been used to visualize reasons for concern, which aggregate climate-change-related impacts and risks to various systems and sectors. Burning ember diagrams use color transitions to show changes in the assessed level of risk to human systems and ecosystems as a function of global warming levels (GWLs), but do not consider changes in exposure and vulnerability, see Figure SPM.4. At the current GWL of 1.4°C, corresponding to an observed mean temperature change in Austria of 3.1°C, moderate risk levels have already been detected and attributed to climate change for a number of key risks, such as mortality due to heat, agricultural crop yield losses due to drought, disturbances to ecosystems (such as changes in species number and composition, ecosystem functions, or range shifts), and losses and damages due to river, torrential, and pluvial flooding. For grassland yields, water scarcity, and ski tourism, moderate risk levels have been observed in some regions (drought risk and water scarcity in some regions and some years; ski tourism in lower altitudes). These risks are projected to intensify and spread to other regions and higher altitudes. Most key risks are characterized by high risk levels at around GWL 3.0°C, due to the larger areas being affected by the risk, persistence of impacts, and impact severity. For some key risks such as mortality, crop and forestry yields, ecosystems, water supply, and ski tourism, very high risks cannot be excluded with current levels of adaptation.

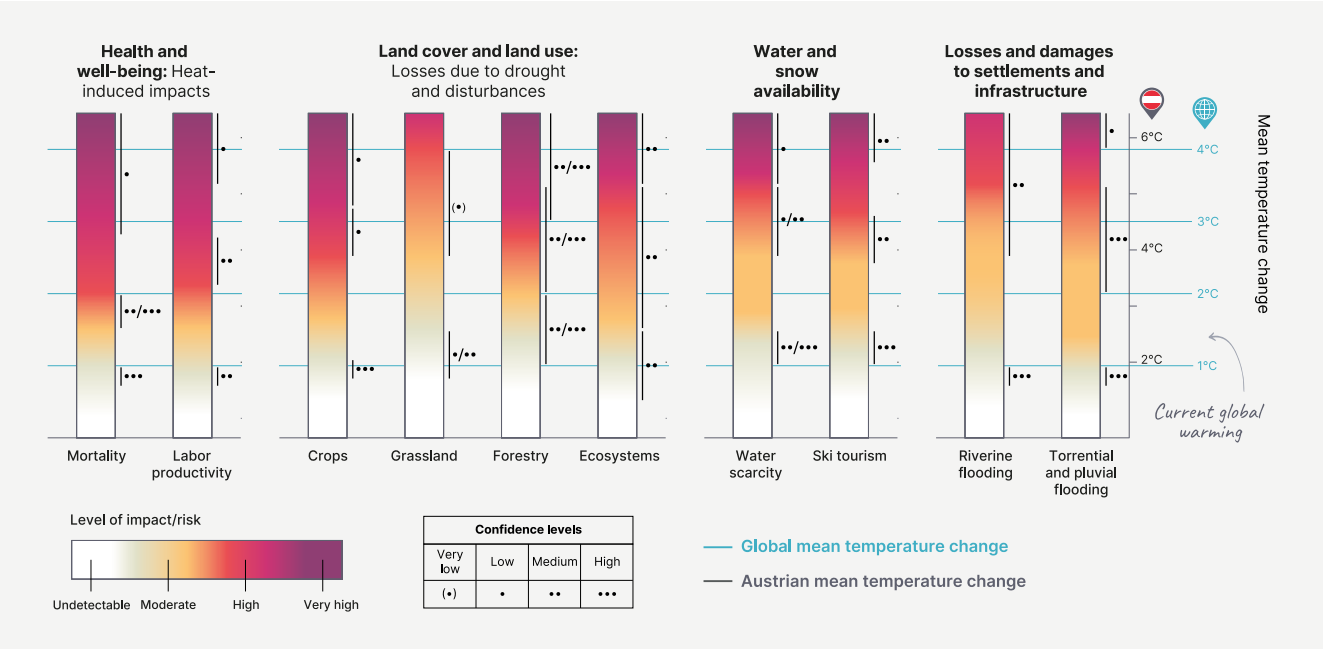


Figure SPM.5 | Burning ember diagram of selected key risks for Austria, clustered by sector or system at risk (Cross-Chapter Box 1 Figure 3). Diagrams show the change in the levels of impacts and risks assessed for 0–4.5°C global surface temperature change relative to the pre-industrial period (1850–1900). The global warming is also converted to mean Austrian surface temperature change. For a number of key risks, confidence levels are given as ranges to indicate that the risk transition will be at a lower global warming level in some regions or altitudes and at a higher global warming level in others. Confidence levels: high (***), medium (**), low (*), very low ((*)). The method is based on O'Neill et al. (2022, p. 2481 ff).

B.15 Increasing temperatures lead to elevated health risks, especially in urban areas, and to reduced labor productivity (*high confidence*). Increasing heatwaves and tropical nights in Austria, particularly in urban areas, pose significant health risks, increasing heat-related morbidity and mortality, and decreasing quality of life and labor productivity. Vulnerable groups include outdoor workers, the elderly, and those with low socio-economic status. Demographic developments overlay and locally amplify the warming effects. Adaptation measures in response to this increasing heat burden include increasing green spaces, improving building quality, and adjusting work schedules. Soft limits of adaptation might be reached for certain population groups, i.e., those who do not have the means to adapt. {3.2, 4.4.3, Cross-Chapter Box 2, Figure SPM.6}

B.16 Drought risk will increase in Austria (*high confidence*). Increasing evapotranspiration and precipitation variability heighten drought risks, impacting agricultural production and vulnerable ecosystems in Austria, especially in the east. This increases irrigation needs and may degrade ecosystems and water supplies (*medium evidence, high agreement*). Households and businesses will face more frequent water scarcity. Adaptation options include drought-tolerant crops, sustainable soil management, and adapted water supply networks. {1.2.2, 1.6, 1.8, 2.2.1}

B.17 Risk of pluvial and river flooding will increase in Austria (*medium confidence*). Pluvial and river flooding will become more frequent and intense in Austria, causing damage to buildings and major economic losses, especially in areas with extensive surface sealing. Flooding impacts transport infrastructure and community accessibility, with varying vulnerabilities. Lack of mandatory building insurance amplifies economic vulnerability. Effective adaptations include improved spatial planning, drainage systems, and monitoring. {1.4, 1.8, 3.2.3, 3.4.5, 7.4.1}

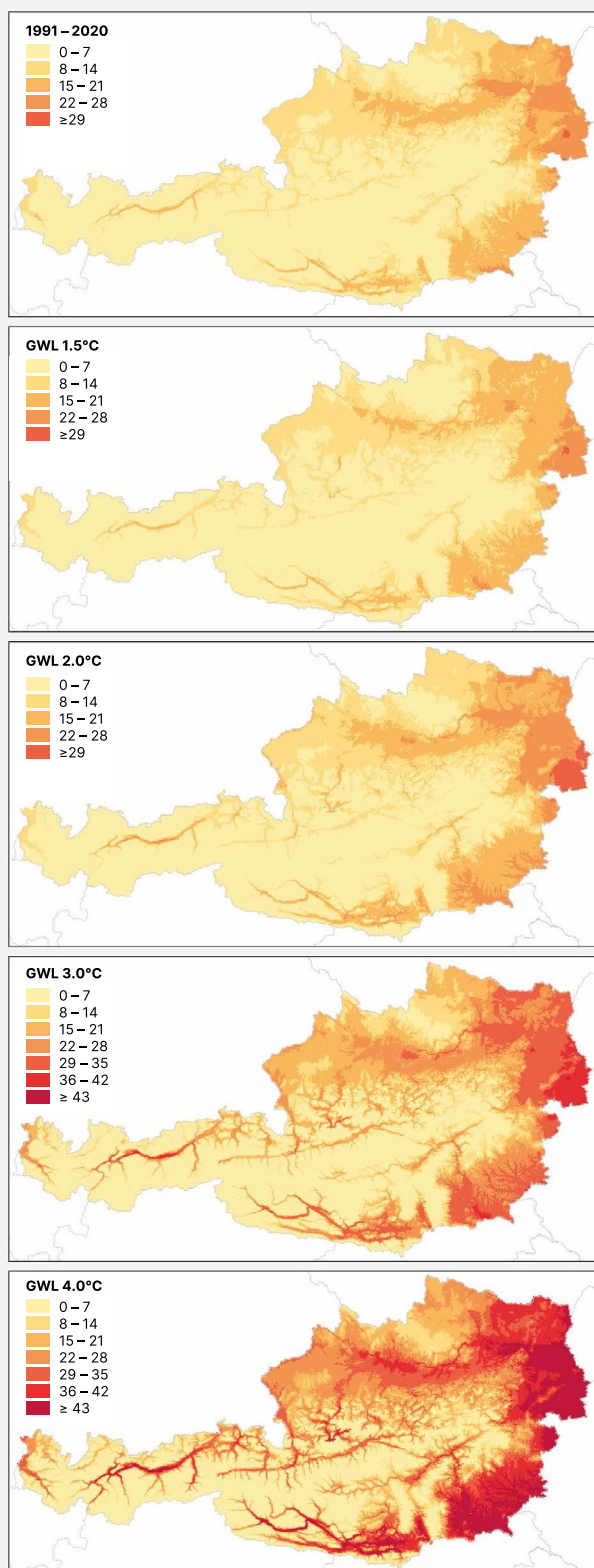
B.18 The risk of torrential flooding will increase in Austrian mountain valleys (*robust evidence, medium agreement*). Torrential flooding in Austria's Alpine region will increase due to more intense precipitation and higher sediment availability from glacier retreat, permafrost degradation, and stronger weathering. This will cause major economic losses, affect transport infrastructure, and disrupt community accessibility. Adaptation measures include stricter land-use regulations, mandatory building insurance, and pooled prevention funds for local protection. {1.4, 1.8, 3.4.4, 7.4.1}

B.19 Wildfire risk will increase in Austria (*high confidence*). Climate change will increase heatwaves and alter precipitation patterns, raising wildfire risk in Austria. This will cause local economic losses and disrupt infrastructure, especially in expanding settlements and wildland-urban interfaces. Adaptation measures include using less fire-prone tree species, improving organizational preparedness, and educating the public, as human activity causes 85 % of forest fires. {1.7, 2.2.2, 7.4.1}

B.20 There is a risk of biodiversity loss and related ecosystem services (*high confidence*). Coupled with anthropogenic stressors such as land-use change, sensitive ecosystems such as wetlands will lose important ecosystem functions and services, e.g., carbon storage. Warmer conditions are causing an upward shift of mountain species, shrinking cold environments above the tree line and leading to biodiversity losses in the Austrian Alps. Warm-demanding species are replacing endemic cold-adapted ones above 2,600 m above sea level. Forests will suffer from limited water supply and intensified disturbance regimes, weakening tree vitality, increasing disturbance regimes (e.g., bark beetle susceptibility), and decreasing their ecosystem services and protective function. The pervasive, irreversible consequences, including genetic diversity loss and species extinction, demand increased public awareness and conservation efforts to mitigate human land-use pressures. {1.6.1, 1.6.2, 1.6.4, 2.2.1, 2.2.2, 7.4.1}

B.21 There is a risk of decreasing quantity and quality of protection forests (*high confidence*). Rising temperatures and severe droughts will shift tree species and forest composition, reducing the protective effects of forests below 1,000 m above sea level. Natural disturbances like wind, fire, and pests will further decrease forest protection, especially in monocultures. This increases hazard frequencies and magnitudes of snow avalanches and debris flows and threatens communities and infrastructure in valleys. Adaptation includes maintaining diverse, multi-layered forests with sufficient canopy cover and natural regeneration. Deadwood can help maintain protection post-disturbance. {1.6.2, 2.2.2, 7.4.2}

Heat and persons exposed

(a) Hot days ($\geq 30^{\circ}\text{C}$)

(b) Persons exposed to hot days

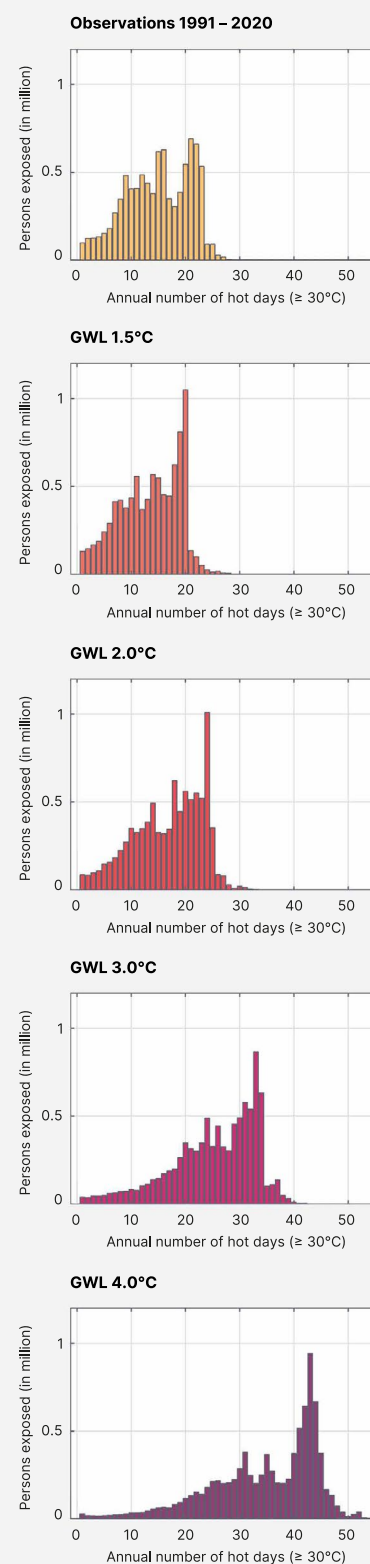


Figure SPM.6 | Heat and persons exposed in Austria: (a) Annual number of hot days ($\geq 30^{\circ}\text{C}$) in Austria at present (1991–2020) and for the future according to different Global Warming Levels (GWLs) (Becs and Formayer, 2024; Chimani et al., 2016; GeoSphere Austria, 2020), (b) number of people exposed to hot days at present and at different GWLs considering the population for year 2050 under Shared Socioeconomic Pathway 2 (Riahi et al., 2017; Wang et al., 2022; data for Austria provided by Marbler, 2024).

B.22 Climate change threatens the extent and quality of services provided by ecosystems (*medium confidence*). In addition to provisioning and regulating services in agriculture and forestry, cultural ecosystem services are also affected. This includes impacts on certain recreational activities through reduced snowfall, increased rock fall, and reduced water quality. However, warmer temperatures also create opportunities for bathing activities and summer tourism, for example. {2.2.2, 2.2.3}

B.23 Human health is highly dependent on functioning provisioning systems, which include global supply systems, local infrastructure, and many ecosystem services. These are threatened by ongoing climate change (*medium evidence, high agreement*). Both ongoing long-term changes and acute extreme events can have long-lasting negative consequences for physical and mental health and social well-being. Pressures from climate change elsewhere in the world could affect health and the health care system in Austria. Chronic effects, especially on mental health, of extreme events and climate change have been documented elsewhere but are still heavily understudied in Austria. The interplay between ecosystems and human health, together with animal health, is an important aspect of One Health. {2.2, 2.3, Chapter Box 2.1, Cross-Chapter Box 3}

B.24 Climate-related impacts pose a risk to the energy system infrastructure, limiting energy security in Austria (*high confidence*). Increased electrification implies even stronger reliance on the power system, which faces increased risks from climate-related extreme events. Potential impacts include damage to energy generation and transmission infrastructure, disrupting supply to households, industries, and infrastructure. Adaptation measures include resilient infrastructure design, diversified energy sources, enhanced European energy system interconnections, reduced energy consumption, decentralized energy solutions, and climate-adapted grid planning to mitigate cascading disruptions. {4.5.2}

B.25 Compound weather events pose an increasing risk of power shortage (*high confidence*). Weather events like wintertime European-wide cold spells and associated low stream discharge could strain Austria's renewables-focused electricity system and cause power shortages. Fluctuations in demand and supply can destabilize the electricity grid, with increasing summer cooling needs exacerbating the situation. Adaptations include enhancing European energy interconnections, reducing energy demand, diversifying energy sources, and boosting backup capacities to mitigate economic losses and maintain grid stability. {4.5.2}

B.26 Climate change leads to a loss of competitiveness in the Austrian tourism industry, in particular for snow and ice sports (*high confidence*). Decreasing snowfall and snow cover at lower altitudes due to warming temperatures threaten the competitiveness of snow- and ice-based tourism in Austria. The natural snow season is shrinking rapidly, affecting resorts economically dependent on winter sports. Adaptation options include diversifying tourism offerings to reduce reliance on snow-dependent activities. {1.3, 4.3.3, 4.3.4, 7.4.2}

B.27 Effective disaster and crisis management plans and other responses to climate-related risks reduce the expected impacts, whereby the impacts can be amplified if coordination and communication between institutions and the public fails (*medium evidence, high agreement*). Addressing energy shortages, resource scarcity, and extreme weather and hazard events is crucial in mitigating impacts. Communication and compliance strategies that take into account individual behavior, such as defaults for emergency notifications and support from societal role models, enhance the effectiveness of adaptation measures (*high confidence*). Integration with existing risk management structures, including climate impact response training, strengthens preparedness. {Chapter Box 5.1}

Adaptation measures, needs, and challenges

B.28 Comprehensive and coordinated adaptation measures are necessary to safeguard Austria's economy, infrastructure, and communities against rising climate-related impacts in the coming decades (*high confidence*). Adaptation necessitates both sector-specific and cross-sectoral measures to build long-term resilience. Under higher warming levels, localized limits to adaptation may emerge (*low confidence*). Integrating adaptation into sectoral policies and planning is essential to ensure resilience and avoid maladaptation (*high confidence*). Embedding climate-related risk considerations into health care, trans-

portation, urban planning, tourism, energy systems, forestry, and agricultural and water management strategies is critical to reducing vulnerabilities and strengthening adaptive capacity across sectors. {2.3, 3.2.3, 3.4.4, 7.5.4, 8.5.5}

B.29 With intensifying climate-related impacts, incremental adaptation measures will no longer suffice, and adaptation limits are likely to be reached under higher global warming, threatening societal goals and critical ecosystems (*robust evidence, medium agreement*). Even with immediate and strong mitigation efforts, adaptation needs will continue to grow in the short to medium term due to accelerating climate change impacts. When passing the threshold of global warming of 3°C (GWL 3.0°C), key adaptation limits are expected in vulnerable ecosystems such as Alpine regions and flood-prone areas, as well as in areas facing water scarcity and land shortages. Current strategies and risk management systems are insufficient to cope with compound and cascading risks related to extreme weather and hazards events, which can lead to long-lasting or even irreversible consequences for communities, infrastructure, and ecosystems. Examples include mega-droughts triggering water shortage and natural hazards affecting critical infrastructure and economic stability. {1.8, 6.5.2, 6.7, 8.5.5, 8.3}

B.30 The rising costs of inaction on climate change far exceed the investment needed for effective adaptation and mitigation (*limited evidence, high agreement*). Beside the investments for mitigation, the investment need for achieving adequate adaptation levels (to minimize residual damage from future climate change impacts) is also substantial, and the currently existing adaptation gap is projected to increase unless adaptation finance is scaled up. Investment needs for mitigation and adaptation are below the expected monetized annual costs of inaction, especially when considering the multiple climate change impacts that have so far not been expressed in monetary terms, e.g., biodiversity loss and health impacts of mental stress. {6.7, 8.6}

B.31 Enhancing climate resilience in Austria's built environment requires adaptive measures to be integrated into planning, design, and regulatory frameworks (*high confidence*). Adapting to climate change in Austria's built environment would entail enhanced prioritization of resilient water management, greening initiatives for cooling and water retention, protection from natural hazards through retrofitting, hazard mapping in land-use planning, mandatory insurance schemes for households, and compact urban development. Robust early warning systems and better communication are essential for preparedness. Integration of climate considerations into design guidelines and standards, including adaptable building codes and infrastructure regulations, is crucial. {3.2.3, 3.3.3, 3.4.4, 7.5.4}

B.32 Adapting Austria's transport infrastructure to climate change requires urgent updates to legal standards and regulatory frameworks to ensure resilience and functionality over its long lifecycle (*high confidence*). To ensure long-term resilience, Austria's transport infrastructure needs to account for the rising climate-related impacts, such as extreme weather events, floods, and temperature fluctuations. Current regulations and legal standards fail to adequately address these risks, leaving critical assets vulnerable. The second progress report on the Austrian Strategy for Adaptation to Climate Change (BMK, 2021), highlights the need for action, as the adaptation of legal standards for transport infrastructure are considered to be insufficient. The infrastructure being constructed today has operational lifetimes extending well beyond 2100. However, existing policies do not account for changing climatic conditions over such long time horizons, which leaves critical gaps in resilience planning. {3.4.4, 7.4.3}

B.33 Infrastructure networks and natural hazard protections need to be climate-proofed (*medium evidence, high agreement*). Current structural measures focus on mitigating current risks rather than addressing long-term transformative adaptation (e.g., systemic updates to design standards). Structural adaptation measures and their upgrades that can withstand long-term climate-related risks hold critical importance for enhanced risk reduction. Key initiatives include retrofitting transportation infrastructure, strengthening protection against natural hazards, and integrating climate considerations into spatial planning and construction regulations. To prevent maladaptation and ensure sustainability, the implementation of these measures should be guided by detailed cost-benefit analyses and robust monitoring frameworks, and construction methods should minimize carbon footprints. These strategies are vital to balancing immediate adaptation needs with long-term environmental and economic sustainability. {7.5.4}

B.34 Adaptation to increasing water demands during droughts requires innovative water management strategies and improved monitoring of agricultural irrigation (*medium evidence, high agreement*). Increasing water demands during drought events necessitate new approaches to water availability, particularly as agricultural irrigation significantly impacts resource planning nationwide. While drinking water provisioning will only be impaired in specific regions such as northern and eastern Austria, the lack of monitoring data on actual irrigation water use restricts accurate projections and informed adaptation decisions. Collecting and utilizing such data is critical to quantifying adaptation limits and enhancing water resource management under changing climatic conditions. {2.2.1, 3.2.3}

B.35 In the Alpine region, shifting transit and holiday traffic to rail and transitioning winter tourism to snow-independent activities are critical adaptation strategies to reduce risks related to climate change (*high confidence*). The Alpine region exhibits an overlap of tourism, transit traffic, and local mobility. This puts significant pressure on the infrastructure, necessitating a shift to rail-based systems to reduce congestion, emissions, and vulnerabilities where possible (*high confidence*). Declining snow cover and shortened ski seasons threaten winter tourism, requiring a transition to snow-independent activities such as hiking, cycling, and cultural tourism to prevent economic losses, unemployment, and out-migration (*medium evidence, high agreement*). These strategies demand coordinated planning and investment to ensure resilient and sustainable infrastructure and tourism models in the region. {7.4.2, 7.4.3}

B.36 Nature-based solutions are essential for Austria's adaptation strategy, offering multi-benefit approaches that enhance biodiversity, reduce climate-related risks, and strengthen ecosystem resilience (*high confidence*). Nature-based solutions, such as wetland restoration, river renaturation, and urban greening, provide significant climate adaptation benefits. For example, protective forests in Austria mitigate natural hazards such as avalanches and rockfalls, while wetlands act as natural water retention areas, reducing the probability of floods and improving water availability during droughts. Urban greening initiatives contribute to cooling during heatwaves, improved air quality, and public health in cities. However, their full potential is hindered by limited legal frameworks, competition for land use, and insufficient financial incentives for implementation and maintenance. Strengthening ecological restoration laws, expanding subsidies for nature-based solutions projects, and establishing long-term monitoring systems are critical to ensuring their effectiveness and integration into Austria's broader adaptation strategy. {1.6.4, 2.3.3, 3.2.3, 6.5.2, 7.5.4}

B.37 Natural regeneration of tree species faces challenges under climate change, requiring innovative forest management approaches that balance biodiversity preservation and adaptation to changing conditions (*medium confidence*). Natural regeneration is hindered by browsing damage from high ungulate populations and competition among tree species adapting to new climatic conditions (*robust evidence, low agreement*). While foresters suggest introducing non-native tree species as promising alternatives where native species struggle, this approach remains highly debated due to ecological uncertainties (*robust evidence, low agreement*). Forest management strategies that reduce pressures from anthropogenic activities and promote adaptive practices, such as selective logging and mixed-species plantations, can reduce degradation while supporting carbon storage and biodiversity (*medium confidence*). Maintaining ecosystem functionality will depend on effective forest management that balances biodiversity preservation with adaptive measures (*medium confidence*). {1.6.2, 2.2, 2.3, 7.4.2}

B.38 Transforming land-use systems is critical for reducing biodiversity loss, addressing land-use conflicts, and ensuring ecosystem resilience in the face of climate change (*high confidence*). Wildlife and habitat corridors play a crucial role in enabling species migration and behavioral adaptation, preserving biodiversity, and maintaining ecosystem functionality under climate stress. Maintaining high species and genetic diversity in agriculture and forestry enhances the resilience of ecosystems to climate impacts, facilitating evolutionary adaptation and reducing the risk of species loss. Intensified land-use conflicts, such as competition between biomass extraction, carbon storage, renewable energy production (e.g., agrivoltaics, wind and water energy), agriculture, forestry, biodiversity, and conservation, demand balanced policies to minimize trade-offs and prioritize long-term ecological sustainability. {1.6.4, 2.4, 7.4.1}

B.39 Adaptation efforts in smaller Austrian municipalities face critical challenges due to resource constraints, current structure of governance, and reliance on voluntary measures, highlighting the need for binding frameworks, enhanced funding, and institutional support to strengthen local adaptation (*medium confidence*). Austria's reliance on voluntary, collaboration-based governance for climate change adaptation limits the enforceability and effectiveness of measures, with significant gaps at the municipal level caused by resource constraints and weak policy enforcement. Programs like the climate change adaptation model regions ('Klimawandel-Anpassungsmodellregionen', KLAR!) showcase the potential of local leadership and funding to drive effective adaptation, but broader institutional support is needed. Introducing a binding climate adaptation law with mandatory risk assessments, adaptation plans, and reporting obligations, alongside increased financial and technical resources, can enhance coordination and coherence across governance levels and ensure long-term resilience. {6.4.1, 8.5.5}

C. Which mitigation options are available? Potentials, costs, synergies, and trade-offs

This section outlines Austria's sector-specific mitigation potentials, emphasizing energy demand reduction, electrification, and technological transitions in key sectors like energy, industry, transport, and buildings. Electrification, particularly in heating, cooling, and transport, offers the highest emission reduction potential, complemented by nature-based solutions and demand-side measures such as dietary shifts and urban densification. Additionally, this section explores the alignment of mitigation efforts with the Sustainable Development Goals (SDGs), focusing on maximizing co-benefits and managing trade-offs through integrated policies.

Mitigation potentials in different sectors

C.1 There are numerous options for emission reductions across all sectors (*high confidence*). Costs and potentials of mitigation options differ across sectors, with electrification in transport, industry, and buildings associated with significant carbon dioxide reduction potential when combined with renewable energy expansion. {8.3.2, 8.4.2, 8.4.3, Figure SPM.7, SPM Method Box 3}

Method Box 3: Assessment of costs and potentials

The assessment of mitigation options considers potentials that can be realized until 2040 and related costs expressed as the equivalent carbon price that would make this option cost-competitive. These costs reflect the current perspective including a forward-looking component and represent additional costs in comparison to a conventional (fossil-based) reference option that reflects current practice in the respective field. Underlying data generally relies on literature, partly complemented by expert judgments. The uncertainty and, consequently, large bandwidth applicable in the data on both potentials and costs caused the expression as lower and upper bounds.

Because of the methodology applied for assessing costs and potentials, the mitigation potentials of different options should not be added up, due to possible interactions between individual options.

C.2 Electrification exhibits the highest net emission reduction potential if it facilitates the phase-out of fossil fuels for heating as well as in the transport sector (i.e., e-mobility) (*high confidence*). Five key options (PV rooftop, PV ground-mounted, hydropower, biomethane, wind) are assessed, with individual potentials ranging from 3.4 to 7.3 MtCO₂-eq/year in the lower bound, and 4.8 to 29.4 MtCO₂-eq/year in the upper bound, respectively. These emission reductions, however, can only be achieved if sector-coupling between electricity and heating and cooling as well as with the transport sector (i.e., e-mobility) is pursued. Key low-cost options therefore include wind and PV systems, which offer large potentials. Hydropower represents another key renewable source for electricity generation, but relevant potentials have been already exploited to a large extent. {Chapter Box 3.2, 4.4, 4.5, 8.3, Figure SPM.7}

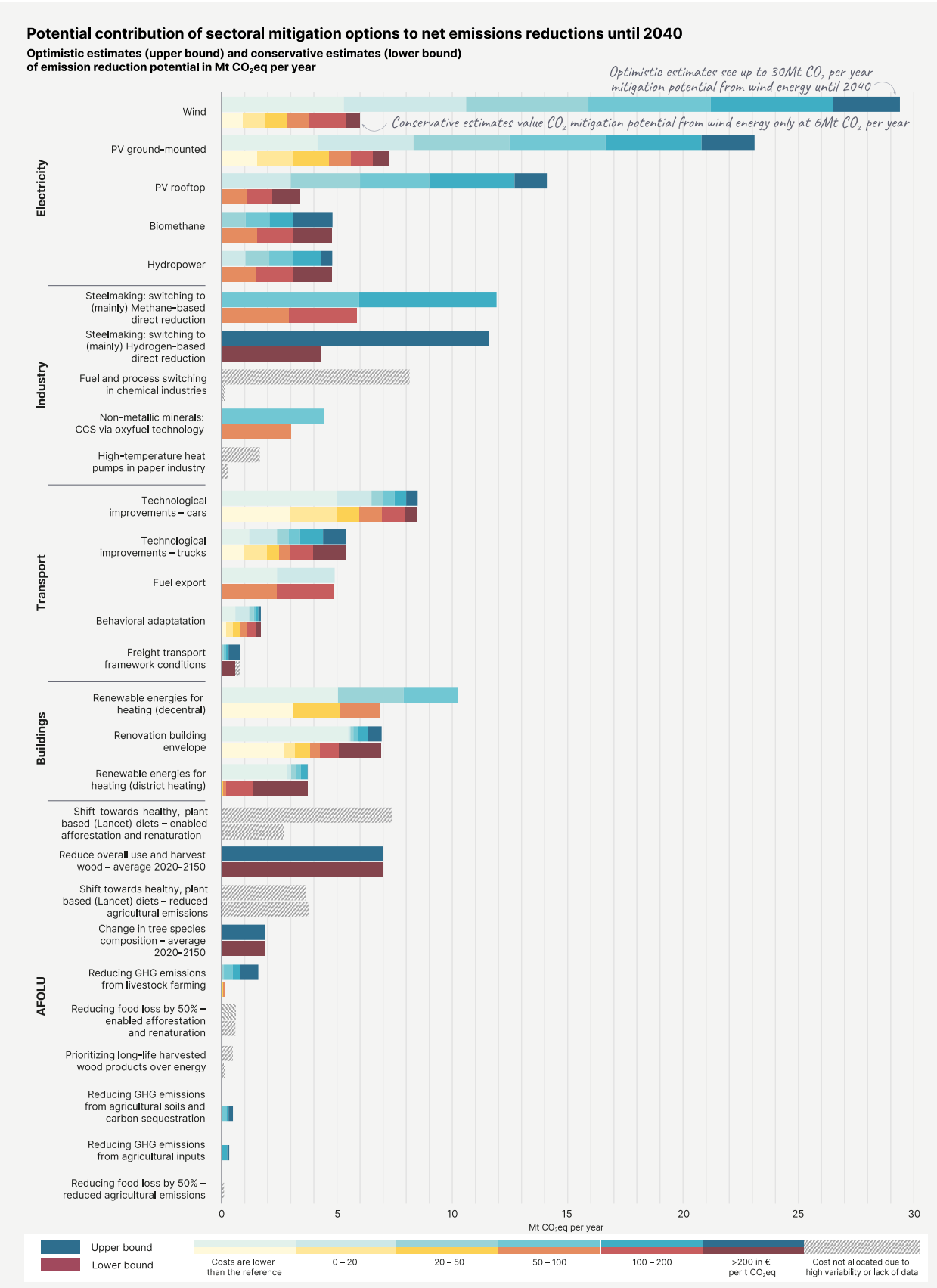


Figure SPM.7 | Lower and upper bound of the potentials and related costs of individual mitigation options. Estimation of optimistic and conservative emission reduction potentials until 2040. The potentials for relevant measures are categorised according to the costs based on the equivalent CO₂ price that would be necessary to make a measure competitive in comparison to a reference technology (see SPM Method Box 3).

C.3 The industry sector in Austria holds the second-highest mitigation potential, with steelmaking standing out as a key opportunity for substantial emission reductions. Transitioning to direct reduction technologies based on methane (CH₄) and hydrogen (H₂) provides the largest mitigation potential within the industry sector (*high confidence*). Here five different options were identified, with individual potentials ranging from 1.5 to 8.5 MtCO₂-eq/year in the lower bound and 1.7 to 11.6 MtCO₂-eq/year in the upper bound, respectively. Apart from steelmaking processes, assessed mitigation options for other industry subsectors include fuel and process switching in chemical industries, carbon capture and storage via oxyfuel technology in clinker for cement production, and high-temperature heat pumps in the paper industry. Cost estimates are applicable for several key options (i.e., decarbonizing steelmaking and cement production), ranging from EUR₂₀₂₃ 50 to more than EUR₂₀₂₃ 200 per ton of CO₂-equivalent. {4.4, 8.3, Figure SPM.7}

C.4 Mitigation potentials in Austria's transportation sector range from 0.8 to 8.5 MtCO₂-eq/year, with the highest potentials from e-mobility adoption and technological improvements in cars and trucks (*limited evidence, medium agreement*). Transitioning to e-mobility offers the most significant mitigation potential, particularly when coupled with decarbonizing the electricity supply. Additional reductions can be achieved through fuel tax reforms targeting 'cross-border shopping for fuels' and by encouraging shifts to public transport and active mobility (walking and biking). Efficient freight logistics and enhanced rail infrastructure further amplify these potentials, many of which are cost-effective. {3.4, 8.3, Figure SPM.7}

C.5 Emission reduction potentials in Austria's building sector range between 3.7 and 10.2 MtCO₂-eq/year (*medium confidence*). This estimate includes indirect emissions, in particular carbon dioxide emissions of fossil-based district heat generation. Cost-effective mitigation of emissions can be realized in particular using building renovation and envelope insulation as well as via a switch to renewable energies in both decentralized and district heating, for example via the use of electric heat pumps. Individual net emission reduction potentials range from 3.7 to 6.9 MtCO₂-eq/year in the lower bound, and from 3.7 to 10.2 MtCO₂-eq/year in the upper bound. {3.3.1, 3.3.3, 8.3, Figure SPM.7, Appendix of Chapter 8}

C.6 Mitigation options in agriculture, forestry, and other land use (AFOLU) are critical for achieving net-zero CO₂ emissions despite uncertainties and high marginal abatement costs (*medium confidence*). Ten distinct AFOLU mitigation options were assessed, with individual mitigation potentials ranging from 0–7.0 MtCO₂-eq/year at the lower bound, and from 0.1–7.4 MtCO₂-eq/year at the upper bound, depending on key assumptions. The highest potentials arise from shifting toward plant-based diets, enabling afforestation and habitat restoration, and reducing overall wood use and harvest intensity. Although some measures involve costs exceeding EUR₂₀₂₃ 200 per ton of CO₂-equivalent, their implementation is essential to reach reduction targets. {2.3, 8.3.2, 8.4, Figure SPM.7}

C.7 Net emissions from land use, land-use change, and forestry (LULUCF) are the balance of sources and sinks in this sector. The sink (i.e., land-based carbon dioxide removal, CDR) can be increased through afforestation, reducing the overall scale of biomass harvest and use, and dietary changes. However, increasing the carbon sink has trade-offs with the provision of biomass for materials and energy use (*high confidence*). Technical mitigation measures on agricultural land (e.g., reducing the conversion of grassland, fostering hedges) can reduce land-use related emissions and increase sinks by 0.1 to 0.4 MtCO₂-eq/year (*medium confidence*). Changing the composition of tree species in forests in favor of more local and climate resilient species could increase the carbon sink in forests by 4.1 to 4.9 MtCO₂-eq/year on average between 2020 and 2150 (*low confidence*). A shift in nutrition and diets toward fewer calories and more plant-based proteins combined with halving food losses would enable afforestation and renaturation of agricultural land, yielding an additional carbon sink of 3.0 to 12.9 MtCO₂/year compared to reference scenarios (*medium confidence*). Reducing the overall harvest and use of wood to 15 Mm³/year (25 Mm³/year when including logging residues and natural losses) would increase carbon sinks in forests by 9.3 to 11.1 MtCO₂/year, compared to a reference scenario using 20 Mm³/year of wood (30 Mm³/year when including logging residues and natural losses), on average between 2020 and 2150 (*low confidence*). {2.3, 8.5.2, Cross-Chapter Box 6}

C.8 Several mitigation options particularly in demand-side sectors are not quantified in terms of mitigation potential or costs in this assessment due to limited Austrian-specific data or literature. This includes mitigation measures such as reducing floor space in the building sector, tackling car dependency in the transportation sector, and shifting away from high-emission dietary patterns. Reductions in per capita floor space in residential and commercial buildings could lower energy demand for heating and cooling and decrease embodied carbon in construction materials. Similarly, measures to reduce car dependency, such as promoting urban densification and active mobility (e.g., cycling and walking), lack robust data despite their potential to address a significant portion of transport emissions. In agriculture, the transition to less emission-intensive diets, particularly reducing red meat consumption, and the mitigation impacts of halving food waste remain under-assessed, despite their high mitigation potential. Furthermore, cross-sectoral synergies, such as integrating circular economy principles in material use and reducing embedded emissions in consumer goods, have not been comprehensively evaluated. {2.3, 2.4, 3.3.1, 3.3.2, 3.4.2, 8.3.2, 8.4.5}

Synergies and trade-offs with the Sustainable Development Goals (SDGs)

Method Box 4: Assessment of the Sustainable Development Goals (SDGs)

The assessment of the synergy and trade-off potential of different mitigation options and the SDGs follows the analysis in the IPCC's Special Report on 1.5°C of Global Warming (Roy et al., 2018). It is based on a review and expert judgment based on the comprehensive global assessment, incorporating the evaluation of sectoral mitigation options in the Austrian context. The assessment considered several factors: (a) How mitigation options interact with specific SDGs; (b) the magnitude of these interactions using the Nilsson scale; (c) the consistency of evidence; (d) the degree of expert agreement; (e) the resulting confidence level; and (f) references relevant to Austria. International spillover effects related to SDG attainment beyond Austria and trade-offs between national and global SDG targets were not considered. Consequently, ocean-related mitigation options such as iron fertilization, blue carbon, and enhanced weathering were excluded from the analysis. Additionally, SDGs with limited immediate relevance to the Austrian context – such as SDG 14 (Life Below Water), SDG 16 (Peace, Justice and Strong Institutions), and SDG 17 (Partnerships for the Goals) – were excluded. All climate mitigation options are directly concerned with SDG 13 (Climate Action), so SDG 13 is not displayed either. {8.3.1, 8.A.1}

C.9 Mitigation measures across all sectors show co-benefits with the Sustainable Development Goals (SDGs). The synergies are generally larger than the negative side-effects and trade-offs, particularly in the demand-side and agriculture, forestry, and other land use sectors (*high confidence*). Synergy potentials are especially high for SDGs related to the development of the economy, including SDG 12 (Responsible Consumption and Production), SDG 9 (Industry, Innovation and Infrastructure), SDG 8 (Decent Work and Economic Growth), and SDG 7 (Affordable and Clean Energy). Synergies and trade-offs depend on implementation practice, which needs to manage trade-offs while maximizing the potential for synergies with the SDGs. {8.3.1, 8.4.5, Figure SPM.8}

C.10 Mitigation options targeting energy demand reductions and shifting energy consumption exhibit the highest synergies with the SDGs, particularly SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production) (*high confidence*). For instance, energy efficiency measures in industry not only reduce greenhouse gas emissions but also offer co-benefits such as lower water consumption and reduced wastewater generation. These measures enhance environmental and economic resilience, amplifying the positive impacts on sustainable development. {8.3.1, 8.3.2, Figure SPM.8}

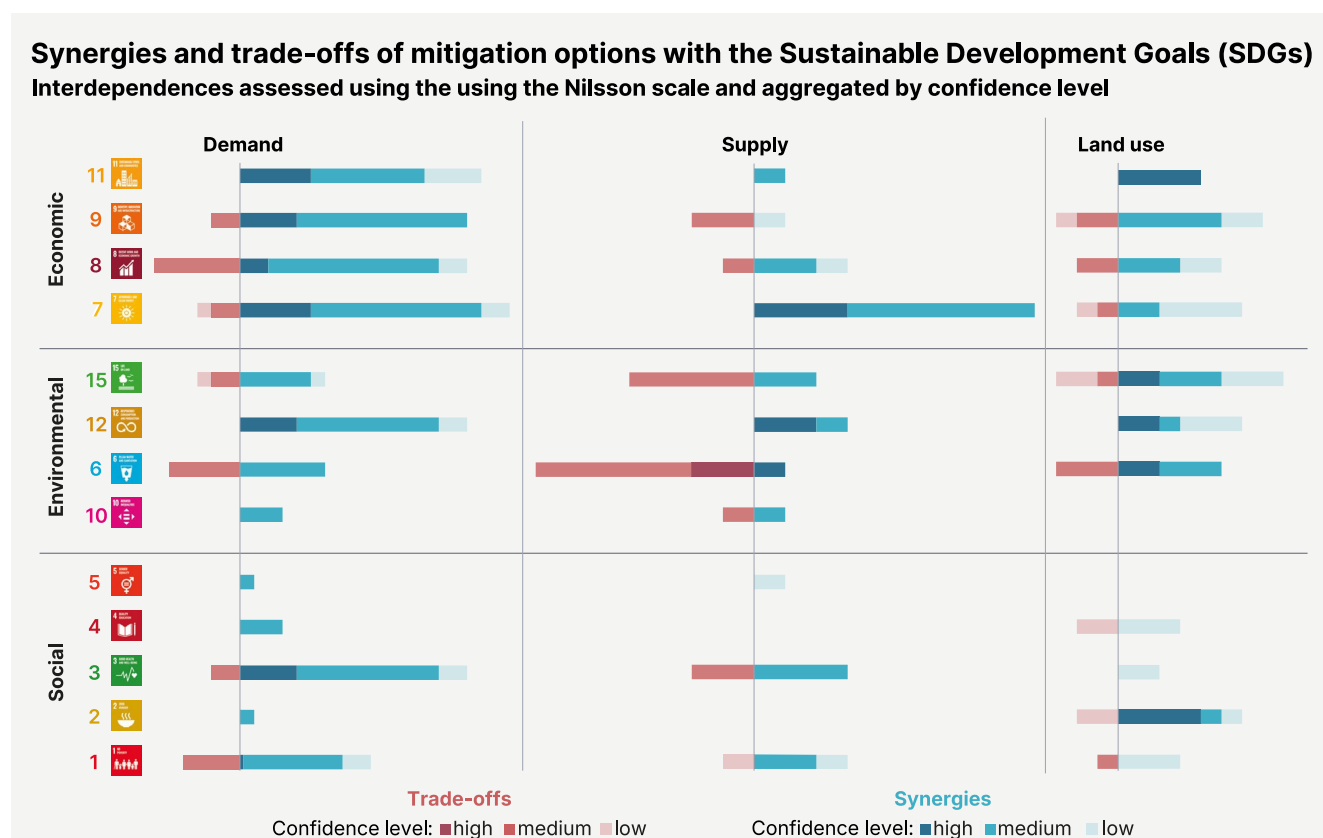


Figure SPM.8 | Indicative linkages between aggregated mitigation options and SDGs. Economic SDGs include SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities). Environmental SDGs include SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production) and SDG 15 (Life on Land). Social SDGs include SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 4 (Quality Education), SDG 5 (Gender Equality) and SDG 10 (Reduced Inequalities). The bar length indicates the respective synergy/trade-off potentials according to the Nilsson scale, which is used to assess the interactions between different SDGs. The scale ranges from -3 to +3. Figure based on IPCC (2022, p. 20).

C.11 The realization of synergies and management of trade-offs in mitigation measures depend on their design and implementation (*medium confidence*). Targeted subsidies for the transition to energy-efficient technologies and renewable energy systems reduce barriers to adoption, particularly for low-income households. Land-use planning and zoning to minimize conflicts between biodiversity conservation and urban or agricultural expansion highlight the importance of integrated approaches. These strategies demonstrate how carefully designed policies can maximize synergies and reduce trade-offs across sectors. {1.6.4, 2.3.2, 3.2.2, 8.3.1, 8.4.5}

C.12 Mitigation options tied to international trade, including exports and imports, can support the SDGs on the global level (*medium evidence, high agreement*). For example, scaling up achievement renewable energy investments could lead to trade-offs if critical raw materials are sourced from countries with weak environmental or labor protections. Addressing these supply-chain impacts is essential to ensure global equity in achieving the SDGs. {8.3.1, 8.4.5}

C.13 Similar to mitigation, adaptation measures exhibit higher potential for synergies than trade-offs with the SDGs (*medium evidence, high agreement*). Infrastructure-focused adaptation measures, such as resilient water management systems, align strongly with SDG 11 (Sustainable Cities and Communities) by reducing vulnerability to flooding and droughts, while simultaneously improving public health. Nature-based solutions, such as urban greening and wetland restoration, provide multi-benefit approaches by mitigating heat stress, improving air quality, and supporting biodiversity, aligning with SDG 15 (Life on Land) and SDG 13 (Climate Action). {1.6.4, 3.2.1, 3.2.3, 3.4.4, 7.4.3, 8.3.1, 8.4.5, Chapter Box 3.1}

C.14 Scenarios with low energy demand and high imports exhibit the highest potential for synergies with Austria's Sustainable Development Goals (SDGs), but they may transfer trade-offs to exporting countries (*medium evidence, high agreement*). Prioritizing low domestic energy consumption through energy efficiency measures and behavioral shifts contributes to achieving SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production). However, increased reliance on imports, particularly of renewable energy technologies and critical raw materials, can create environmental and social pressures in exporting countries. Ensuring sustainable international cooperation requires responsible sourcing practices, integration of labor and environmental standards, and transparency in supply chains to address global sustainability challenges while fostering equitable outcomes. {4.5.3, 8.3.2, 8.4.5}

D. How can Austria meet climate targets?

Scenarios and pathways

This section outlines Austria's transition to climate neutrality, focusing on quantitative scenarios, technological feasibility as well as necessary political, economic, socio-cultural, and technological framework conditions. Electrification accompanied by the decarbonization of the electricity supply and measures to reduce energy demand are key mitigation strategies in all scenarios. The immediate implementation of ambitious policies and investments, such as expanding the renewable energy infrastructure, enhancing energy efficiency, and phasing out fossil fuels, is needed for Austria to achieve net-zero CO₂ emissions within the next two decades. Additionally, this section describes qualitative climate-friendly transformation pathways that align emission reduction and adaptation measures.

Quantitative scenarios toward net-zero CO₂ emissions

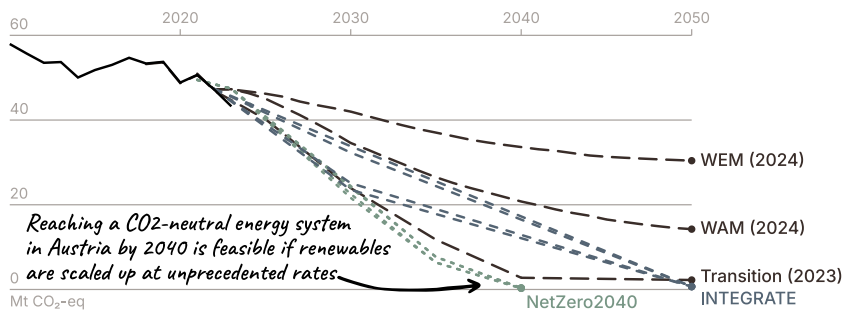
D.1 Reaching a CO₂-neutral energy system by 2040 is feasible if unprecedented rates of change in the expansion of renewable energy capacity in Austria alongside significant transformations in the associated institutional, regulatory, and legal set-ups are realized. Immediate actions that go beyond current policy measures are urgently needed to overcome inertia in key sectors such as energy, industry, housing, and mobility (*high confidence*). Current policies as implemented in the 'with existing measures' (WEM) scenario and those currently discussed in the policy arena – in particular in the 'with additional measures' (WAM) scenario – are insufficient to reach net-zero CO₂ emissions in Austria. Absolute growth in renewable electricity generation technologies needs to be higher than historically observed for any other electricity generation technology in Austria, including hydropower and gas power. Within a decade, wind power has to increase its generation by twice the amount of the fastest historical expansion of run-of-river hydropower in Austria (*medium evidence, high agreement*). {2.3.4, 4.5.2, 8.4, 8.5, Figure SPM.9}

D.2 All available scenarios achieving net-zero CO₂ emissions in the energy system rely on a significant increase in electrification and on a high share of renewables (*high confidence*). Electricity use as a share of energy consumption increases from 22 % in 2023 to 35–47 % in 2040. Direct use of renewables (e.g., biogenic fuels, wood pellets) as a share of final energy consumption increases from 16 % in 2023 to 30–44 %. Electrification implies a significant reduction in domestic primary energy consumption due to efficiency gains. All scenarios also rely on changes in energy service demand and imports of low-carbon fuels from outside of Austria, reducing the domestic primary energy demand. Gross domestic energy demand in net-zero scenarios is 18–33 % lower in 2040 compared to 2023. {2.3.4, 4.4, 4.5, 4.6.2, 8.4, Figure SPM.9}

D.3 Technological options (e.g., electrification, the use of synthetic fuels, carbon capture, utilization, and storage (CCUS), and biomass) are available to enable a transition to net-zero CO₂ emissions in Austria's industry and manufacturing sector, but key technologies such as hydrogen-based steelmaking and the integration of CCUS need further research and development (*high confidence*). In particular, future industrial systems will heavily rely on the direct use of electricity, and additionally on electricity-based fuels such as green hydrogen. Thus, the short-term availability of zero-carbon electricity is key to avoid shifting emissions to the energy sector. When keeping current production output constant, electricity demand for direct use in emission-intensive industries will more than double in scenarios that reach carbon neutrality (*high confidence*). {4.4.2, 4.6}

Scenarios to reach net-zero CO₂ emissions

(a) Mitigation scenarios for CO₂ emissions related to energy use: Scenarios from the NetZero2040 and INTEGRATE studies show emissions pathways to a net-zero energy system.



Model-based scenarios

Umweltbundesamt

- **WEM** With Existing Measures (2024)
- **WAM** With Additional Measures (2024)
- **TRA** Transition (2023)

INTEGRATE

- **H** High-demand
- **L** Low-demand
- **H1** High-Demand/Limited-Import
- **L1** Low-Demand/Limited-Import
- **H2** High-Demand/Unlimited-Import
- **L2** Low-Demand/Unlimited-Import

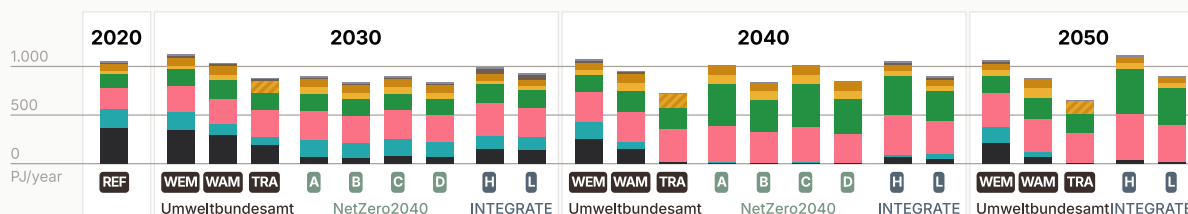
NetZero2040

- **A** High-import/High-demand
- **B** High-import/Low-demand
- **C** Low-import/High-demand
- **D** Low-import/Low-demand

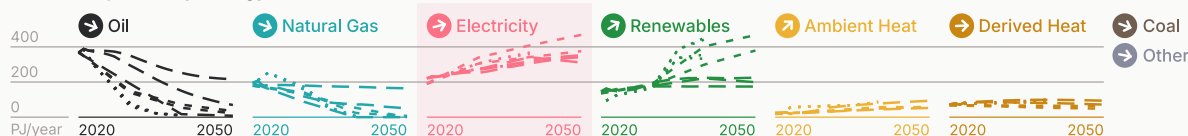
Final energy consumption

Mitigation scenarios show a decrease in total energy use due to electrification and higher efficiency as well as a rapid phase-out of fossil fuels.

(b) Development of the energy system



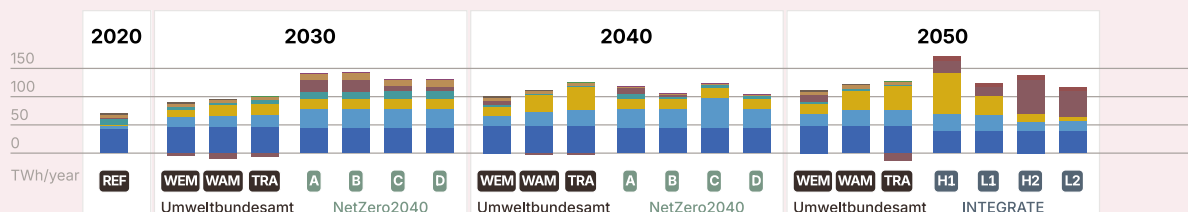
(c) Development by energy source



Electricity generation

Electricity use increases rapidly across all mitigation scenarios driven by solar PV and wind power.

(d) Development of the electricity system



(e) Development by electricity source

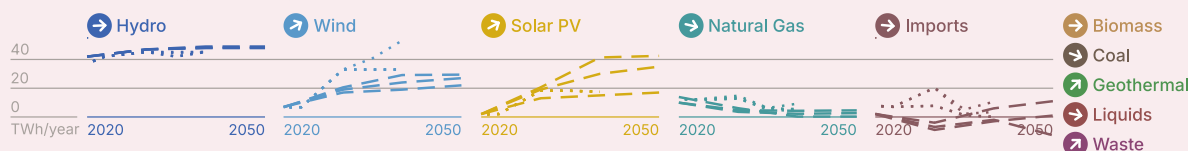


Figure SPM.9 | Scenarios of Austrian CO₂ emissions and energy use by source across scenarios. CO₂ emissions related to energy use (panel a), final energy consumption by energy source (panels b and c) and electricity use by source (panels d and e) in quantitative, model-based scenarios (Schmidt et al., 2025; Steiner et al., 2024; Umweltbundesamt, 2024a, 2024b).

D.4 Decisions need to be taken today to reach net-zero carbon emissions within the next two decades due to considerable lead times and path dependencies (*medium evidence, high agreement*). Measures have to be implemented immediately in order to achieve the emission reductions required by the European Climate Law and the national target of climate neutrality by 2040 due to significant inertia in the energy system and other provisioning systems (mobility, housing, food, etc.) as well as related industrial processes and land use. This inertia also limits the technological scope of action, reflected in strong similarities between net-zero scenarios in their technology mix up to 2030. Despite the technological similarities, the assessed net-zero scenarios differ in terms of climate and energy policies, the portfolio of measures and implications for consumer practices, and overall economic system arrangements such as the circular economy and resulting business models even before 2030. {3.3.3, 4.5, 8.4.3, 8.7}

D.5 Several mitigation strategies are possible after 2030 (*high confidence*). Scenarios differ regarding infrastructure for energy storage, grids, and public transport, implying the need for swift and determined decisions today so that the necessary infrastructure is available in time given the substantial construction time for energy and rail infrastructure. {3.4.4, 4.5.2, 4.5.3, 8.4.3}

D.6 Wind power and solar photovoltaics (PV) are crucial for the power sector in all scenarios, with wind providing 5–25 % and solar PV providing 6–20 % of gross domestic consumption in 2040 (*medium evidence, high agreement*). Systems with varying shares of those technologies differ considerably in terms of the lead times required for project development and the supporting infrastructure. Import dependency of gross domestic consumption varies considerably between 28–40 %, and respective international supply chains for new energy carriers such as green hydrogen or carbon-free synthetic fuels have to be established in a timely manner. Biomass use, e.g., wood pellets, remains a highly important resource in the energy sector across all scenarios, ranging between 23–31 % of gross domestic consumption, but this has trade-offs with the available carbon sequestration potential. {4.5.2, 4.5.3, 8.4.3, Figure SPM.9}

D.7 All scenarios show that fossil fuels have to be phased out rapidly to reach climate neutrality. The fossil share of gross domestic consumption falls from 68 % in 2021 to 2–3 % in 2040. Fossil liquid fuels and fossil methane are partly substituted by varying amounts of biogenic or synthetic fuels; a small share of fossil fuels is used in combination with carbon capture and storage in 2040 in the scenarios (1.25–1.5 MtCO₂/year, equivalent to 5.7–6.7 TWh/year) (*medium evidence, high agreement*). While electrification is the most cost-effective mitigation technology in many applications, scenarios indicate that there is still a need for carbon-neutral liquid fuels and gases in 2040. Their use ranges from 48 to 54 % of gross domestic consumption in 2040. These energy carriers are provided as green hydrogen or synthetic fuels and gases (i.e., green hydrogen, potentially combined with carbon capture and utilization, CCUS), as biomass, biogas, and biofuels, or as fossil fuels with carbon capture and storage. To satisfy the demand, ambitious levels of both domestic production and imports will be required. These fuels are mostly used in industry (50–63 % of all liquid fuel and gas use), in transport (10–12 %), in households, services, and agriculture (22–26 %), and in power generation and district heating (4–23 %). {3.4.2, 3.4.3, 4.5.2, 4.6}

D.8 Achieving net-zero CO₂ emissions by 2040 in the energy system requires additional annual investments in the range of EUR₂₀₂₄ 6.4 billion to 11.2 billion, corresponding to between 1.1 % and 1.9 % of average projected annual GDP (estimates from 2024). These investments are expected to have substantial positive impacts on employment and income, and overall economic welfare (*medium confidence*). Additional investments in the energy system (generation, transmission and storage) and other sectors including buildings, transport and industry can serve as drivers of production and creators of green jobs. {8.4.4, 8.5.3, Table 8.1, Figures 8.16–8.18}

D.9 Decarbonizing the economy requires disinvestment from unabated fossil infrastructures as well as investment in new and existing material stocks (*medium confidence*). Total material stocks need to be transformed or downsized to become more durable and resource-efficient, and act as long-term carbon sinks to attain climate neutrality. If high imports of renewable energy resources or primary materials are not plausible due to geopolitical rivalry, highly efficient material use needs to be complemented by sufficiency strategies to mitigate climate change and reduce vulnerabilities (e.g., due to import de-

pendencies). Future material supply may rely on low-carbon and high-quality (infra)structures, replacements, extended life-times, and material loops for eco-designed products and may thus be accomplished domestically. {3.3.2, 3.4.4, 4.2, 8.5.1, 8.6.1, Cross-Chapter Box 3, Cross-Chapter Box 7}

D.10 Legacy effects cause the continued use of fossil fuels or the growth of synthetic fuel use in transportation and heating. Due to delayed action in these sectors, a significant stock of assets based on liquids or gases may remain, causing the costly and inefficient use of these fuels in sectors where electrification could provide emission reductions at a lower cost (*medium evidence, high agreement*). As an example, a high share of liquid fuel use in the transportation sector only materializes in one sensitivity scenario, where the rate of electrification of land transportation is maintained at current levels. Otherwise, liquid fuels are only used for aviation and shipping in all scenarios, indicating that the phase-out of combustion engines is crucial if climate neutrality is to be achieved quickly and cost-effectively. Similarly, scenarios show no liquid fuel or gas use in heating after legacy effects are overcome. {4.5.2}

D.11 To achieve net-zero emissions, residual emissions from industrial processes, waste, and agriculture have to be balanced by negative emissions from land-based carbon dioxide removal (CDR) methods or, in the longer-term, by novel but costly CDR measures (*high confidence*). Residual emissions from agriculture (4.3 MtCO₂/year), waste (1.7 MtCO₂/year), and, depending on the scenario, from industrial processes (0–5 MtCO₂/year) will remain (*limited evidence, medium agreement*). For residual emissions in agriculture and waste, uncertainty is higher than indicated by the point estimates, as only one scenario explicitly assesses these sectors. {Cross-Chapter Box 6}

D.12 Carbon dioxide removal (CDR) options available in Austria include land-based biological (i.e., afforestation, reforestation, ecosystem restoration, and soil management) and technical processes to capture and permanently store CO₂, i.e., bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS). These options are interdependent and differ in terms of their technical and plausible potentials, synergies and trade-offs, and technical readiness levels (*medium confidence*). The potential of each CDR option relies in part on the same energy and area resources, so the options should be considered as interdependent. The successful implementation of CDR options also depends on several external factors, such as technological developments, the regulatory framework, public perception, existing land use, and energy demand under changing climate conditions. {2.3, Table 2.3, 4.6, Cross-Chapter Box 6}

D.13 Novel technologies such as direct air carbon capture and storage (DACCS) or bioenergy with carbon capture and storage (BECCS) are costly and depend on the availability of carbon storage potential (*high confidence*). Domestic depleted oil and gas reservoirs are estimated to provide storage capacities of 100 to 250 MtCO₂, which would be sufficient to store Austria's cumulative expected hard-to-abate emissions from one to a few decades. No robust assessment for additional capacity in domestic aquifers is currently available (*medium evidence, high agreement*). Exporting hard-to-abate CO₂ emissions, e.g., via a CO₂ grid through Germany to the North Sea, appears to be a necessity in the future, but international storage capacities are limited and subject to competition. All the above implies that there are limits on the amount of CO₂ that can be captured and stored, domestically or elsewhere in Europe (*medium confidence*). {2.3, 4.6, Cross-Chapter Box 6}

Political, economic, socio-cultural, and technological framework conditions

D.14 Framework conditions, like laws, norms, infrastructures, and governance structures, can be decisive enablers and inhibitors for climate-friendly transformations (*high confidence*). Climate policy is entangled with power relations, laws and standards, economic incentives and social policies, infrastructures, social norms, the composition of national governments and the EU commission, and global climate governance. Politico-economic and socio-cultural framework conditions can inhibit or enable climate-friendly transformations. Overcoming inhibitors, like science-skepticism and the instrumentalization of climate policies in culture-war rhetoric, is as important as promoting enablers. {3.3.3, 4.2, 5.6, 6.2, 6.5.2, 8.5, Table SPM.1}

Table SPM.1 | Overview of inhibitors and enablers of climate-friendly transformations. {Table 8.2}

Meta-level policy fields	Inhibitors of climate-friendly transformations	Enablers of climate-friendly transformations
Global governance	- Contested global climate governance - Market-biased governance limiting policy space - Precedence of national security policies over cooperative governance	- Effective democratic policy space - Increasing strategic autonomy and reduced import dependency through sufficiency and avoid-measures
Democracy, law and science	- Democratic climate-action-delaying policies - Science skepticism and culture war-rhetoric	- Linking representative with deliberative and participatory forms of democracy, and scientific expertise - Emphasizing benefits of climate action alongside costs of inaction - Climate litigation and lawsuits
Politico-economic framework conditions	- Macro- and micro-economic growth imperatives - Power of incumbent business interests - Dominance of de-risking policies - Contested European Green Deal	- Coordinated economic planning to foster innovation and exnovation - Limiting incumbent business interests - Fiscal, monetary and industrial policies combining a “sticks and carrots” policy mix
Socio-cultural framework conditions	- Status quo bias (defending unsustainable and inequalitarian consumption patterns) - Awareness-action gap - Advertisement promoting fossil fuel-based overconsumption	- Eco-social policies to reduce inequalities and enhance well-being for all - Broader alliances based on benefits for everyday life
Adaptation	- Implementation gap due to missing sense of urgency, insufficient political leadership, and lack of dedicated budgets - Limits to adaptation shrink the action space for policy	- Iterative climate risk management to support the implementation of adaptation measures - Transformative adaptation as an alternative to incremental measures

D.15 Decisive enablers for climate-friendly transformations are measures to increase strategic energy autonomy at the national and European level, emphasize benefits for everyday life, combine ‘carrots and sticks’, promote integrated eco-social policies, and prioritize iterative climate risk management (*medium confidence*). Increased strategic autonomy via sufficiency measures can reduce import dependency. Emphasizing the benefits of climate action for everyday life and the costs of inaction can gain societal support with climate-related impacts as co-benefits. Implementing push measures that limit incumbent business interests can facilitate economic planning to foster innovation. Iterative risk management can foster transformative measures at the intersection of climate change adaptation and disaster risk management. Another important lever is eco-social policies that reduce inequalities and enhance well-being and a climate-friendly lifestyle, e.g., accessible infrastructures for public transport and renewables. {3.4, 6.2, 6.5.2, 8.5, Table SPM.1}

D.16 Policies to reduce emissions can become more effective if embedded in the broader goal of climate-friendly living, defined as a good life for all within planetary boundaries, thereby linking climate neutrality to climate resilience and further socio-economic and environmental goals (*medium confidence*). As climate policy does not happen in a silo independent from other policy fields, achieving climate-friendly living requires policy integration to achieve rapid and far-reaching changes in the provisioning of mobility, housing, food, health, care, and leisure as well as deep changes in institutional set-ups. Focusing on the provisioning of services can emphasize human needs and well-being and identify opportunities along the resource value chain. {6.2, 6.5.3, 8.5, 8.6.1, Table SPM.1, Cross-Chapter Box 3}

D.17 If political goals, such as increasing geopolitical security and short-term competitiveness, fail to account for their climate-related impacts and equity concerns, Austria will not meet its national climate targets or fulfill its international obligations (*limited evidence, medium agreement*). Integrating climate policies that transform the provisioning of mobility, housing, food, health, care, and leisure within broader sustainable development policies can help overcome the policy silos of mitigation and adaptation. Enlarging the policy space is important for planning transformations more effectively. Innovative, democratic, and multi-level governance models can support climate policy integration to better scale up innovations, such as renewable energy expansion, and foster ‘exnovations’, such as phasing out combustion engines (*medium confidence*). {6.5.3, 8.3, 8.5, 8.6.1}

D.18 Three ways to achieve climate targets are (1) avoiding emissions, (2) shifting to low-emission alternatives, and (3) improving the provision of necessary infrastructures, services, and goods. In selecting bundles of measures, the Avoid-Shift-Improve (ASI) framework prioritizes avoid measures over shift and improve measures (*high confidence*). The ASI framework directly targets well-being when formulating and comparing mitigation strategies. It encourages more systematic thinking, making use of different perspectives, to change demand for goods and services by changing supply structures, transforming infrastructures, and modifying choice architectures. This shifts the focus of climate policies onto what people need for a good life, targeting demand, preferences, and choices not as given, but as socially constructed. Human well-being depends on the specific institutions and infrastructures of the socio-economic system. Accessible public transport infrastructures enable the shift from car to train, while accessible alternative heating systems enable the shift away from gas providers. Avoid, shift, and improve measures are not mutually exclusive and are combined in climate-friendly bundles of measures, thereby increasing effectiveness. While avoid and shift measures often depend on changes in regulations, laws, infrastructure, and other framework conditions, improve measures are often compatible with incumbent habits. {3.3.1, 3.4.2, 4.2, 4.4.4, 8.6.1, Cross-Chapter Box 3, Cross-Chapter Box 4}

D.19 Adopting circular economy principles can support climate policy and the transition to carbon neutrality (*high confidence*). Shifting from new construction to services such as refurbishment and optimized use of buildings or repair and reuse can significantly reduce both the demand for bulk and critical raw materials vis-à-vis a pure decarbonization strategy. Limiting the expansion of building and road stock can reduce energy demand for heating and transport by a third, thereby aiding the decarbonization of the power sector. Since unprecedented increases in green energy supply are necessary in all decarbonization scenarios, the circular economy principles reduction potential can contribute to reaching the climate goals. {4.4.4, Cross-Chapter Box 3, Cross-Chapter Box 4}

D.20 Policy and infrastructure changes (e.g., expanding public transport infrastructure) as well as cultural, behavioral, and normative changes (e.g., facilitating and nudging emission-saving practices by building walkable neighborhoods) can reduce emissions by reducing service demand (*high confidence*). Reductions in service demand through lifestyle changes face barriers due to existing infrastructure (e.g., lack of good public transport options), economic disincentives (e.g., subsidies for high-emissions products and services), and social norms (e.g., energy intensive goods such as big cars or big living spaces socially rewarded as status goods). {3.4.2, 5.3.1, 5.3.2, 5.3.3, 8.5.4, 8.6.1}

D.21 Work – including unpaid care and paid employment – dominates daily life in Austria, and the structural dependence of persons and welfare systems on paid work currently tends to impede climate-neutral provisioning as well as climate-friendly living (*high confidence*). Highly productive, energy-intensive work is well-paid and structurally linked to energy-light, unpaid or low-paid, very essential work that is not highly productive (including care) (*limited evidence, medium agreement*). The work-mode of living poses a structural barrier to climate-friendly mobility, food, housing and leisure, and encourages energy- and fossil-fuel-intensive practices (*medium confidence*). {4.7.1}

D.22 A transition to a climate-friendly society will reduce emissions directly related to paid employment and unpaid care (*limited evidence, high agreement*). The greening and sharing of paid employment and unpaid care will ensure a high quality of life, gender equality, good work and climate-friendly living, work-life balance, and adequate provisioning of care (*medium*

confidence). Under the current business-as-usual scenario, work will be severely affected by impacts of climate change, requiring sectoral shifts toward the provisioning of basic goods such as health, care, food, and housing (*limited evidence, medium agreement*). {4.7.2}

D.23 To avoid production with a high emissions profile or large resource use, and to overcome labor supply constraints, climate-friendly regulation of labor markets can enable a shift from excess production to sustainable provisioning of essential services (*medium confidence*). The redistribution of paid work and unpaid care as well as the relocation of jobs to people's living place through economic and labor market policies can enable climate-friendly work-life patterns. More equal distribution of wealth and income, job guarantee, and public provision of basic goods (e.g., housing, food, and health care) can increase economic security and thus enable green labor market transformations. {4.7.3}

Climate-friendly transformation pathways

D.24 Climate-friendly transformation pathways integrate mitigation and adaptation strategies as well as efficiency and sufficiency measures. These pathways thereby draw on narratives that highlight the everyday benefits of climate action and the costs of inaction (*robust evidence, medium agreement*). While various pathways exist, they have in common that they provide a narrative for societal organization and behavior aiming to reduce both direct and indirect emissions to achieve climate targets, while simultaneously reducing vulnerability to climate change impacts through adaptation and enhancing climate resilience. More broadly, these pathways aim to ensure a good life for all within planetary boundaries. {8.6.1, 8.6.2, 8.6.3, Table 8.3}

D.25 Climate governance in democracies involves decisions made by elected decision makers, with the effectiveness of climate action depending on four key elements: broadening climate policies, climate-friendly governance models, an expanded mix of instruments, and societal and political support (*medium confidence*). Integrating climate policy into sustainable development can facilitate policy coherence and reduce the influence of vested interests. A diverse mix of measures, including adaptation and mitigation, efficiency and sufficiency, and both incremental and disruptive approaches, strengthens governance frameworks. {6.5.1, 8.6.1, 8.6.2, 8.6.3, Table 8.3}

D.26 Climate-friendly governance models can integrate climate considerations across multiple levels and policy areas while ensuring that enforceable administrative rules remain compatible with safeguarding individual rights (*medium confidence*). Societal support, both through public discourse and political commitment by decision-makers, is decisive for the feasibility of climate action. A broad understanding of climate policy as part of sustainable development supports policy integration and can counteract the power of incumbent vested interests. {6.5.1, 8.6.1, 8.6.2, 8.6.3, Table 8.3}

D.27 Climate-friendly transformation pathways comprise a balanced portfolio of incremental and disruptive measures (*robust evidence, medium agreement*). Relying solely on incremental measures, especially those that focus narrowly on technological options and efficiency improvements, constitutes a form of climate delay because such measures alone are insufficient to achieve climate targets. Climate-friendly transformation pathways require bundles of incremental and structural measures that combine broadly accepted actions (e.g., green spaces and public transport expansion) with less popular approaches (e.g., reduction of parking spaces in cities and transition to healthy diets). Strategic autonomy and reduced fossil fuel import dependencies can be achieved by lowering demand through sufficiency measures. The advantage of regulations, whether they are speed limits or product provisions, is that these measures are cheap for the public. Furthermore, they can potentially lead to immediate results and may also increase the fiscal room for maneuver (*medium confidence*). {8.6.1, 8.6.2, 8.6.3, 8.7, Table 8.3}

D.28 Narratives with a focus on markets, technology, and efficiency improvements are currently dominating the climate policy discourse (*high confidence*). These narratives can broaden alliances and integrate additional parts of middle-class and upper-class milieus if they more explicitly consider fairness aspects as well as short-term co-benefits, like attractive public

transport options (e.g., the ‘KlimaTicket’) and incentives for circular-economy strategies (e.g., repair subsidies like the ‘Reparaturbonus’). This can also be attractive to people who are skeptical of ambitious climate policy. {8.6}

D.29 Narratives with a focus on systemic change, sufficiency, and avoid measures can become more effective and feasible if they focus on ensuring decent living standards, better working conditions, and improved social protection (*medium confidence*). This can attract diverse milieus, including low-income households, by combining an ambitious social-ecological agenda with the re-orientation of the economy to satisfy the basic needs of health, care, food, housing, energy, and mobility. {8.6}

D.30 Transformation pathways that focus on demand reduction strategies can maximize synergies with the Sustainable Development Goals (*limited evidence, high agreement*). Reducing new constructions (e.g., buildings and roads) not only lowers emissions but also decreases soil sealing, thereby improving biodiversity. Reducing meat production can cut emissions while improving public health and lowering health care costs. Reducing car dependency can enhance neighborhood quality of life. However, it is essential to find an appropriate balance, as overly emphasizing demand reduction could provoke resistance from certain societal groups and stakeholders. {8.5, 8.6, 8.7, Figure 8.3}

D.31 Transformation pathways based on a single perspective tend to be less effective in meeting climate targets than comprehensive ones based on multiple perspectives (*high confidence*). Ecomodernist transformation pathways relying on market- and technology-based solutions and on high energy imports may trigger resistance as they imply increases in energy and carbon pricing to implement emission reductions. In contrast, transformation pathways prioritizing demand reduction strategies may face public opposition due to loss aversion and a perception of restriction. {8.4, 8.6, 8.7}

D.32 Climate-friendly transformation pathways combine multiple perspectives from different socio-cultural milieus and therefore may help overcome delay in action toward climate neutrality (*medium confidence*). All climate-friendly transformation pathways bear challenges, so implementation should combine multiple perspectives to facilitate effective compromise and overcome interest-based decisions. {8.4, 8.6, 8.7}

E. Which policies can support effective and equitable climate governance? Institutional and societal dimensions

This section explores the necessary framework conditions for effective and equitable climate policy integration facilitating a transition to a carbon-neutral and climate-resilient society. Key topics include governance reform, the importance of diverse policy instruments, and the acceptability of measures by addressing societal concerns. This section illustrates that a climate-friendly transformation is achievable and beneficial.

Addressing structural barriers to foster effective climate governance

E.1 Achieving climate-friendly living and well-being for all requires new production and provisioning systems and enabling sustainable infrastructures, including a carbon-neutral energy system (*high confidence*). Current infrastructures and provisioning systems, especially in the areas of mobility and housing, often impede climate-friendly living despite individual willingness to reduce carbon footprints (e.g., high train ticket prices to international destinations and tax exemptions for aviation disincentivizing shifts from air travel to train, lack of options to switch to low-carbon heating in specific situations). {4.2, 8.4, 8.5.4, Cross-Chapter Box 3}

E.2 Social acceptability of policies strongly supports effective implementation (*high confidence*). Measures supporting a just transition and tackling excessive income and wealth inequality are found to enhance the social acceptability of climate policies and remove barriers to changing lifestyles and consumption (*medium confidence*). This includes the Just Transition Mechanism as proposed by the European Union, which aims to “ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind”. Evidence indicates that public acceptance of climate policies depends on whether they are perceived as fair and effective. Policies considered intrusive but ultimately necessary for effective greenhouse gas emission reduction need to be particularly well designed to ensure social acceptance. {5.6.3}

E.3 Comprehensive vertical and horizontal integration of climate policy, along with provisions for prioritizing policies in case of target conflicts are a precondition for implementing policies aligned with the goals of the Paris Agreement across all levels of government (*high confidence*). Climate policies are more effective when they are mainstreamed in sectoral policies (e.g., agricultural policy, transport policy, energy policy) than when they are designed as separate policies. Climate policy integration is primarily concerned with considering climate aspects across all areas of policymaking. {6.5.3}

E.4 The shared responsibilities for climate and environmental protection between the federal government and the federal states need to be revised to ensure the effective design and implementation of climate policies (*high confidence*). The recently adopted ‘Fiscal Equalization Agreement’ (‘Finanzausgleich’) for 2024 to 2028 does not foresee substantial reforms to strengthen inter-governmental climate governance. One example evidencing a lack in climate policy integration in Austria is the high rate of soil sealing that undermines mitigation efforts, illustrating the need to reorganize spatial planning competences to reach climate targets. {3.2.2, 6.4.1, 6.5.3}

E.5 The current climate policy mix in Austria is skewed toward subsidies and weakened by competing interests, leaving the potential of other policy instruments largely untapped. To be effective, climate policy instruments need to enable structural change toward climate-friendly lifestyles and provisioning systems and increase resilience to unavoidable climate change (*high confidence*). In terms of institutional design, National Climate Advisory Bodies, as suggested in the European Climate Law, can play an important role in convening stakeholders and providing expert scientific advice on climate policy to the relevant authorities. Establishing such an independent Climate Advisory Board in Austria could improve the effectiveness of national climate change mitigation. {6.3, 6.4, 6.5}

E.6 Achieving the climate targets requires a balanced set of measures, combining regulation, planning instruments, economic incentives, and other policy instruments such as awareness and information instruments (*high confidence*). Table SPM.2 provides an overview of both implemented and available but yet untapped climate policy instruments in Austria in different sectors, distinguishing between instruments according to their implementation status and their alignment with climate policy targets. So far, the potential of most implemented instruments has not been fully exploited due to insufficient policy design measured against existing climate targets. However, the ultimate choice of instruments and their contribution to achieving the climate targets depends on the desired policy mix. {6.5}

E.7 Effective climate governance intervenes in deep-rooted political and economic structures and associated power relations. As a result, it requires strategies for dealing with the political resistance it may provoke (*robust evidence, medium agreement*). Economic growth and wealth in Austria have been based on the use of fossil fuels and related infrastructures (e.g., pipelines and roads). This implies strong political and economic interests in maintaining a fossil-fuel-dependent status quo, which hinders incremental ecological modernization and resists more disruptive transformation toward climate neutrality. Managing potential political and societal resistance against such far-reaching interventions requires systematic integration of justice considerations and political strategies to design winning coalitions and demobilize opposition. {6.2}

E.8 Fiscal policy and public budgets, in terms of both revenue and expenditure, are a crucial lever for climate policy. Their potential is currently underutilized and undermined by counterproductive measures such as climate-counterproductive subsidies (*high confidence*). Current fiscal rules in the EU limit public investment for climate action. Phasing out counterproductive measures, such as climate-counterproductive subsidies, could increase available public climate finance for both mitigation and adaptation. As a complementary measure, effective climate action also requires the mobilization of private funds to bridge the investment gap. This can be achieved by providing adequate standards for green finance and reducing the carbon exposure of the economy. {6.5, 6.7, Cross-Chapter Box 8}

E.9 The mix of climate policies chosen to achieve carbon neutrality depends on societal and political preferences (*high confidence*). Carbon pricing instruments (such as the EU Emissions Trading System and the National Emissions Trading System for Austria) are used to steer relative prices, which affect the incentive structures of production and consumption activities. They focus on market interactions and the efficient allocation of scarce resources. Second-order effects, such as distribution impacts or carbon leakage, require additional instruments. Regulatory instruments are highly sector-specific, ranging from building codes to feedstock regulations and bans on fossil-fuel use in combustion engines. In addition to mitigation policies, adaptation instruments are required to compensate for the negative effects of unavoidable impacts from climate change. Measures to support a just transition are crucial for the successful implementation of climate mitigation measures as they can alleviate undesired social hardships and improve social and political acceptance. {6.1, 6.5}

Table SPM.2 | Summary table on the status of mitigation policy instruments in Austria. {Table 6.2}

	Agriculture / forestry / other land use	Transport (excluding aviation)	Buildings	Non-ETS industries	ETS industries	Energy supply	Aviation	
Economic instruments: taxes and ETS	National emission trading system				EU ETS			
	Energy taxes						Fuel taxes	
	Carbon border adjustments				Carbon border adjustments			
	EU level border-meat-adjustment tax				VAT exemption for PV systems		VAT on inter- national flights	
	Elimination of reduced VAT or higher taxes rate for meat and dairy products	Road pricing trucks	Vacancy fee	Resource taxes			Passenger taxes	
	Higher taxes for emission- intensive products	Road pricing cars / city toll	Secondary residence fee					
	Fertilizer tax	Vehicle taxes	Real estate tax					
	Soil sealing taxes	Parking fees						
Economic instruments: subsidies	R&D subsidies							
	Investment subsidies	Subsidies for low emission mobility	Subsidies for change of heating systems	Environmental protection subsidies		Investment subsidies		
	(Restructuring of) subsidies		Subsidies for thermal refurbishment	Feed-in premiums				
	Payments for eco-system services							
	Premiums for the reduction of livestock							
	De-sealing premiums							
	Earmarked compensation payments directed to re-naturation							
		Commuting subsidies						
	Subsidies for company cars							
Planning instruments	Reduction of rezoning of green spaces	Spatial planning						
			Energy planning			Energy planning		
		Unsealing / greening	Re-densification	Re-naturation of industrial sites				
		Expansion and electrification of public transport	Adaptation of infrastructure			Expansion & adaptation of grid infrastructure		
		Infrastructure for e-mobility						
Other instruments	Non-Financial disclosure regulation							
	Qualification programs							
	Information campaigns							
	Fiscal equalization			Fiscal equalization				
	Labeling							
	Reform of communal tax							
	Guideline for fertilizer applications							

Not implemented / missing | 11%

Implemented but insufficient | 77%

Implemented and (fairly) sufficient | 9%

Counterproductive instrument | 3%

	Agriculture / forestry / other land use	Transport (excluding aviation)	Buildings	Non-ETS industries	ETS industries	Energy supply	Aviation
Regulatory instruments	LULUCF regulation	CO ₂ fleet emission limits / ban of fossil drives	Building codes	Product design standards		Renewable quotas	Ban of short flights
	Feedstuff regulation	Speed limits	Moratoria on expansion of natural gas network	Obligatory energy audits		Regulations for energy communities	Ban of private jets
	Supply chain responsibility regulation	Vehicle access restrictions	Ban of fossil heating systems (new buildings)	Obligatory waste heat utilization		Sustainability standards for biofuels	
		Environmental impact assessment		Environment impacts assessment			
	Regulation on deforestation-free products	Parking space management	Ban of fossil heating systems (old buildings)		IPPC standards		
	Afforestation obligation	Obligatory shift of longer freight transport to rail	Adaptation of residential property law		CCU/S regulation		
	Fertilizer regulations	Obligatory transport on rail for certain goods	Adaptation of heritage protection				
	Restrictions regarding menus in public canteens	Mobility budgets	Adaptation of tenancy law				
	Conservation of biodiversity, nature restoration law	Adaptation of building regulations					
	Regulation on the sustainable use of plant protection products	Moratoria on building of high-ranking roads	Refurbishment of public buildings				
	Maximum livestock-to-land ratio	Right to telework					
	Re-naturation of forests through reduced timber extraction						
	Guidelines for soil protection						
	Advertising bans for meat		Advertising bans for cars		Advertising ban for airlines		
	Public procurement						
	Change in the forestry act		Parking space obligation				
	Just transition instruments / compensation instruments	Coupons for vulnerable consumers	Subsidies for public transport for low-income households	Subsidies for changing heating systems and refurbishment for low-income households	Financial support for affected regions		
		Lump-sum payments ('Klimabonus')		Reductions in corporate taxes			
			Energy efficiency programs	Reductions in labor taxes			
			Consumer protection and information	Employment subsidies			
			Preferential loans / energy efficient mortgages	Active labor market policies			
				Curbing monthly back payments of tenants for renovation measures			

Not implemented / missing | 11%

Implemented but insufficient | 77%

Implemented and (fairly) sufficient | 9%

Counterproductive instrument | 3%

Societal concerns about climate change and mitigation policies

E.10 The distribution of greenhouse gas emissions across household incomes is highly unequal (*high confidence*). Rich households in Austria consume disproportionately more resources and energy, producing significantly more emissions, to maintain their lifestyles compared to low-income households. {5.2.2, Figure SPM.10}

E.11 Low-income households are disproportionately more affected by environmental pollution and climate extremes (*high confidence*). These groups are also often more exposed to the impacts of climate change and environmental pollution in their work, including agriculture and construction. Women are generally more affected, largely due to factors such as the gender pay gap, their lower participation in the labor market, and the unequal distribution of care responsibilities within families. Energy poverty is linked to a number of social factors including unemployment, gender inequality, educational attainment, housing status, disability, and age. {5.2.2, 5.3.4}

E.12 There is strong societal climate concern and demand for action in Austria. Societal and political support for policies strongly determines effective implementation (*medium evidence, high agreement*). Societal support, i.e., societal acceptance that is articulated in policy space, and political support, i.e., the political will of political decision makers, are decisive for effective measures to become feasible. Accompanying measures to alleviate fears of negative effects (e.g., lump-sum payments to compensate for loss in purchasing power due to carbon pricing as the ‘Klimabonus’) as well as genuine societal engagement and co-creation approaches (e.g., civil consultation council) yield more effective measures. Together, these measures are likely to enhance the social acceptability of climate policies and remove barriers to changing lifestyles and consumption. {5.1, 5.4, 5.6.3, 8.5.4, 8.6.1}

E.13 Collective action schemes have proven to be effective and stimulate broader and longer-term action when specific preconditions for participation, organization, and integration into overarching policies are met (*high confidence*). Key elements include building a sense of community, empowerment, and trust that goes beyond individual benefits; attracting the widest possible range of participants; integrating collective action with supportive policies; and avoiding the perception of these initiatives as elitist, which could lead to polarization and climate backlash in the wider society. {5.3, Figure 5.4}

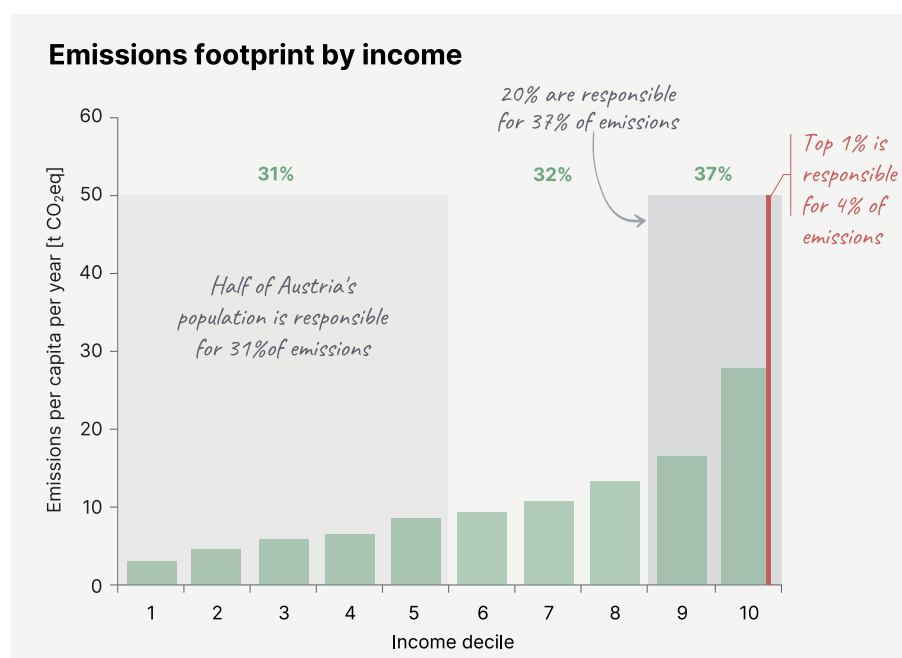


Figure SPM.10 | Distribution of greenhouse gas footprints per capita across Austrian income deciles and the highest percentile (Nabernegg et al., 2023; Theine et al., 2022).

Method Box 5: Social tipping points

The concept of social tipping points refers to certain social norms, behaviors, and technologies that can spread rapidly from a minority group to the majority in society. A tipping point, in both social and natural systems, refers to a critical threshold in the system control parameter. Once this is exceeded by a small amount, the factors mentioned above can influence a crucial system feature of relevance. This leads to qualitative change in the system once a reference time has passed, allowing for the emergence of the effect. For these changes to materialize, they need the support of policies, regulations, technology standards, and infrastructural changes enabling low-carbon lifestyles for all.

E.14 Firms, civil society organizations, and education organizations can foster behavioral change toward climate-friendly lifestyles by providing leadership and implementing change within their organizations (*medium confidence*). For example, collective action can play a significant role as a bottom-up component in the energy transition (e.g., through the formation of energy or sharing communities known as ‘Energiegemeinschaften’) and in adaptation efforts at the local community level. {5.3, 5.4}

E.15 Social tipping elements that can trigger system-wide change in Austria include the higher social status of climate-friendly lifestyles, climate-friendly cities and municipalities, cost reductions for climate-friendly technologies, social movements, and enhanced equity (*limited evidence, medium agreement*). For Austria, eleven areas have been identified where rapid change in greenhouse gas emission reduction is possible along with 14 interventions that are likely to trigger lifestyle changes (e.g., the higher social status of climate-friendly lifestyles). The areas of norms and value changes and energy production and storage show the highest potential. {5.6.2, SPM Method Box 5}

A climate-friendly transformation is achievable and beneficial

E.16 Climate-friendly behavior is associated with improved subjective well-being and crucially depends on comprehensive infrastructure provisioning (*high confidence*). To make low-carbon lifestyles attractive and the preferred options for citizens, and to ensure the long-term effect of such changes, comprehensive changes in the infrastructure are urgently needed in all areas of life (e.g., enabling car-free mobility, especially beyond urban centers). However, such profound changes cannot happen without the support of society, individuals, communities, and different stakeholder groups. Lifestyle changes carry important co-benefits, at the local level in terms of health improvements through, e.g., reductions in air pollution and the promotion of healthier lifestyles (food, mobility choices), and in terms of better mental health. {5.1, 5.2}

E.17 A climate-friendly transformation requires short-term structural adjustments for long-term emission reductions (*high confidence*). Governance models need to assess the feasibility and effectiveness of alternative pathways and steer transitions, balancing short-term goals with long-term needs to avoid privileging the present over the future. {8.5.2, 8.6.1}

E.18 Technological innovation will be crucial to achieving climate targets but over-reliance on technological solutions risks justifying inaction and climate delay (*high confidence*). Enabling a climate-friendly society, economy, and governance architecture requires societal changes that combine pioneering mitigation action with just transition measures and enabling provisioning systems to ensure broad popular support and effectiveness. {8.7}

E.19 Political feasibility critically hinges on the design of policy packages (*robust evidence, medium agreement*). The acceptance of a given policy by the general public and decision makers can be increased when bundles of measures combine popular pull measures (e.g., subsidies) with push measures (e.g., technology standards) that are crucial for effectiveness but unpopular. Feasible and effective bundles to change modes of living as well as provisioning systems consist of adequate institutional changes, up-front public and private investments, and effective instruments. {3.4.2, 8.6, 8.7}

E.20 Redistributive policy instruments, standards, and bans on particularly polluting activities and emission-intensive technologies can help achieve more equitable outcomes (*limited evidence, high agreement*). At least for a transition period, energy prices are likely to rise, reflecting climate policy measures. The social and political feasibility of ambitious climate policy is challenged by these higher prices. While wealthy consumers respond to higher prices by adapting their consumption choices, higher prices are a challenge for low-income households. Policies such as lump-sum transfers like the ‘Klimabonus’ compensate for these price increases and support social cohesion. Restricting the transfers to low-income households would both improve distributional outcomes and have positive macroeconomic effects. {5.1}

E.21 Well-being for all and reduced inequality is achievable by implementing a system-wide transformation that also achieves climate mitigation and adaptation (*medium confidence*). From the provisioning systems perspective, the goal of ensuring well-being and increasing equity can be achieved through high-quality services available to large parts of the population. The transformation needs to be linked to drastically lower energy and resource demands to have positive environmental, social, and economic impacts. {5.2}

E.22 Achieving climate neutrality is feasible and beneficial but requires a clearly defined long-term decarbonization pathway with immediate and far-reaching action across all sectors that ensures broad societal acceptance, balances diverse interests between stakeholder groups, and ensures a just and equitable transition for all (*high confidence*). The transition to a carbon-neutral and climate-resilient society will necessitate a combination of mitigation and adaptation actions, including rapid decarbonization of the energy, transport, and building sectors. A just transition framework is vital to avoid adverse impacts on vulnerable groups, ensure equitable access to opportunities, and balance economic, social, and environmental priorities. Immediate actions are essential to overcome current inertia and align with Austria’s commitments under the Paris Agreement. {5.6.2, 5.6.3, 6.5, 6.7, 8.3.1, 8.4.5, 8.6}

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