



1.5°C Pathways for the Council of Europe: accelerating climate action to deliver the Paris Agreement

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Supplementary material

A digital copy of this report is available at: www.climateanalytics.org/publications.

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About Climate Analytics

Climate Analytics is a non-profit institute leading research on climate science and policy in relation to the 1.5°C limit in the Paris Agreement. It has offices in Germany, the United States, Togo, Australia, Nepal and Trinidad and Tobago.



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Executive summary

Global action remains insufficient to meet the Paris Agreement's long-term temperature goal. Increasing the ambition of 2030 climate targets and accelerating emissions reductions in this decade are essential. This report presents technically feasible 1.5°C compatible energy and emissions pathways for the group of countries that make up the Council of Europe (CoE), and assesses whether CoE member states' current 2030 climate targets (the Nationally Determined Contributions, NDCs) are collectively aligned with limiting warming to 1.5°C.

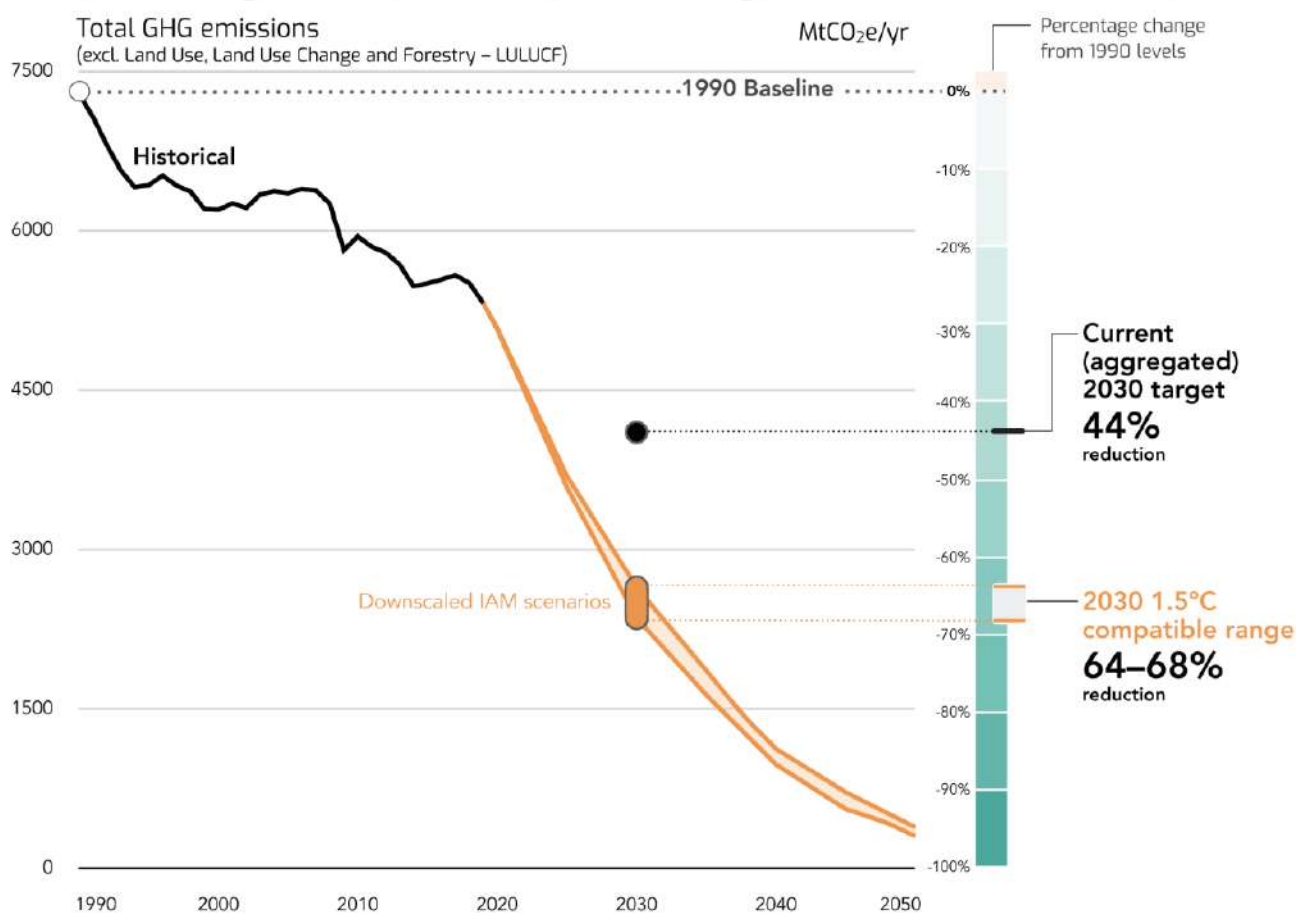
The report finds that, to be 1.5°C compatible, CoE member states would need to cut their domestic emissions faster than currently planned. Pathways compatible with 1.5°C and filtered to meet sustainability constraints were analysed in this report. These pathways show that countries within the CoE can feasibly:

- Reduce their collective greenhouse gas (GHG) emissions between **63–68% below 1990 levels** excl. land use, land use change and forestry (LULUCF). Assuming the minimum LULUCF sink within the CoE region, this corresponds to a **68–73% reduction by 2030, relative to 1990 levels**.
- Reach net zero GHG emissions between **2041–2054**.
- Limit their total cumulative CO₂ emissions to **27–35 GtCO₂** from 2020 until mid-century (incl. LULUCF).

If each CoE member state achieved its current individual 2030 NDC target, the total mitigation effect would be a **44% reduction of emissions below 1990 levels**. Our analysis therefore suggests that the current 2030 mitigation ambition of the CoE region cannot be seen as compatible with 1.5°C. There is an **emissions gap of 1457–1746 MtCO₂e in 2030** between the CoE member states' aggregated NDCs and 1.5°C compatible domestic pathways.

The report also demonstrates how CoE member states could achieve these 1.5°C compatible benchmarks through a rapid transition to an efficient energy system powered by renewable energy sources. It focuses on three illustrative pathways, the HighRE, SSP1 and SusDev scenarios. All three are downscaled versions of Integrated Assessment Model (IAM) pathways taken from the IPCC's latest assessment report (AR6). They represent different possible 1.5°C compatible futures: the HighRE scenario focuses on renewables deployment and electrification, the SSP1 scenario represents a world in which there are broader shifts towards a more sustainable and equitable society, and the SusDev scenario explicitly focuses on meeting the sustainable development goals alongside the 1.5°C goal. This diversity of pathways improves the robustness of the report's results.

Europe must significantly increase pace of energy transition to be 1.5°C compatible



This figure shows domestic 1.5°C compatible GHG emissions for the CoE region, compared to the expected pathway under the current aggregated Nationally Determined Contribution (NDC) of CoE member states. The CoE's combined NDCs do not currently align with 1.5°C, as assessed in this report. These emissions pathways do not include LULUCF emissions, which could enable all CoE member countries to reach net zero GHG emissions by as early as 2041. Historical data from PRIMAP (Gütschow, Günther, and Pflüger 2021).

In the analysed pathways, electricity provides **57–66%** of final energy in 2050. There are also strong and sustained reductions in final energy demand, which means that by 2050, total energy demand in the CoE region can be up to **45%** lower than in 2019. Overall, renewables provide **39–46%** of final energy demand in 2030, rising to **82–91%** by 2050.

Fossil fuels are rapidly displaced from the energy system in 1.5°C compatible pathways for the CoE area. In the most ambitious pathways, coal is phased out of the energy system by **2030**, and fossil gas by **2050** at the latest. Although residual oil demand remains in 2050, this is concentrated in non-energy demand in the transport, industry and aviation sectors.

Synthetic fuels and feedstocks (which are not represented in the illustrative pathways) could further reduce oil consumption in these sectors.

There is a particularly strong action in the power sector, where rapid deployment of wind and solar is the cornerstone of the energy transition. Key milestones for the power sector in these illustrative pathways include:

- Coal phased out of power generation **by 2030** and fossil gas by the **mid-2030s**
- A **99%** fossil fuel free electricity mix by **2035**
- Electricity generation **more than doubling** by **2050**

In addition to strengthening domestic climate action, rich member states of the CoE (e.g., the EU27, United Kingdom, and Switzerland, among others) also have an obligation, under the fair share and equity considerations embedded in the Paris Agreement, to assist less wealthy countries to accelerate sustainable economic development and take climate action. Without such assistance, the global effort required to limit warming to 1.5°C could be distributed unfairly and will likely not be enough.

It is clear that member states of the CoE can do more to align with the Paris Agreement's 1.5°C target and provide global leadership on the climate crisis. By providing updated NDCs that collectively cut emissions by at least 68% (incl. LULUCF) by 2030, by committing to fossil-free electricity by the mid-2030s, and by rapidly reducing demand for fossil fuels, CoE countries can drive ambitious climate action and help keep 1.5°C alive.

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1 Introduction

Achieving the Paris Agreement's long-term temperature goal requires rapid, large-scale, and sustained reductions in global greenhouse gas (GHG) emissions. The latest report from the Intergovernmental Panel on Climate Change (IPCC) found that, in pathways which limit warming to 1.5°C with no or low overshoot, global GHG emissions fall 43% by 2030 relative to 2019, and CO₂ emissions reach net zero around mid-century (IPCC 2022). Achieving such transformative change requires ambitious leadership from every country in the world.

To date, this leadership is still lacking at a global level. The world is not on track to limit warming in line with the Paris Agreement's long-term temperature goal. Current 2030 targets, or Nationally Determined Contributions (NDCs), put the world on a path to approximately 2.4°C of warming by 2100, if fully implemented (Climate Action Tracker 2021a). This is almost a full degree above the 1.5°C limit. It is essential that governments substantially strengthen their NDCs and take action to achieve greater emissions reductions by 2030. At COP26 in Glasgow, the parties to the Paris Agreement acknowledged this, and agreed to 'revisit and strengthen' their pledges in advance of COP27 in Egypt (UNFCCC 2021). At the same time, Russia's invasion of Ukraine has further highlighted the benefits of energy independence and the need to rapidly reduce fossil fuel consumption.

In this context, every country should re-assess their climate targets in the run-up to COP27, considering whether their current action is aligned with 1.5°C, and if not, take steps to close the ambition gap. This report provides such information for the Council of Europe (CoE). It assesses whether the current objectives of CoE member states, as submitted by each country in the form of their NDC, are collectively sufficient to meet the objectives of the Paris Agreement.

The Council of Europe is an international organisation that was founded in the wake of World War II to uphold human rights, democracy and the rule of law in Europe. It is a separate entity to the European Union (EU). The CoE is comprised of 46¹ member states (Figure 1), of which 27 countries are within the EU, with a combined population of around 675 million people. The Statute of the Council of Europe, Article 1(a), states that the aim of the CoE is: "[...] to achieve a greater unity between its members for the purpose of safeguarding and realising the ideals and principles which are their common heritage and facilitating their economic and social progress." (Council of Europe). As an international organisation, the CoE does not have the power to formulate laws, but it can establish and enforce international agreements, such as the European Convention on Human Rights. Although the CoE views climate change as among "the most serious" problems it faces today, it currently has no binding agreements on climate or the environment at the Council of Europe level, despite numerous calls to do so (ENNHRI 2021).

Even so, nations within the CoE have a critical role to play in the transition to a zero-carbon future, given that it is host to a number of advanced economies with a historical responsibility for climate change and economic and regulatory capacity to address it. CoE states should reduce their domestic emissions in line with the highest plausible ambition. Moreover, countries in the CoE have an important role in equitable global transitions and should provide climate finance to developing countries to circumvent high carbon growth. While the focus of this report is on aggregated impact of emissions targets of the CoE (NDCs), CoE member states will also need to increase their support for climate action in developing nation to contribute its "fair share" target.

¹ There were previously 47 states in the Council of Europe. However, the Russian Federation was removed from the CoE on 16 March 2022 following its illegal invasion of Ukraine.

The report uses the latest evidence from the IPCC (Byers et al. 2022), as well as other lines of scientific evidence, to explore 1.5°C compatible action for the CoE. The analysis focuses on four main milestones: 1) the level of emissions reduction by 2030; 2) the date of net zero GHGs; 3) the transition in final energy demand; and 4) the transition to a decarbonised electricity sector. A range of 1.5°C compatible benchmarks can be derived at the CoE level.

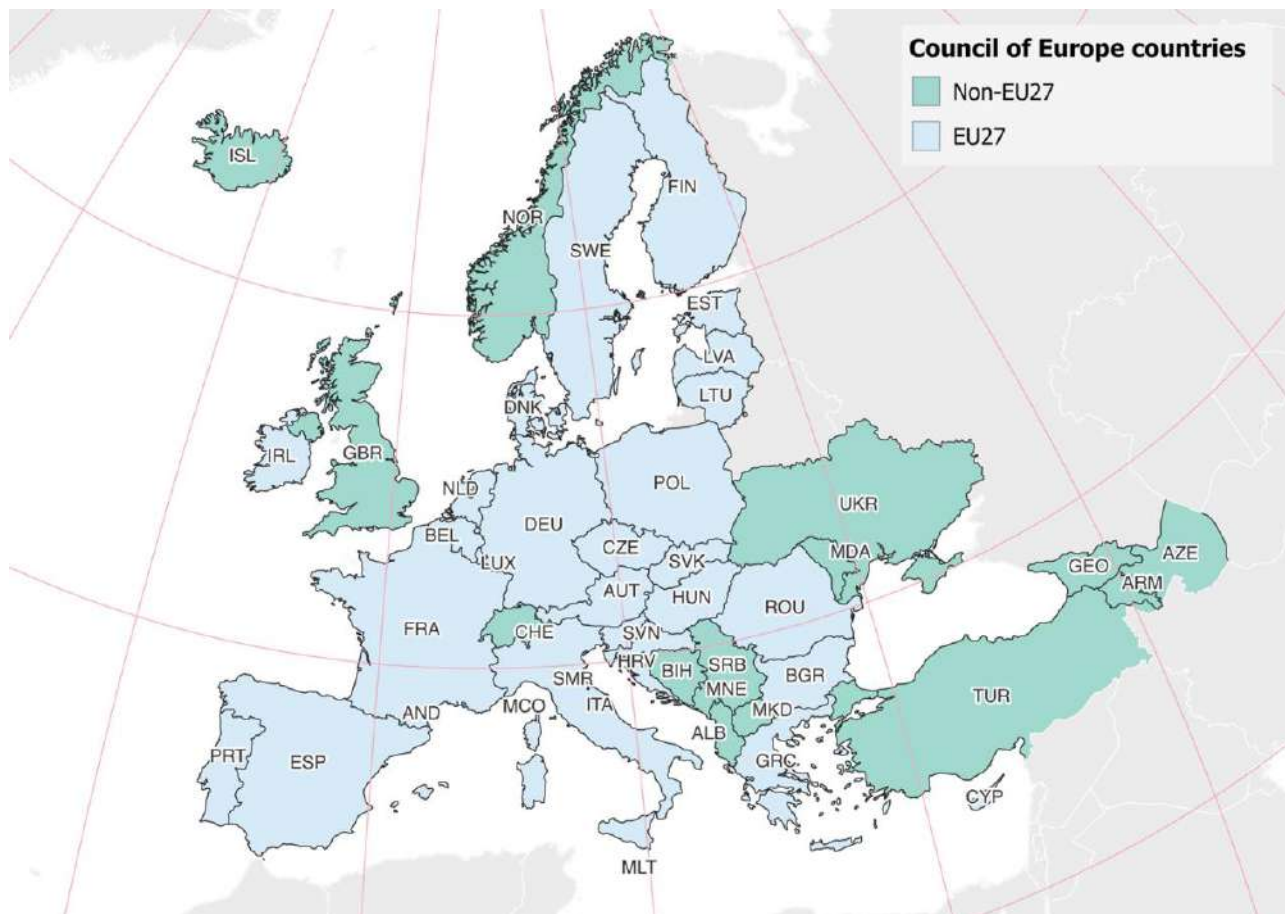


Figure 1: A map of the Council of Europe (CoE), also showing member states of the EU27.

This report shows that CoE countries can considerably increase the ambition of their individual 2030 NDCs. In pathways consistent with the highest plausible ambition for the CoE, emissions fall 63–68% below 1990 levels by 2030 (excl. LULUCF). The current NDC targets collectively fall short of 1.5°C compatible pathways by 1432–1723 MtCO_{2e} in 2030 (excl. LULUCF). Our analysis shows that there remain technically feasible routes to higher near-term action. In particular, by rapidly reducing the use of fossil fuels, while preserving and expanding the LULUCF sink, net zero GHG emissions could be reached by 2041 in the CoE area.

The pathways assessed in this report involve a rapid upscaling of renewable energy technologies over the coming decades, with wind and solar the cornerstone of the energy transition. The CoE achieves 99% fossil-free electricity mix by 2035 in these pathways. The transition to a more electrified and efficient energy system, coupled with behavioural and societal change, leads to strong reductions in final energy demand. This enables the rapid phase-out of fossil fuels from the energy system, with renewables providing 39–46% of final energy demand by 2030 and 82–91% of final energy demand in 2050. This demonstrates that CoE countries can still align themselves with the Paris Agreement’s 1.5°C limit, but they need to take strong action in this decade.

2 Latest mitigation pathways consistent with the 1.5°C temperature limit

2.1 The goal of the Paris Agreement

In 2015, countries adopted the Paris Agreement. Article 2.1 of the Paris Agreement commits signatories to “[...] strengthen the global response to the threat of climate change [...], including by holding the increase in the global average temperature to well below 2°C [...] and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels” (UNFCCC 2015).

Article 4.1 of the Paris Agreement outlines key elements that would enable the achievement of this long-term temperature goal (LTTG), including:

- To “reach global peaking of greenhouse gas emissions as soon as possible”
- To “undertake rapid reductions thereafter in accordance with best available science”
- To “achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century”

The Agreement establishes a mandatory requirement for all parties to take action to contribute to the reduction of global greenhouse gas emissions. It further affirms that action taken for implementation should “reflect equity and the principle of common but differentiated responsibilities and respective capabilities (CBDR)”.

Therefore, in order to make a fair contribution to meeting the Paris Agreement’s goals, developed countries need to both reduce emissions domestically and assist developing countries to reduce their emissions through both financial and technological transfers. A developed country’s total “fair share” action range is the total sum of domestic reductions plus support for emission reductions overseas (Climate Action Tracker, 2018).

2.2 Highest plausible ambition

A variety of equity principles can be used to distribute global climate effort across different countries and regions. The pathways considered in this report do not align with a particular equity principle, but instead use the concept of “highest plausible ambition”. For the CoE, we define this as 1.5°C compatible pathways that are technically and economically feasible, that demonstrate the steepest near-term domestic GHG emissions reductions and that do not violate sustainability criteria as laid out in Section 2.3. Where these derived pathways are not aligned with the CoE members’ “fair share” climate action, then they would need to either outperform these pathways (by taking further action that has not been considered in this analysis) or increase the provision of finance to support climate action in less wealthy countries (Climate Action Tracker 2022a). However, we do not extend our analysis to evaluate the fairness of the derived pathways in this report.

2.3 Deriving 1.5°C compatible pathways for the CoE region

2.3.1 AR6 scenarios

This report uses three global 1.5°C compatible pathways to assess the CoE’s role in addressing climate change, all of which are derived from the IPCC’s Sixth Assessment Report (AR6) based on the findings of the Working Group III on Mitigation of Climate Change. All three scenarios are produced by the REMIND Integrated Assessment Modelling (IAM) framework (Luderer et al. 2020), and are briefly summarised in Table 1.

Table 1: 1.5°C compatible scenarios selected for analysis. The SSP1 scenario was produced by Baumstark et al (2021); the SusDev by Soergel et al (2021); and the HighRE by Luderer et al. (2021).

Model	Scenario	Abbrev.	Description
REMIND 2.1	R2p1_SSP1-PkBudg900	SSP1	A global scenario that limits warming to 1.5°C with no/low overshoot. This scenario uses the SSP1 socio-economic pathway, representing a more sustainable future in which there is reduced consumption, greater equity, and continued progress in low-carbon technologies.
REMIND-MAgPIE 2.1-4.2	SusDev_SDP-PkBudg1000	SusDev	A global scenario that limits warming to 1.5°C with no/low overshoot. This scenario has an explicit focus on achieving the SDGs via sufficient and healthy nutrition, improved access to modern energy in the developing world, and ambitious lifestyle shifts in industrialised countries.
REMIND-MAgPIE 2.1-4.2	DeepElec_SSP2 HighRE_Budg900	HighRE	A global scenario that limits warming to 1.5°C with no/low overshoot. This scenario displays highly ambitious near-term emissions reductions, underpinned by high renewable deployment.

The AR6 report provides the most comprehensive assessment to date of greenhouse gas (GHG) emissions pathways which reduce emissions in line with the Paris Agreement (Riahi et al 2022). It provides the results from a wide range of quantitative, model-based scenarios, presenting a diversity of possible low-carbon futures.

The AR6 scenario database contains a total of 3034 quantitative scenarios, which map transformation pathways for key sectors such as energy, transportation, industry, and land use, under varying patterns of socio-economic development and levels of GHG reductions. For this report, we filter the entire AR6 ensemble based on the following criteria: 1) pathways should limit warming to 1.5°C with “no or low overshoot”; 2) pathways should be consistent with Article 4.1 of the Paris Agreement; 3) pathways should limit use of carbon dioxide removal (CDR) technologies; and 4) pathways should reflect the “highest plausible ambition”. The process of filtering the scenarios is illustrated by Figure A1 and is detailed in Section 2.3.2.

2.3.2 Scenario filtering

Firstly, we remove specific sector and country-level pathways from the AR6 ensemble as their focus falls outside of the scope of this report, which provides 2304 scenarios for further analysis. We then filter these scenarios to obtain only those pathways that limit warming to 1.5°C with *no or low overshoot*. This means they have:

- More than a 33% chance of limiting warming to below 1.5°C throughout the 21st century, and;
- At least a 50% chance of limiting warming to below 1.5°C in 2100.

There are 97 such pathways in the AR6 scenario database. The majority of these pathways are simultaneously very likely (>90% chance) to limit warming to 2°C. They are therefore consistent with the long-term temperature goal as set out in Article 2.1 of the Paris Agreement (Schleussner et al. 2022). Each pathway reflects a unique set of economic and technological developments that achieves this temperature goal.

As well as the temperature goal of holding warming “well below 2°C” and pursuing efforts to limit warming to 1.5°C”, Article 4.1 of the Paris Agreement sets out an objective to achieve a balance between anthropogenic emissions by sources and sinks in the second half of the century. This represents a commitment to achieving net zero GHG emissions at a global level, in line with the best available science. We apply this second filter, which removes another 48 scenarios. This leaves a set of 49 pathways for further analysis, which are consistent with both Article 2.1 and Article 4.1 of the Paris Agreement (Schleussner et al. 2022).

Of these 49 “Paris compatible” pathways, we apply a further filter to select pathways which limit the use of carbon dioxide removal (CDR) to sustainable levels, using sustainability thresholds from the literature (Fuss et al. 2018). This means they deploy less than 5GtCO₂/y of bioenergy with carbon capture and storage (BECCS) in 2050, and under 3.6GtCO₂/y of afforestation/reforestation in the second half of the century. In total, 31 scenarios fail this condition, leaving 18 pathways for further analysis.

Finally, to represent the “highest plausible ambition” for the CoE area, we then filter to select pathways in which the emissions of the European macro region fall by at least 62% in 2030, relative to 1990. This represents the upper quartile of the distribution in terms of emissions reductions by 2030 and ensures that selected pathways show a transformative pathway towards a decarbonised energy system and identify what could be described as the highest plausible domestic ambition for the CoE area. This final filter provides two pathways, which are compatible with the Paris Agreement, use sustainable levels of CDR, and demonstrate the highest plausible ambition for Europe². These are: **R2p1_SSP1-PkBudg900** (termed “SSP1” in the rest of the report), **SusDev_SDP-PkBudg1000** (described as “SusDev” in this report).

² The scenario filtering actually provides three scenarios. However, one of these was identified as a duplicate and was dropped, leaving two pathways for analysis.

We complement these two pathways with the REMIND-MAgPIE scenario **DeepElec_SSP2_HighRE_Budg900** (described as “HighRE” in this report). This scenario fails the second filter shown by Figure A1 because it does not reach net zero GHG emissions globally by 2100. It is therefore not fully compatible with Article 4.1 of the Paris Agreement. However, it remains a valuable scenario for the following reasons:

- It still undertakes ambitious emissions reductions compatible with limiting warming to 1.5°C and holding warming to ‘well below’ 2°C.
- Until the mid-2040s, this scenario is more ambitious than either of the SSP1 and SusDev scenarios, at both a global and European level. It is only post-2050 that the HighRE scenario displays slower emissions reductions, which prevent it from reaching net zero GHG emissions at a global level.

The HighRE scenario demonstrates the feasibility of rapidly reducing emissions by relying on renewables. While it does not reach net zero GHG emissions by 2100, the rapid decarbonisation of the energy system by 2050 means this scenario would be well-placed to achieve net zero GHG emissions, if so desired. For example, it could achieve this while still deploying *less* CDR than the SSP1 scenario, or by achieving comparable non-CO₂ emissions reductions as observed in the SusDev scenario. It remains a valuable scenario for analysis, particularly when the timescale of analysis is focused on the pre-2050 period.

2.3.3 Description of the SSP1, SusDev and HighRE scenarios

The REMIND (REgional Model of INvestment and Development) model is an integrated assessment model with a special focus on the development of the energy sector and its climate implications (Luderer et al. 2020). REMIND can be coupled with the global land-use model MAgPIE (Model of Agricultural Production and its Impact on the Environment) (Dietrich et al. 2018), or run as a standalone energy-economy model.

The goal of REMIND is to find the optimal mix of investments in the economy and energy sectors of each modelled region given a set of population, technology, policy, and climate constraints. REMIND is an energy-economy general equilibrium model that links a macro-economic growth model with a bottom-up engineering-based energy system model. The macro-economic growth model projects growth, savings and investments, factor incomes, energy, and material demand, while a nested production function with constant elasticity of substitution determines the final energy demand. For a full discussion of the model, see (Baumstark et al. 2021). REMIND disaggregates the world into eleven “macro regions”, including the Europe region and the Reforming Economies region, from which the CoE pathways for this project are derived (Described in Section 2.3.4).

The three IAM scenarios used in this report are all derived from the REMIND modelling framework. Each scenario provides a different perspective on how the world could limit warming to 1.5°C. This diversity of possible low-carbon futures highlights the multiple possible actions the global community could take to reduce emissions.

The **SSP1** scenario (Baumstark et al. 2021) uses the underlying shared socio-economic pathway SSP1, which represents a shift to a more sustainable society (Riahi et al. 2017; van Vuuren, Stehfest, et al. 2017). In this scenario, there is moderate progress towards the Sustainable Development Goals (SDGs). Greater access to education, healthcare and modern energy leads to improved equality within

and between regions. As well as development progress, there are some shifts which help enable stronger climate action in this scenario. These include changes in consumption patterns towards low material growth, and greater progress in resource and energy efficiency. This therefore represents a future in which climate action occurs alongside broader progress towards sustainable development.

The **SusDev** scenario (Soergel et al. 2021) builds on the SSP1 scenario, envisaging further changes which help achieve the SDGs. As well as an SSP1 socio-economic set-up, there is a global shift in dietary habits to reduce meat consumption (Willett et al. 2019), which reduces pressure on land and enables zero malnutrition to be achieved by 2050. High-income countries further reduce their energy demand, while in lower-income countries energy demand grows rapidly to enable decent living standards to be achieved by all. The SusDev scenario demonstrates particularly large cuts in non-CO₂ emissions, as the shift to sufficient, healthy and sustainable diets leads to reduced CH₄ and N₂O emissions. As a result, the scenario cuts CO₂ emissions at a slightly slower pace.

The **HighRE** scenario (Luderer et al. 2021) uses the shared socio-economic pathway SSP2, which is a middle-of-the-road scenario (Fricko et al. 2017). In this scenario, social, economic and technological trends do not shift markedly from historical trends. This leads to higher overall energy demand, and therefore the scale of the decarbonisation challenge is greater. The HighRE scenario explores the potential for a highly-electrified future energy system. In this scenario, the rapidly declining cost of wind and solar, coupled with progress on battery storage, flexible hydrogen generation and demand response leads to large-scale deployment of renewables and electrification of end-use sectors.

2.3.4 Scenario downscaling

The three IAM pathways do not provide energy and emissions data at the CoE level, but for a larger geographical region. The pathways disaggregate the globe into eleven “macro regions”, which represent groupings of countries in similar regions of the world. The Council of Europe contains countries which are included within two of these macro regions: Europe and the Reforming Economies. The European macro region is a grouping of 45 European countries, including the EU27 as well as a range of non-EU countries such as Norway, Switzerland and the United Kingdom. 41 of the 46 CoE member states are included in the European macro region. The Reforming Economies macro region consists of Russia and a range of former Soviet states. Five CoE member states are included in this region: Ukraine, Moldova, Armenia, Azerbaijan and Georgia.

A downscaling process disaggregates coarse resolution data to a finer spatial scale. In this case, the IAM pathways for the European and Reforming Economies macro regions were downscaled to the national level. This is performed using the SIAMESE (Simplified Integrated Assessment Model with Energy System Emulator) tool (Sferra et al. 2019a). SIAMESE allocates energy consumption to individual countries within a given macro region by equating marginal fuel prices across all countries. This is equivalent to maximizing welfare in the macro region as a whole, providing a cost-effective allocation of energy demand and emissions across the underlying countries. Once the Europe and Reforming Economies data had been downscaled to the national level, this could then be summed to provide an aggregate energy and emissions pathway for the CoE. For more details, see Appendix B.

2.3.5 Emissions from the land use, land use change, and forestry (LULUCF) sector

The land use, land use change, and forestry (LULUCF) sector covers CO₂ emissions from a range of human activities in the land use sector, including from forests, croplands, grasslands and wetlands. The LULUCF sector can either be a source of emissions (e.g., via deforestation or peatland degradation), or a sink that removes CO₂ from the atmosphere and stores it in the biosphere (e.g., via ecosystem restoration and afforestation). As such, the LULUCF sector has an important role to play in the mitigation of climate change.

Table 2: Emissions by the land use, land use change, and forestry (LULUCF) sector in 2030 and 2050, as projected in the literature for seven key countries / regions in the Council of Europe.

Net LULUCF emissions (MtCO ₂)					
Region	2030		2050		Source
	Min	Max	Min	Max	
EU27	-225*	-570	-225*	-780	(Böttcher et al. 2021)
Norway	-24	-24	-24	-24	(Norwegian Ministry of Climate and Environment 2019)
Switzerland	+2	-2	+2	-1	(UNFCCC 2020)
Turkey**	-39	-70	-39	-70	(UNFCCC 2019)
Ukraine	-50	-54	-44	-54	(UNFCCC 2017)
United Kingdom	-4	-10	-7	-38	(CCC 2020)
Rest of CoE***	-4	-4	-4	-4	(ClimateWatch 2022)
TOTAL	-334	-734	-341	-971	

*Maximum allowed under European Climate Law.

**Emissions in 2050 assumed the same as 2030 due to a lack of data.

***Assumed the same as the historical sink due to lack of data. This assumption would have a negligible impact on the results of our analysis given that the emissions share of the remaining CoE region is less than 1% of the total CoE LULUCF emissions.

The downscaled pathways used in this report do not incorporate LULUCF emissions, and therefore separate assumptions are made for emissions from this sector. By combining data from downscaled IAM pathways and LULUCF emissions, we can estimate the economy-wide decarbonisation achieved through policy interventions before and after the LULUCF sink is included.

In this report, we compile forecasts of LULUCF emissions across six key countries/regions in the CoE area, which are: Turkey, Norway, Ukraine, Switzerland, United Kingdom, and the EU27. We focus on these areas for three main reasons:

- Emissions by the LULUCF sector in these six regions make up the majority of LULUCF emissions in the CoE (>98%).
- These six regions contribute the dominant share of total greenhouse gas emissions by the CoE (~95%).

- Data on projected LULUCF emissions can be difficult to obtain and is associated with a high degree of uncertainty. However, due to their high GHG emissions, these six regions are relatively better studied and more data is available on their estimated future LULUCF emissions.

Projections of future emissions by the LULUCF sector are collected for the six regions from a literature review. To account for uncertainty in future LULUCF emissions, we calculate a minimum and maximum value of the sink in 2030 and 2050 for each region, where available. For the remaining CoE countries, we assume that the size of the LULUCF sink remains the same as the historical data. This assumption is made under the lack of data, but it would have a negligible impact on the results of our analysis since the LULUCF emissions of these countries make up a relatively small portion of the total emissions by the CoE (~1%). Table 2 shows the assumed net LULUCF emissions values in 2030 and 2050 by region, as well as the sum of emissions calculated. These estimates of projected net LULUCF emissions are used in this report to convert 1.5°C compatible emissions levels excluding LULUCF into economy-wide emissions data that covers all sources and sinks.

We note here that all of the assumptions based around Ukraine in this report are on the basis of their most recent climate assessments and publications (e.g., Ukraine's 2021 updated NDC). These analyses were published before the illegal Russian military invasion in the country. We are using these analyses nonetheless to demonstrate the Ukrainian government had plans to combat climate change and transition to a low-carbon economy. Once peace is restored in Ukraine, it will need international support to build a Paris compatible economy, in addition to very large reconstruction and humanitarian needs.

3 1.5°C compatible mitigation pathways for the CoE region

3.1 Current targets and policy context

Greenhouse gas (GHG) emissions by CoE countries have been declining gradually since 1990, when measured on a territorial basis (this excludes the emissions associated with the CoE’s consumption of imported goods). In 1990, GHG emissions (excl. LULUCF) stood around 7281 MtCO_{2e}. This declined to 5310 MtCO_{2e} by 2019, equivalent to a 27% reduction (Figure 2). Emissions fell significantly in 2020 during the COVID-19 pandemic due to reduced energy demands and associated emissions. However, it appears highly likely that emissions rebounded in 2021 as shuttered portions of the economy began opening up (Friedlingstein et al. 2021). There are significant opportunities to align COVID-19 recovery packages with more ambitious climate action.

Table 3: Total GHG emissions in six key regions in the Council of Europe from 1990, as well as the projected reductions in 2030 through NDC commitments (excluding LULUCF).

Emissions (MtCO _{2e})		
Region	1990	2030 (NDC excl. LULUCF)
EU27	4871	2246 (-54%)
Norway	51	25 (-53%)
Switzerland	54	37 (-31%)
Turkey	220	999 (+354%)
Ukraine	943	322 (-66%)
United Kingdom	791	254 (-68%)

*Calculated as the sum of NDC emission reductions in 2030 in all seven regions.

Note: The number in the parenthesis shows the percentage change relative to 1990 values. The 2030 NDC for the Rest of CoE was calculated using analysis from the Net Zero Tracker group (Net Zero Tracker 2022), while all others were obtained from the Climate Action Tracker (Climate Action Tracker 2022b).

The spatial distribution of emissions in the CoE differs significantly (Figure B1). The EU27 represents the major source of emissions in the grouping, accounting for 61% of CoE emissions in 2019. The CoE is a grouping of independent countries, and does not set coordinated targets or policies to reduce GHG emissions at the level of the CoE (as in the case of the EU27). However, all CoE member states commit to work together on a range of issues of common concern. This includes environmental protection and climate action. Individual member states of the CoE all submit Nationally Determined Contributions (NDCs) following the process of the United Nations Framework Convention on Climate Change (UNFCCC). It is therefore possible to calculate an “aggregated NDC” for the CoE by combining the mitigation target of each individual member state.

For the six key regions identified in Section 2.3.5 (Turkey, Norway, Ukraine, Switzerland, United Kingdom, and the EU27), we obtained NDC emissions reductions from the Climate Action Tracker (CAT) (Climate Action Tracker 2022b). For each of these countries, the CAT provides a 2030 GHG emissions estimate based on the targets within the country’s NDCs, which excludes emissions by

the LULUCF sector. Meanwhile, for the remaining CoE countries (not in the CAT database), the 2030 NDC emission reduction was calculated based on data published by the Net Zero Tracker group (Net Zero Tracker 2022), which is detailed in Appendix D1. The aggregated NDC is then calculated as the sum of 2030 NDC reductions across the seven regions (The aggregated NDC shows the CoE’s emissions would reach 4095 MtCO_{2e} in 2030, if all member states achieved their NDC targets (excl. LULUCF). This is equivalent to an emissions reduction of 44% relative to 1990 levels.).

The aggregated NDC shows the CoE’s emissions would reach 4095 MtCO_{2e} in 2030, if all member states achieved their NDC targets (excl. LULUCF). This is equivalent to an emissions reduction of 44% relative to 1990 levels.

Europe must significantly increase pace of energy transition to be 1.5°C compatible

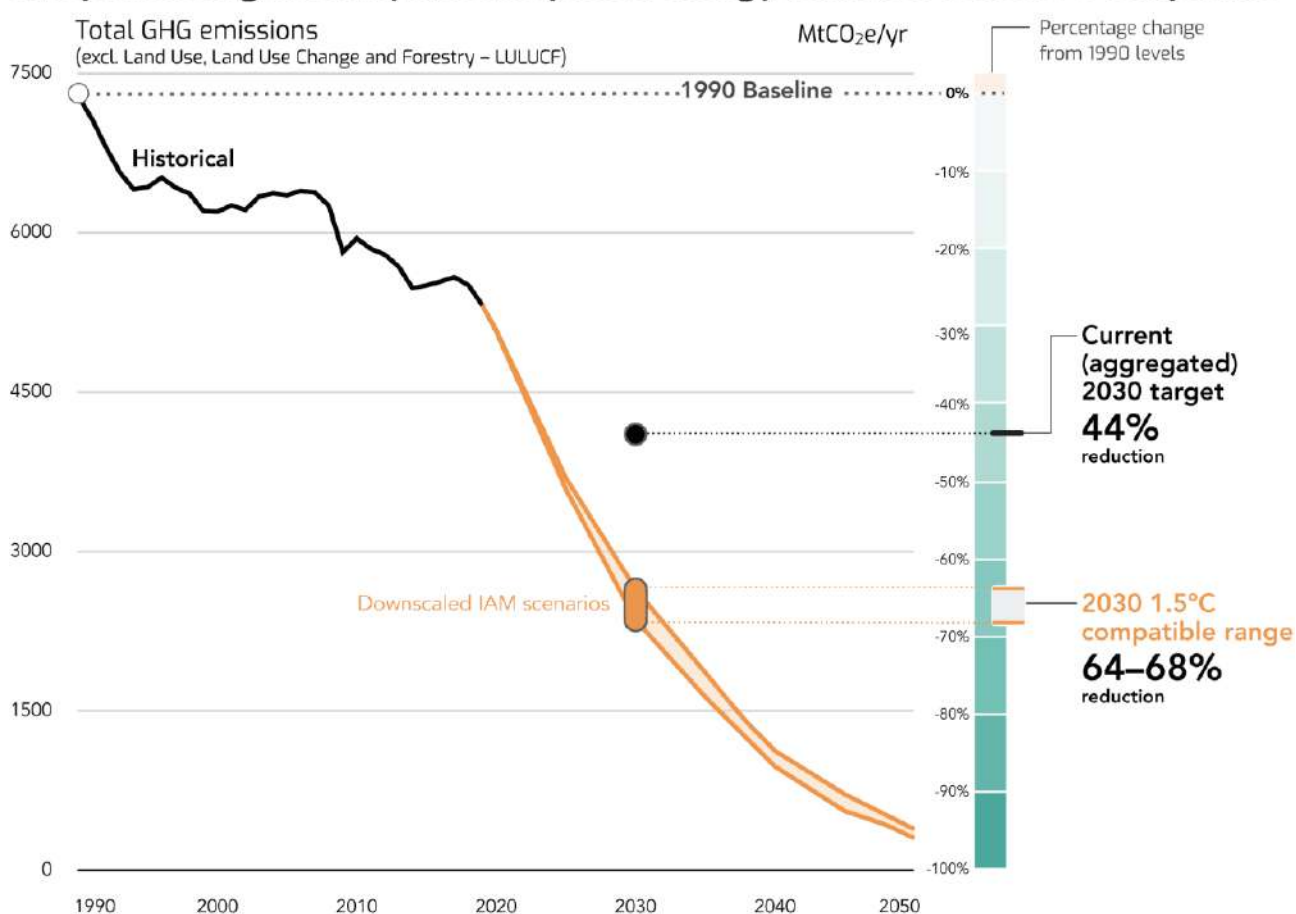


Figure 2: Economy-wide domestic 1.5°C compatible greenhouse gas emissions pathways for the Council of Europe (CoE).

This figure shows domestic 1.5°C compatible GHG emissions for the CoE region, compared to the expected pathway under the current aggregated Nationally Determined Contribution (NDC) of CoE member states. The CoE’s combined NDCs do not currently align with 1.5°C, as assessed in this report. These emissions pathways do not include LULUCF emissions, which could enable all CoE member countries to reach net zero GHG emissions by as early as 2041. Historical data from PRIMAP (Gütschow, Günther, and Pflüger 2021).

3.2 Emissions pathways and the adequacy of climate targets in the CoE

In the 1.5°C compatible scenarios assessed in this analysis, total GHG emissions reach 64–68% below 1990 levels in 2030 (excl. LULUCF). The combined effect of the current NDCs of CoE states result in a total emissions reduction of 44% to 2030 (4095 MtCO_{2e}), and therefore fall considerably short of this range. There is an emissions gap of between 1457 and 1746 MtCO_{2e} (20–24%) in 2030 between the current combined NDCs and the 1.5°C compatible scenarios assessed in this report. The EU27's recently announced actions in the REPowerEU plan, could go some way to closing this gap, but there would remain a substantial ambition gap of around 1195 and 1515 MtCO_{2e} in 2030. Further action would be needed from the EU27 and other CoE member states, for the all of the CoE's targets to be deemed 1.5°C compatible.

There are technically feasible routes for CoE countries to cut emissions much faster than current targets in their NDCs. Member states of the CoE would need to strengthen their NDCs to be considerably more ambitious to close the emissions gap to 2030 and align with the Paris Agreement. Table 4 highlights what a 1.5°C compatible emissions level in 2030 would entail for the CoE, based on the IAM pathways analysed here, and these are compared against the Council of Europe's current combined NDC target.

Table 4: Emissions reductions to 2030 assessed for 1.5°C compatible scenarios and compared against the Council of Europe members' current Nationally Determined Contributions (NDCs).

Emissions reductions 2030 (relative to 1990 levels)		
Scenario	Excluding LULUCF	Including LULUCF
HighRE	68%	71–72%
SusDev	64%	67–68%
SSP1	63%	66–67%
Current aggregated NDC of the CoE	44%	47–48%

For CoE countries, actions that are compatible with 1.5°C pathways require not only rapid reductions in emissions to 2030, but also continued decarbonisation after 2030. In the IAM pathways assessed here, total GHG emissions reach 95–96% below 1990 levels in 2050 before plateauing to near zero around 2060–2065 (excluding LULUCF). In other words, the CoE region would achieve net zero in 2065 at the latest, excluding LULUCF. However, the date of net zero would be substantially earlier when accounting for LULUCF emissions.

The scale of the future LULUCF sink in the CoE region is uncertain, and is itself subject to climate change impacts. A range of scenarios suggest that it could be increased from its current levels³. If the minimum LULUCF sink estimated by the literature is achieved, the CoE region could reach net zero between 2051 and 2054. However, under the maximum LULUCF sink, the date of net zero could be brought forwards by up to thirteen years, to between 2041–2043. Expanding the LULUCF sink can help CoE countries cut emissions faster, reach net zero GHG emissions sooner, and further

³ Although in some countries (e.g., Switzerland) it could decrease depending on LULUCF policies (Table 2)

limit their total contribution to global warming. Table 5 shows the date of net zero GHG emissions by scenario, depending on the size of the LULUCF sink.

There is a finite carbon budget remaining if warming is to be limited to 1.5°C. To do so with a 50% likelihood, global emissions from 2020 onwards need to be limited to 500 GtCO₂ (IPCC 2021). In the 1.5°C compatible pathways assessed here, cumulative CO₂ emissions from 2020 to 2050 (excluding LULUCF) are 40-48 GtCO₂. If the minimum LULUCF sink from the above sources is included, then the combined carbon budget of CoE countries from 2020–2050 would be 27–35 GtCO₂.

These budget calculations assume that CoE countries take 1.5°C compatible action from 2020 onwards. In reality, this has not occurred, and even if more ambitious 2030 targets were set by each CoE member state, it would take time for policies to be developed and emissions to be reduced in the real economy. As immediate alignment with 1.5°C compatible emissions pathways is not possible, the CoE’s cumulative CO₂ emissions will likely exceed these numbers to some extent. However, they demonstrate that the 1.5°C aligned carbon budget for the CoE is very small. The current NDCs are not compatible with limiting warming to 1.5°C, and so CoE countries would need to reduce cumulative emissions much further to align with the Paris Agreement.

Table 5: Date of net zero GHG emissions for the Council of Europe by scenario based on different projections of net emissions in the LULUCF sector.

Date of net-zero GHG emissions		
Scenario	Minimum LULUCF sink	Maximum LULUCF sink
2019	2054	2041
HighRE	2054	2043
SusDev	2051	2042

3.3 Final energy transitions for the CoE region

This section describes the transition necessary for the CoE to achieve a 1.5°C compatible energy sector, based on the results from the three downscaled IAM scenarios. The description of the results primarily focuses on the HighRE scenario as this exhibits the most rapid transition out of the three scenarios considered. However, all three scenarios show similar trends at the CoE level: final energy demands fall out to 2050 due to a combination of efficiency gains and reduced demand for energy services; fossil fuels are rapidly phased out of the energy system; there is widespread electrification of energy demand; and renewables form the backbone of the future energy system. The sections below describe these results in more detail.

3.3.1 Demand reduction and electrification

Electrification is a key step on the road to net zero emissions. Electric vehicles, heat pumps and other electric technologies are highly efficient applications that can save energy, cut energy bills, reduce fossil fuel use, and avoid air pollution. The efficiency gains from electrification result in substantial reductions in final energy demand. This reduces the amount of costly supply infrastructure that is needed in the energy system.

All three IAM pathways show final energy demands falling out to 2050, while electricity meets an increasing share of the final demand (Figure 3). In the HighRE pathway, final energy demand falls by 11% in 2030 and 26% in 2050 (relative to 2019 levels). At the same time, demand is rapidly electrified. Electricity provided around 23% of final energy demand in the CoE in 2019, but in the HighRE scenario this share rises to 36% by 2030 and exceeds 65% by 2050. The SusDev and SSP1 scenarios generally show a greater reduction with final demand falling by 32–45% in 2050. This is because these scenarios show more ambition on lifestyle shifts and energy efficiency than the HighRE scenario. As a result, the scale of total electricity growth can be smaller, but the overall share of electrification is similar across the three scenarios.

Reducing final energy demand is an often overlooked, but key, strategy in reducing emissions. Reducing energy demand can accelerate the pace of fossil fuel phase-outs (Barrett et al. 2022), reduce the need for large-scale carbon dioxide removal (Grubler et al. 2018), and have substantial wellbeing benefits (Creutzig et al. 2022). Demand can be reduced by a combination of improved energy efficiency and reducing overconsumption of goods and services by households and businesses where possible.

3.3.2 Rapid reduction in fossil fuel demand

The demand for fossil fuel energy declines sharply across the three IAM pathways (Figure 3). Current coal demands in the CoE are relatively low (~1.9 EJ), and this fossil fuel is phased out first. In the HighRE case, coal is effectively phased out⁴ by 2030. Oil and fossil gas demand also falls rapidly in all three scenarios. Fossil gas shares were around 24% (11 EJ) in 2019 and decline to 18% (7 EJ) by 2030, before a full phase-out in 2050. Meanwhile, oil demand shows a comparatively slower decline: reaching 30% (13 EJ) and 5% (2 EJ) in the total shares by 2030 and 2050, respectively. Unlike coal and fossil gas, demand for oil does not reach zero by 2050. There are two possible reasons for this. Firstly, in the absence of synthetic fuels, the residual oil demand could be attributed to the aviation sector. The AR6 scenario database does not contain sub-sectoral resolution, and therefore we are unable to validate this. A second possibility is that the remaining oil consumption represents non-energy demands within industry and transport sectors, where oil is used as a chemical feedstock and as a lubricant. The incorporation of non-energy feedstocks into final energy is an artefact of the REMIND modelling framework. Explicitly modelling renewable-based synthetic fuels and feedstocks would further reduce oil consumption in these pathways, so the shares of fossil fuels would fall to negligible levels faster.

These results highlight the urgent need to phase out fossil fuels within the CoE. Without large-scale and rapid action to reduce fossil consumption, CoE countries will be unable to align with the Paris Agreement.

3.3.3 Growth in renewable energy

Renewables provide an increasing share of final energy in 1.5°C compatible trajectories (Figure 4). This is driven by growth in renewable electricity, renewable hydrogen and biomass consumption (Discussed in Section 3.4). Renewables provided around 21% of final energy in the CoE in 2019. In

⁴ Phase-out dates are defined by the year in which coal/gas provides <2.5% of total electricity generation/total final energy demand. We term this the ‘effective phase-out’ year. For more details see (Climate Analytics 2022a).

the HighRE scenario, this share grows to 47% by 2030. The growth in renewables share continues sharply, reaching 94% of final energy by 2050. While there is no renewable energy target at the CoE level, the European Commission (i.e., applying to the EU27) has a target to reach 45% renewables by 2030, as part of their REPowerEU plan. Such targets are welcome, but the results here show that the level of ambition will need to be further increased to align the energy system with 1.5°C compatibility, and that there are technically feasible routes to achieve this. Table 6 provides further information on the 1.5°C compatible final energy mix in 2030 and 2050.

Electrification and efficiency gains can help Council of Europe member countries achieve net zero

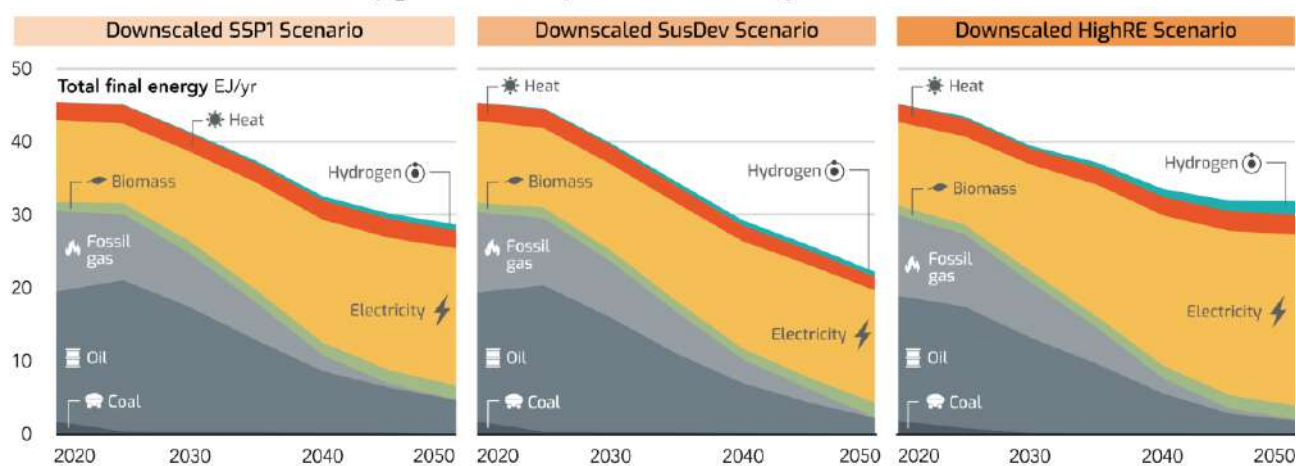


Figure 3: 1.5°C compatible final energy demand pathways in the Council of Europe (CoE) under the three Integrated Assessment Model (IAM) scenarios.

This figure shows 1.5°C compatible final energy demand in the CoE between 2019–2050. All CoE countries can rapidly reduce consumption of fossil fuels by transitioning to a more efficient and electrified energy system.

3.3.4 The role of other fuels

While electricity provides the largest share of final energy in the 1.5°C compatible scenarios (discussed in Section 3.3.1), a range of other fuels also help cut emissions. Biomass and renewable hydrogen are the key low-carbon fuels used in analysed IAM pathways. Renewable hydrogen helps to reduce emissions by displacing fossil fuels, via two central functions: 1) it provides high-temperature heat and replaces fossil fuels in production processes in industry; and 2) it helps decarbonise long-distance transport (such as shipping). Under the three illustrative pathways, renewable hydrogen provides around 1% and up to 5% of final energy for these two functions in 2030 and 2050 respectively. None of the scenarios uses hydrogen in the buildings sector, which is instead decarbonised by the widespread roll-out of heat pumps and greater use of district heating.

Biomass is also used in the end-use sectors across all 1.5°C compatible pathways. In the HighRE scenario, the share of biomass in final energy approximately doubles between 2019 and 2050, reaching 16% by 2050. Across all three IAM scenarios, biomass provides 16–23% of final energy in 2050, which represents a relatively large consumption of biomass fuels. This can be partially attributed to the fact that the IAM scenarios do not consider the use of renewable synthetic fuels as a mitigation option. In the absence of renewable-based synthetic fuels, biomass fuels are deployed to serve demands in the transportation sector because they represent a valuable energy dense fuel for long-distance transportation.

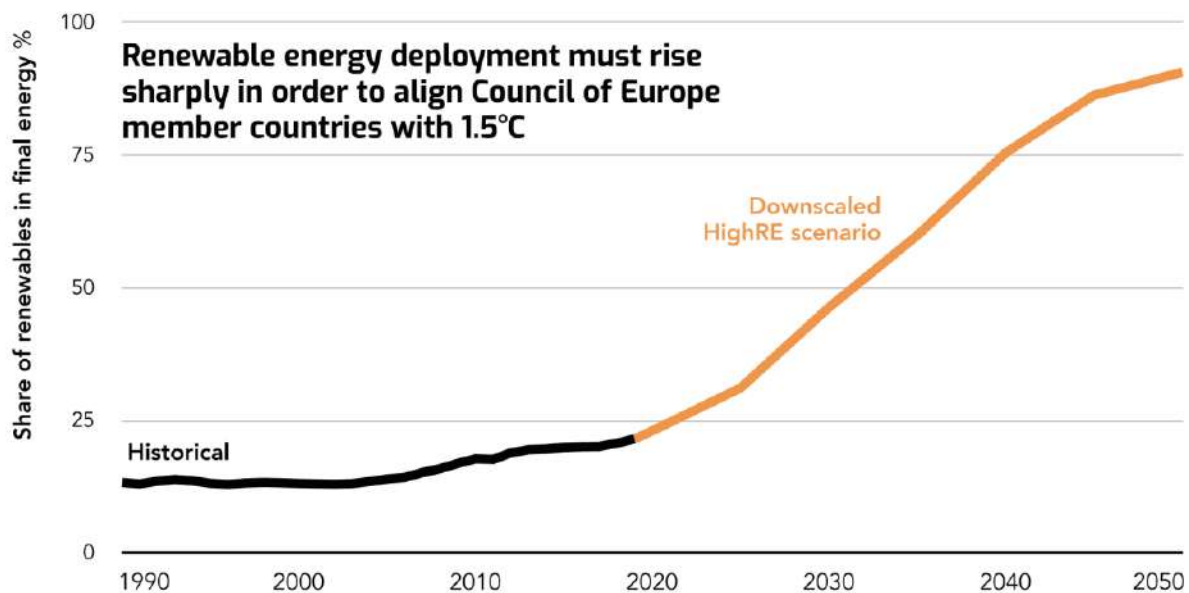


Figure 4: Share of renewables in final energy in the Council of Europe (CoE) region for the HighRE pathway.

This figure shows the share of renewable energy in final energy demand of the CoE region until 2050. The HighRE scenario demonstrates that all CoE member countries can rapidly achieve a higher share of renewables. Historical data is taken from the IEA World Energy Balances (IEA 2021).

It is critically important to ensure any biomass used in a future energy system is sustainably sourced, avoiding upstream emissions from land use change, competition with food crops, negative biodiversity impacts, and respecting the rights of indigenous peoples who may be the traditional users of the land (Energy Transitions Committee 2021). The HighRE scenario assumes that the global potential for bioenergy is 100 EJ/y, approximately double today's levels (Luderer et al. 2021). The specific European biomass potential is derived internally from the land use component of the REMIND-MagPIE model. While the assumed potential is at the low end of global 1.5°C compatible scenarios, it still represents a considerable growth in biomass supply. Further reductions in biomass consumption, via further fuel switching to hydrogen, electricity and synthetic fuels, or reduction in overall energy service demands, could help avoid some of the negative side effects of biomass production. The SusDev and SSP1 scenarios assume that the global biomass potential can be larger still, at 120 EJ/y and 170 EJ/y respectively. This explains the greater biomass consumption in these scenarios. Such a biomass potential, however, may transgress sustainability boundaries. Where possible, reliance on large amounts of dedicated bioenergy crops should be avoided.

The three IAM scenarios considered in the report do not explicitly model synthetic fuels. These are fuels produced using renewable electricity, green hydrogen and atmospheric CO₂ captured by direct air capture. Scaling up synthetic fuels can not only enable the decarbonisation of economic functions that are more difficult to abate (e.g., heavy vehicle transport, shipping and manufacturing, amongst others), but also reduce the need for biofuels, minimising the associated social and ecological risks. The corollary of the absence of synthetic fuels in the IAM scenarios is a high deployment of biofuels, as well as the residual oil demand for aviation to 2050. Explicit modelling of synthetic fuels and hydrogen in bottom-up models would likely decrease the reliance on biofuels, and so the shares of biomass in final energy would be reduced (Breyer, Khalili, and Bogdanov 2019).

Table 6: 1.5°C compatible final energy mix in 2030 and 2050 in Council of Europe countries, derived from the three Integrated Assessment Model (IAM) scenarios studied in this report.

Year	Electricity	Biomass	Renewable heat	Renewable hydrogen	Coal	Fossil gas	Oil
2019	24%	8%	5%	0%	4%	24%	36%
2030	27–34%	10–11%	5–6%	0–1%	0%	16–18%	31–38%
2050	57–66%	16–23%	7–8%	2–5%	0%	0%	5–14%

3.4 Power sector decarbonisation

One common phenomenon underlines all three 1.5°C compatible pathways analysed here: a large-scale and rapid deployment of renewable energy technologies in the power system (Table 6). The CoE has witnessed a gradual increase in the shares of renewable electricity since 1990. The build-out of renewable electricity is expected to expand in the CoE area due to regional climate commitments, but increasingly also due to costs, given that renewables are now cost-competitive with fossil fuels in many parts of the world (IRENA 2021). The levelized costs of technologies such as solar and wind have declined remarkably (Figure 5), which is accelerating the global energy transition. Integrated Assessment Models take advantage of the cost competitiveness of renewable electricity, envisaging rapid deployment of wind and solar in 1.5°C compatible pathways. These two technologies are therefore crucial for decarbonising the energy systems of CoE countries.

Wind and solar are now cost competitive with fossil fuels

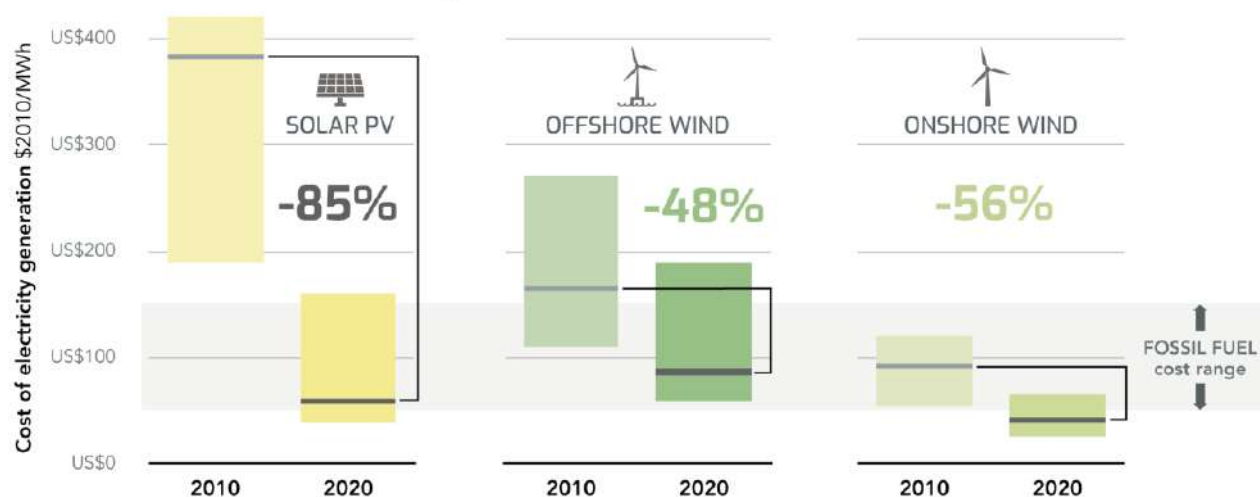


Figure 5: Cost reduction in renewables over the past decade.

This figure shows the cost reductions in electricity from wind and solar over 2010–2020. The bars represent the 5th and 95th percentile of all projects, while the yellow diamonds give the global median. The grey bar shows the cost of generating electricity from fossil fuels. The cost of electricity from solar PV fell 85% over the decade, while the cost of wind fell by 48–56%. Data is taken from IRENA (IRENA 2021).

Figure 6 shows the annual electricity generation to 2050 under the HighRE pathway. We see that the total electricity generation more than doubles out to 2050, and the share of generation from non-biomass renewables (solar, wind, hydropower, and geothermal) increases dramatically. These technologies were responsible for around 32% of total generation in 2019 (3733 TWh), and the share increases to 81% (4966 TWh) and 92% (8896 TWh) of the total generation in 2030 and 2050, respectively. When combined with renewable hydrogen and biomass, the HighRE scenario achieves 100% renewable-based electricity generation by 2050.

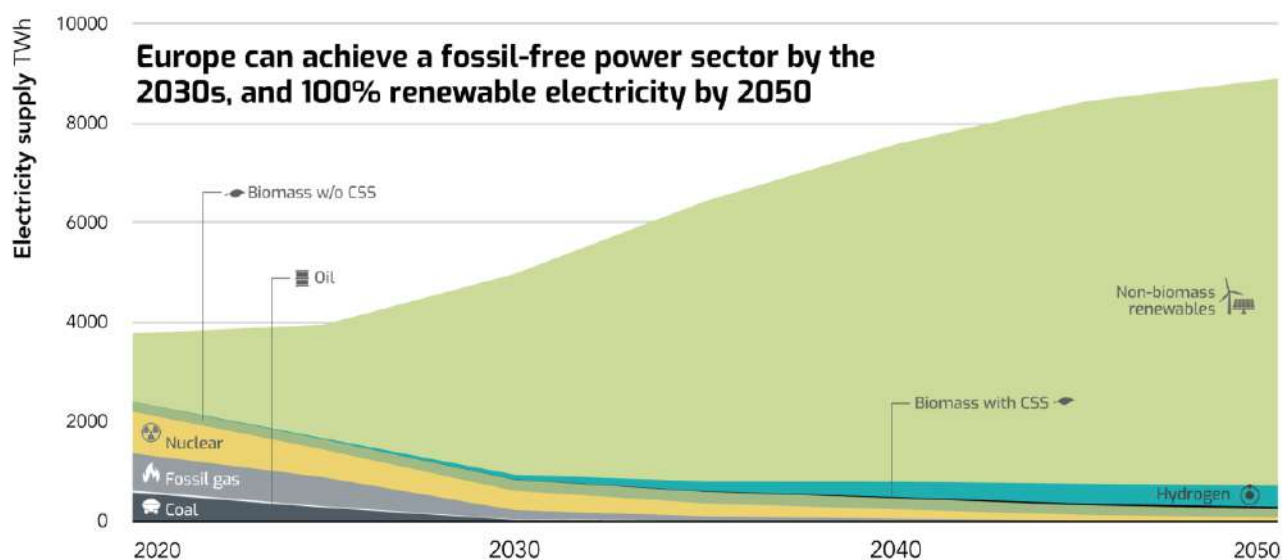


Figure 6: Power sector transition with 1.5°C compatible emissions pathways

This figure shows 1.5°C compatible electricity generation in the CoE region between 2019-2050. There is rapid expansion of non-biomass renewables such as wind and solar. Coal is phased out by 2030, and fossil gas is effectively phased out during the 2030s. Large-scale biomass and nuclear deployment are not needed to align with 1.5°C.

Large-scale biomass and nuclear electricity generation are not necessary for 1.5°C compatible action in the future. All three IAM scenarios display a diminishing role for nuclear in the future power mix, with phase-out by 2050. While biomass is not phased out, it plays a relatively minor role in the power sector, remaining relatively constant until around 2040, and then gradually declining thereafter. Rapid deployment of wind and solar, coupled with a limited and declining role for biomass and nuclear, means that around 99% of the CoE’s electricity production is generated from fossil-free sources in 2035 in these pathways. This represents a transition to a carbon-free power sector in just over a decade’s time.

None of the 1.5°C compatible pathways build new nuclear capacity because new nuclear plants are outcompeted by renewables as a source of new low-carbon electricity (Way et al., 2022). The underlying pathways also do not consider the potential for extending the lifetime of existing nuclear plants, which is more cost-effective than building a new plant. This could explain why existing plants are also shut down by 2050. However, as renewables may increasingly outcompete nuclear lifetime extensions, this would not necessarily change the results of the analysis at a whole.

Fossil fuels are rapidly displaced from the power sector. Coal is phased out of the sector by 2030, as shown by the HighRE case (Figure 6b), while fossil gas is effectively phased out of the power sector around 2035. These results show an urgent need to phase out fossil fuel generation to align the power sector with 1.5°C compatible pathways at the CoE level. Yet, member states of the CoE are exhibiting regressive energy policies in this regard. For example, Turkey, which is the second

largest GHG emitter in the CoE and at the time of writing has a “critically insufficient” NDC that aligns with a +4.0°C world (Climate Action Tracker 2021b), is planning on constructing a number of new coal-fired power plants (~10 GW in capacity) (Global Energy Monitor 2022). There are a range of other CoE member states that are currently constructing or planning to build new coal plants, including Poland, Greece, Serbia, and Bosnia and Herzegovina. The evidence is clear: these types of projects do not align with 1.5°C compatible pathways, as shown by the three IAM scenarios here.

Pathways from IAMs were developed before the illegal invasion of Ukraine by Russia, a former member of the Council of Europe. The war in Ukraine has been a major contributor to the energy crisis in Europe, in the form of unprecedented price spikes of fossil fuels (particularly fossil gas) due to shortages caused by Russia’s weaponisation of energy supply. Today, the CoE’s energy sector faces three critical challenges: a need to decarbonise; very high consumer prices for fossil fuels; and vulnerabilities in supplies from Russia. Renewable energy can be a solution to all three problems, strengthening the case for rapid deployment as observed in 1.5°C compatible pathways.

Table 7: 1.5°C compatible power sector fuel mix in 2030 and 2050 in the CoE region.

Year	Coal	Gas	Oil	Nuclear	Renewables		
					Non-Biomass	Biomass	Hydrogen
2019	16.8%	21%	1%	24%	32%	5%	0%
2030	0%	4-8%	0%	8-10%	75-81%	4-5%	1-2%
2050	0%	0%	0%	0-1%	89-92%	2-5%	3-5%

To realise an energy system with such a high penetration of renewable energy, renewables deployment will need to be complemented with other infrastructure, as well as structural changes in energy markets. As with any highly renewable energy system, variability in solar and wind will need to be smoothed using a combination of transmission, storage, and demand-side flexibility. However, it has been shown that additional electricity transmission infrastructure in Europe, to help balance the grid at a continental scale, could realise a zero-carbon power system at substantially lower costs than the current grid configuration (Schlachtberger et al. 2017). In fact, most of these benefits can be achieved with only around 25% more transmission capacity than what is installed currently (Horsch and Brown 2017).

Demand-side flexibility, the ability within a system to shift peak demands, also offers considerable untapped potential in Europe to integrate higher proportions of renewables at lower cost. Estimates show around 15–30% of the peak load can be shifted (Söder et al. 2018). Unlocking this potential could not only reduce the total capacity needed, but also help to stabilise the variability in renewable supplies. Fortunately, the technological barriers to rolling out demand-side flexibility at scale are limited given that solutions already exist, such as smart metering and grids. The main barriers to greater adoption of the technology are the roll-out of infrastructure, as well as the structure of energy markets, which for the moment does not sufficiently incentivise consumers to participate in flexibility programmes or change their behaviour (Cardoso, Torriti, and Lorincz 2020).

BOX 1: Accelerating mitigation in Georgia

Georgia is a country of around **3.7 million people** that joined the Council of Europe in 1999. Its cumulative emissions to date amount to around **660 MtCO₂**, equivalent to a **0.03%** share of global emissions. Georgia has had a positive human and economic development record, but there remain significant challenges to address. In particular, there is a need to improve living standards for rural communities and improve economic productivity.

In its NDC, Georgia notes two distinct targets:

- An **unconditional** commitment to reduce GHGs to 35% below 1990 levels in 2030.
- A **conditional** commitment to reduce GHGs to 50–57% below 1990 levels in 2030, subject to international support.

The country's NDC was complemented with a comprehensive climate change strategy in 2021. This document outlined Georgia's: i) environmental and human vulnerabilities to climate change; ii) unconditional and conditional climate commitments; iii) priorities for key sectors (e.g., energy, transport, buildings, agriculture etc.) in relation to climate targets; iv) framework for implementing and monitoring the transition, and vi) financial considerations for funding the transition.

Through its climate change strategy, Georgia has been able to identify, for example, the significant opportunity it has to tap into its relatively high solar energy potential, which can substantially reduce its dependency on fossil fuel imports and create new job opportunities. Yet, it has also identified barriers to the transition, such as current constraints on the power grid.

The NDC and LTS developed by Georgia provides a useful framework for other CoE members to outline conditional mitigation targets (where appropriate), while detailing steps to realising those targets across the economy, in a manner that maximises the potential benefits.

3.5 Accelerating sustainable development in the CoE region

This analysis presents cost-effective pathways which align the CoE area with the 1.5°C target. It does not explore any particular equity principle to understand how mitigation efforts could be distributed fairly across the CoE, but rather focuses on the “highest plausible ambition” to reach 1.5°C compatibility in a technically and economically feasible manner. However, the historical responsibility for climate change and the current status of economic development varies across the CoE, and mitigation efforts would need to be shared accordingly, taking into account the “common but differentiated responsibilities and capacities” of different CoE member states.

Countries with a lower overall contribution to global GHG emissions and unfulfilled development goals should submit conditional NDCs to the UNFCCC, which detail more ambitious mitigation targets that are contingent upon international assistance. In addition to the NDCs, the Paris Agreement also invites countries to submit long-term low greenhouse gas emission development strategies (also known as long-term strategies, or LTS), which serve as a guide to achieving mitigation targets. Long-term strategies are not only essential for guiding ambitious mitigation efforts, but also for identifying the synergies between emissions reductions, adaptation, and economic development. For instance, through an LTS, a country can create a roadmap for a just transition to a zero-carbon and resilient energy sector, which maximises upskilling and job creation within borders, whilst minimising adverse impacts to ecological and food systems (Climate Analytics 2022b). A robust NDC and LTS can also help countries to access international support to meet their more ambitious climate pledges. Georgia, a member state of the CoE, provides a good example of how countries can leverage a conditional NDC with an LTS to outline a vision for sustainable economic development (See Box 1).

Distributing climate mitigation efforts fairly across the CoE would be beneficial for the region as a whole. By increasing their own mitigation targets, while providing support to relatively less developed CoE countries, wealthier CoE member states can catalyse economic transformation at scale, and benefit from the knock-on effects such as: development of new technologies and industries; enhanced trade between countries; creation and dissemination of new knowledge supporting climate action; and reduced regional scale pollution (World Bank 2020).

BOX 2: A note on Russia

The Russian Federation was excluded from the analysis in this report as the country was removed from the CoE on 16 March 2022 following its illegal invasion of Ukraine. Although it is unclear whether Russia will be reintegrated into the CoE once peace is restored in Ukraine, this brief note provides an overview to Russia's pathway to 1.5°C compatibility.

In 2019, Russia emitted more GHG emissions than any CoE country, both in total (2.1 GtCO₂e) and per capita (17.1 tonnes per capita) terms (Appendix B). Decarbonising Russia's economy is therefore vital to achieving the Paris Agreement goals. However, Russia's current climate targets are critically insufficient (Climate Action Tracker, 2022b). If all countries enacted targets and policies in line with Russia's, we would be aligned with a 4.0°C pathway.

Russia's current NDC would see emissions increase by 15% from 2019 levels, meaning it is heading in the wrong direction to what is needed for 1.5°C compatibility (Climate Analytics, 2022c). There is an ambition gap of 1655 MtCO₂e in 2030 between Russia's current NDC and 1.5°C compatible pathways, as assessed by Climate Analytics. Like the pathways presented here for the CoE, aligning Russia with 1.5°C compatible pathways requires rapid action to phase out fossil fuels. This is particularly true in the power sector, where coal and fossil gas would need to be phased out by 2028 and 2039, respectively.

Russia's illegal invasion of Ukraine has further highlighted the benefits of cooperating across the CoE to rapidly phase out fossil fuels (Box 2). The 1.5°C compatible scenarios show that fossil fuel consumption needs to drop urgently across the CoE to align with the Paris agreement. In the most ambitious scenario, the share of unabated fossil power generation drops from 39% in 2019 to just 4% in 2030. Russia's weaponisation of energy continues to reverberate across the CoE, and this only strengthens the case for urgent fossil fuel phase-out.

In light of Russia's war in Ukraine, the Council of Europe has already begun to consider the important question of reconstructing Ukraine. A key outcome of the Ukraine Recovery Conference (URC) of 2022 was a blueprint recovery plan for Ukraine, which estimates more than \$750 billion will be needed to rebuild the country's economy, around 17% of which (~\$130 billion) would be used to reconstruct the energy sector (URC 2022). The energy development programme to 2032 is largely underpinned by the development of nuclear and large-scale expansions in Ukraine's oil and fossil gas production (including unconventional fossil gas). The programme includes only a modest increase in renewable energy (+4 percentage points relative to 2019). A proportion of oil and fossil gas production is expected to be exported to neighbouring European countries. Although the plan is a rough blueprint, it does not currently align with the 1.5°C compatible pathways shown here for the CoE, which show declining shares of fossil fuels and nuclear, and a dramatic increase in renewable energy deployment out to 2030. Decision makers will face tough decisions on the recovery of the Ukrainian energy sector, with a need to quickly and economically establish reliable energy supplies. However, the current recovery plan is not only incompatible with 1.5°C, but also sub-optimal economically. The development of nuclear energy not only requires vast capital and

long lead times, but also entails significant national security, environmental, and human risks. Meanwhile, expanding oil and fossil gas production does not align with 1.5°C compatible pathways (Way et al. 2021), and could substantially increase the risk of stranded assets (Semieniuk et al. 2022). Rapid deployment of low-cost renewables is the best opportunity for Ukraine to rebuild its energy system rapidly and at low-cost, in a manner which is compatible with the Paris Agreement.

3.6 Key characteristics of 1.5°C compatible pathways for the CoE region

Table 8 provides a summary of key derived 1.5°C compatible economy-wide and power sector benchmarks for the CoE region in 2030 and 2050, compared against recent historical values. All three scenarios are used to derive benchmarks for total emissions and reductions in final energy demand.

Table 8: Key characteristics of 1.5°C compatible pathways for the CoE region.

	Historical	1.5°C compatible benchmarks	
	2019*	2030	2050
Total GHG excl. LULUCF	5310 MtCO ₂ e/yr	2341–2644 MtCO ₂ e/yr	294–379 MtCO ₂ e/yr
	27% below 1990	63–68% below 1990	95–96% below 1990
Reduction in final energy demand (relative to 2019)	0%	6–11%	26–45%
Share of renewables in final energy	21%	39–46%	82–91%
Emissions intensity of power generation***	242 gCO ₂ /kWh	23–38 gCO ₂ /kWh	-2–9 gCO ₂ /kWh***
Share of renewables in electricity production	37%	82–88%	96–99%
Share of unabated fossil fuel in power	39%	4–8%	0%
Share of nuclear power	24%	8–10%	0–1%

* Historical data comes from PRIMAP for emissions, and the IEA World Energy Balances for energy consumption

** Does not include upstream emissions

*** The carbon intensity is negative due to the deployment of Biomass with Carbon Capture and Storage (CCS) systems. However, the shares of Biomass with CCS is relatively small (<1% of total generation).

4 Conclusion

As the impacts of a warming planet continue to escalate and the cost of low-carbon technologies fall, the urgency, feasibility and desirability of tackling climate change is becoming ever clearer. The Russian invasion of Ukraine has further emphasised the geopolitical risks of fossil fuel dependency, and the benefits of rapidly transitioning to renewables. In addition, the global community has agreed to return to COP27 with more ambitious climate targets for 2030, to address the alarming discrepancy between current NDCs and 1.5°C compatible pathways. In this context, we must ask: what can the CoE do to help drive climate action at home and abroad, and keep the 1.5°C goal alive?

This report finds that the CoE countries can do more than they currently aim for to reduce their own emissions by 2030. Our analysis of their current NDC commitments shows that collectively, CoE countries' 2030 targets could lead to emissions reduction of 44% below 1990 levels in 2030, falling considerably short of compatibility with the Paris Agreement. To align with the derived 1.5°C compatible pathways assessed in this report, member states of the CoE should submit revised NDCs, which aim to reduce the collective emissions of the CoE by 63–68% in 2030, relative to 1990 levels (excluding LULUCF). Incorporating the minimum estimated LULUCF sink for the CoE in 2030 (352 MtCO₂), this would correspond to an effective collective reduction of 68–73%, including LULUCF. This would represent a feasible target which is in line with the principle of highest plausible ambition for the CoE. We have not assessed what a fair contribution from each member of the CoE would be, but it is likely that relatively less developed countries within the CoE, which historically have contributed less to climate change, will need support from wealthier members to reduce emissions in line with their highest plausible domestic ambition.

The report identifies a range of measures that are critical to align the CoE's energy transition with the Paris Agreement. Rapid deployment of wind and solar power is key, with the CoE achieving a fossil-free power system well before 2040 in the most ambitious pathways. The widespread electrification of energy demand via EVs, heat pumps and industrial electrification can then displace fossil fuels from the wider energy system. The report finds that energy efficiency improvements and behavioural change can lead to strong and sustained reductions in final energy demand, which can help accelerate the phase-out of fossil fuels and reduce the need for engineered CO₂ removal.

While the actions set out in this report require a step-change in ambition, it is important to highlight that they are both technically feasible and economically cost-effective. Taking these actions, alongside strong efforts to preserve and expand the CoE's LULUCF sink, could enable the CoE to reach net zero GHG emissions by 2041.

If CoE member states were to collectively and publicly commit to these more ambitious near-term and long-term targets, this would send a clear message to businesses and consumers about the direction of travel for the CoE. It could also encourage and inspire other countries to reassess their climate targets, catalysing global climate action in the run-up to COP27. A rapid, well managed transition to a renewable future would improve Europe's energy security, reduce premature deaths from air pollution, and create millions of jobs in key growth sectors.

In addition to setting stronger emission reduction targets and adopting more stringent policies to achieve them, certain nations within the CoE (e.g., the EU27, United Kingdom, and Switzerland, among others) also have an obligation, under the fair share and equity considerations embedded

in the Paris Agreement, to assist less wealthy countries to rapidly reduce their own emissions. Without such assistance, the global effort required to limit warming to 1.5°C will be distributed unfairly and will be unlikely to be met in time.

The CoE is at a pivotal moment in its energy transition. Today, it faces three critical energy challenges: a need to decarbonise quickly; very high costs for fossil fuels; and critical security risks of supplies from Russia. A rapid shift to low-carbon energy technologies is a solution across all three of these problems. In fact, moving away from fossil fuels would deliver immense additional benefits, such as economic growth through the creation of new industries and jobs, as well as in areas of health. The Council of Europe therefore faces a historic choice: will it continue its addiction to fossil fuels, or will it demonstrate global leadership, accelerate climate action and realise a more sustainable and prosperous economy for its citizens?

Appendix A: Scenario selection process

Figure A1 provides a visualisation of the scenario selection process in the report.

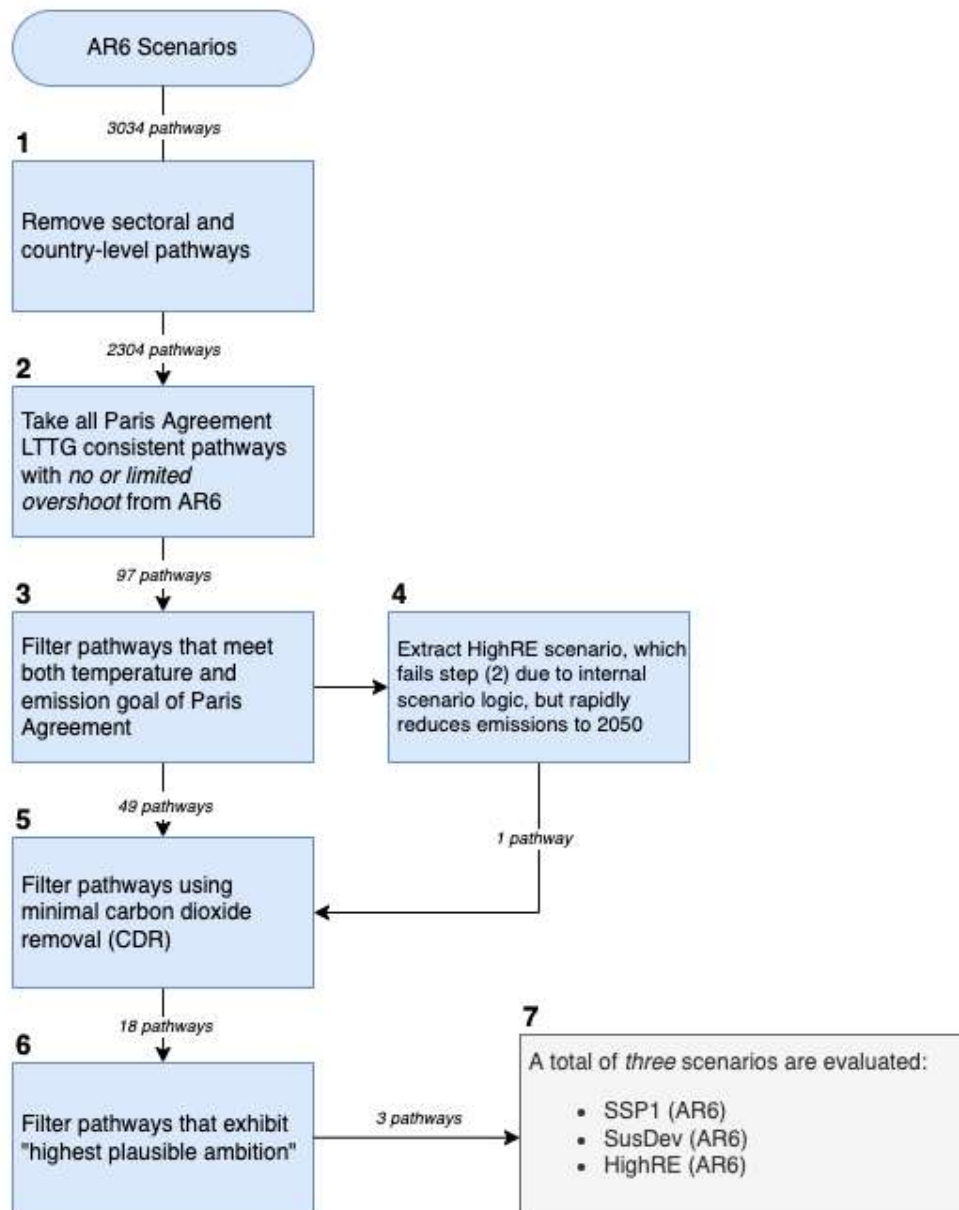


Figure A1: Scenario selection process.

Appendix B: Emissions by CoE countries

Figure B1 shows the total emissions in 2019 by Council of Europe countries.

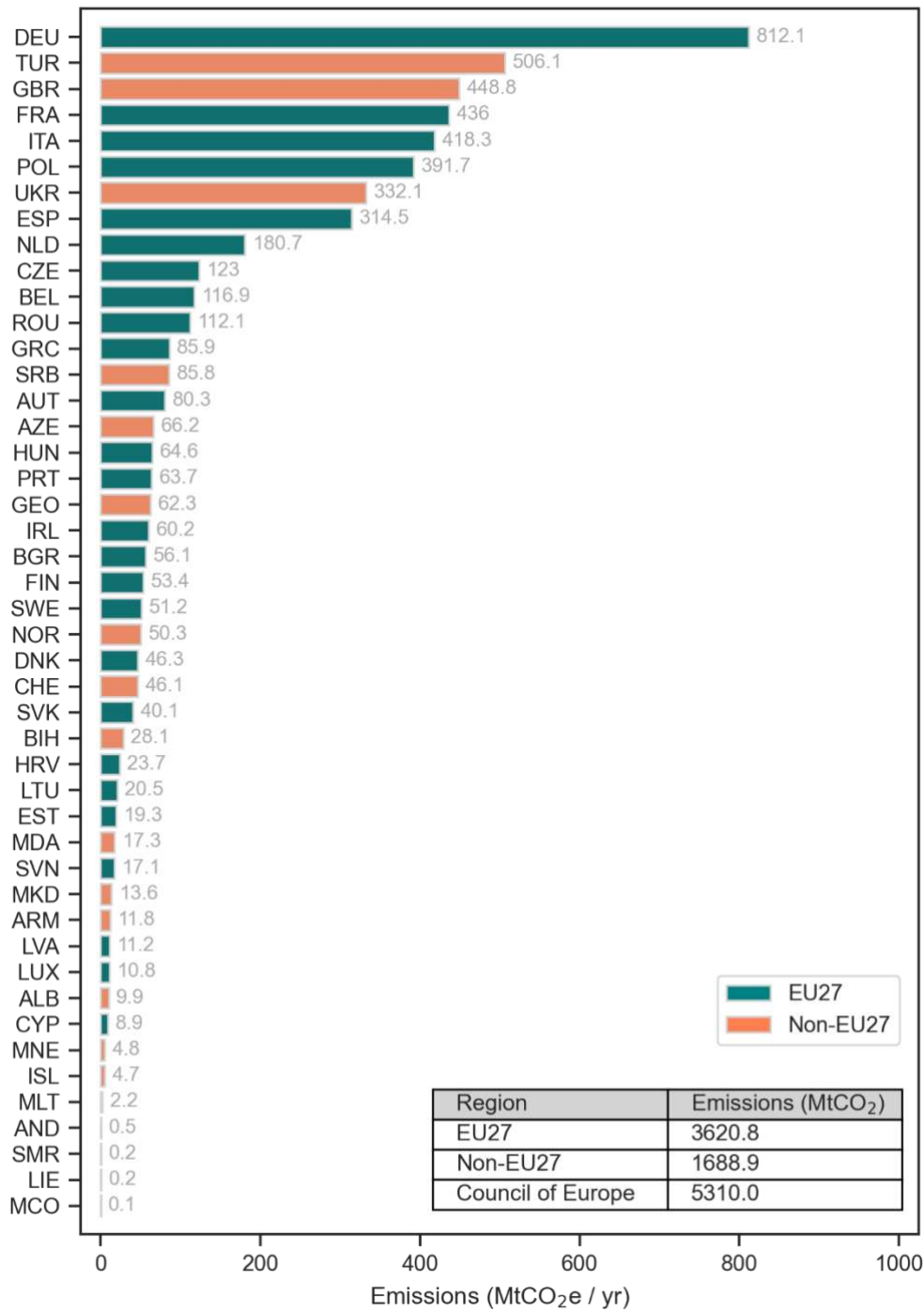


Figure A1: Emissions by Council of Europe countries in 2019, further disaggregated by EU27 member states (ClimateWatch 2022).

Figure B2 shows the per capita emissions in 2019 by Council of Europe countries.

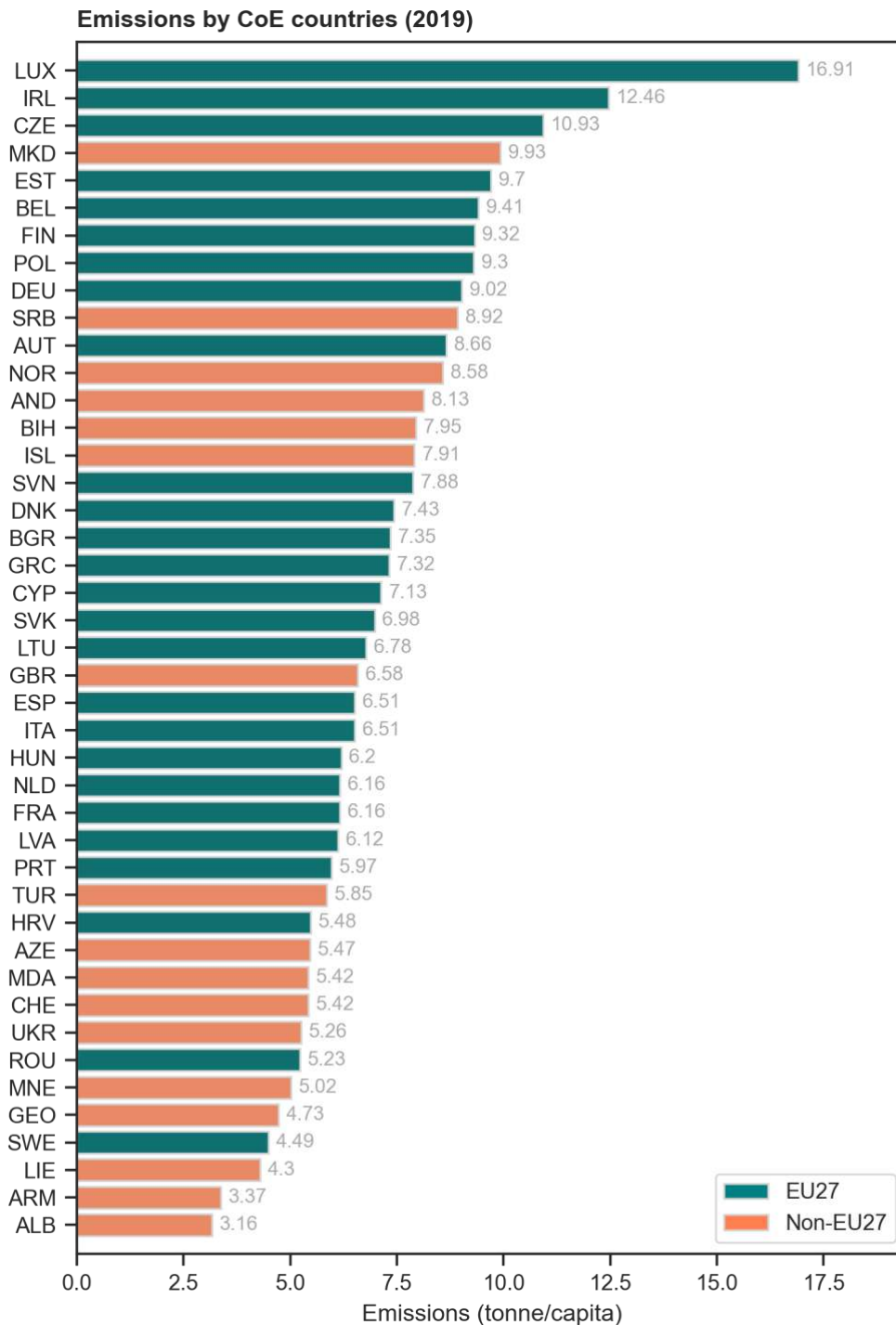


Figure B2: Emissions per capita by Council of Europe countries in 2019, further disaggregated by EU27 member states (ClimateWatch 2022).

Appendix C: Downscaling methodology description

C1: Energy sector downscaling: SIAMESE

The Simplified Integrated Assessment Model with Energy System Emulator (SIAMESE) is a reduced complexity IAM. SIAMESE is used to downscale the energy system transitions produced by global/regional IAMs (Sferra et al. 2019b). These models provide cost-effective energy and emissions pathways for a given *macro region*, but often do not provide results at the national or sub-national level. For example, the PAC scenario provides data for the Europe region, which comprises the EU27+UK, while in the case of the REMIND model, the Europe region represents a set of 45 countries including the EU27 and a range of other non-EU countries such as Norway, Switzerland and the UK.

SIAMESE can be used to downscale these aggregated results to the required spatial resolution, accounting for the relationship between economic growth, energy consumption and associated emissions. SIAMESE provides downscaled energy consumption pathways for the country of interest, as well as a CO₂ emissions pathway for the energy sector. This can be combined with non-energy CO₂ and non-CO₂ emissions pathways to give an economy-wide emissions pathway covering all relevant gases.

When downscaling results from a given model (e.g. REMIND, IMAGE, AIM etc.), SIAMESE uses population and GDP projections from the Shared Socioeconomic Pathway (SSP) associated with the scenario being assessed (van Vuuren, Riahi, et al. 2017). SIAMESE then takes the energy consumption in the wider macro region and allocates it across the underlying countries that constitute this larger region. It does so by equating marginal fuel prices across all countries. This gives a distribution of energy consumption across the underlying countries which maximises the total welfare of the IAM macro region. Therefore, energy consumption and associated emissions are downscaled to the country level on a cost-effective basis, minimising total costs at the macro region level. This mirrors the internal logic of IAMs and ensures consistency between the downscaled results and the initial model pathway used as an input.

In this project, final energy demand in the industry, buildings and transport sectors, and electricity production in the power sector are downscaled.

The downscaling process itself can be broken down into several sub-steps:

1. **The macro regions containing the Council of Europe member states are defined.** This is the European macro region (41 CoE member states included) and the Reforming Economies (5 CoE member states included).
2. **Historical emissions and energy consumptions** are determined for all countries in the macro region for the base year (2019).
3. **Future emissions and energy consumption for the macro region** are obtained from to-be-downscaled 1.5°C compatible pathway.
4. **The macro region's scenario data is adapted to match historical data** in the base year. This process is called *harmonisation*. Harmonisation is required to update the pathways to the latest available historical data.

5. **The macro region's energy consumption is downscaled to the underlying countries using SIAMESE.** It is distributed to the countries in an internally consistent way, which preserves total consumption in the macro region and matches historical consumption in each country in the base year. To optimise computational performance, SIAMESE does not downscale countries which represent <1% of the macro region's GDP.
6. **Once the consumptions are downscaled, then energy sector CO₂ emissions can be determined.** A calibration process is run which calculates emissions factors for coal, oil, gas and biomass in each sector. The calibration process aims to ensure that the sum of downscaled emissions equals the emissions pathway of the macro region as a whole.
7. **The Council of Europe pathway can then be produced by aggregation.** The individual pathways for each CoE member state are summed together to give an overall energy and emissions pathway for the Council of Europe.

C2: Non-energy CO₂ emissions, and non-CO₂ emissions

SIAMESE is used to provide energy consumption and energy sector CO₂ pathways for the Council of Europe. This then needs to be combined with data on non-energy CO₂ emissions and non-CO₂ emissions to give a complete emissions pathway. The following sections explain how this is undertaken in the analysis.

Agricultural emissions

The emissions on the macro region level for the agriculture sector are collected from the REMIND scenario data and harmonised to historical data. The emissions for individual countries are determined by assuming their shares in the base year (2019) are constant over the whole scenario period, a simple downscaling methodology called *base-year pattern*.

Remaining energy system emissions

The emissions for industrial processes, waste and non-CO₂ emissions in the energy sector are collected from the REMIND scenario data and harmonised to historical data in 2019. To perform the downscaling from the macro region to the individual country level, a methodology based on *intensity convergence* is used; more specifically the Impact, Population, Affluence, and Technology (IPAT) method developed by van Vuuren et al (2007) and extended by Gidden et al (Gidden et al. 2019).

This assumes that emission intensities (the ratio of emissions to GDP) will converge from their values in the historical base year to the macro region intensity in the last year of the scenario data (here 2100). This is made possible by an exponential interpolation of emission intensities from the base-year to the convergence year. These emissions intensity trajectories in emissions/GDP are then combined with country-level GDP trajectories for the given SSP, to give country-level emissions pathways for industrial processes, waste and non-CO₂ energy sector emissions.

C3: Global Warming Potentials

All historical and projected emissions series use global warming potentials from the IPCC's Fourth Assessment Report (AR4).

Appendix D: Emissions calculations for the rest of the CoE category

Table D1 shows the assumptions used to calculate the NDC emissions reduction in 2030 in the Rest of CoE grouping.

Table D1: Assumptions used to calculate the NDC emissions reduction in 2030 in the Rest of CoE grouping.

Country	Emissions in 1990 (MtCO _{2e})	LULUCF Sink (2019)	NDC Emissions reduction in 2030 (%)	NDC Emissions reduction in 2030 (MtCO _{2e})	
				Incl. LULUCF	Excl. LULUCF
Albania	5.6	0.24	11.5	7.7	7.9
Andorra	0.5	0	37	0.3	0.3
Armenia	25.4	-0.04	40	15.2	15.2
Azerbaijan	74.5	1.92	35	48.4	50.3
Bosnia and Herzegovina	34.8	1.73	33.2	23.2	25.0
Georgia	65.0	-0.04	35	42.3	42.2
Iceland	3.6	0.08	55	1.6	1.7
Liechtenstein	0.2	0	40	0.1	0.1
Monaco	0.2	0	50	0.1	0.1
Moldova	44.6	-0.11	70	13.4	13.3
North Macedonia	13.2	0	82	2.4	2.4
Montenegro	5.7	-0.03	35	3.7	3.7
San Marino	0.2	0	20	0.2	0.2
Serbia	75.3	0.07	33.3	50.2	50.3
Total	348.7	3.8	-	208.9	212.7

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About the author



Supporting science-based policy to prevent dangerous climate change, enabling sustainable development.

Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Our mission is to synthesise and advance scientific knowledge in the area of climate change.

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