CLIMATE ANALYTICS

Italy's Climate Targets and Policies in Relation to the Paris Agreement and Global Equity Considerations

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Authors

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This report was prepared at the request of A Sud, in the context of legal proceedings brought against the Italian State, for the purpose of assessing the contribution of the Italian State towards meeting the Paris Agreement temperature goal, in line with the principles of equity and common but differentiated responsibilities as enshrined in that agreement.

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Glossary

[1] Assessment Report (AR): The International Panel on Climate Change (IPCC) prepares comprehensive Assessment Reports about knowledge on climate change, its causes, potential impacts and response options. Assessment reports are authored by experts selected by the IPCC Bureau, which is elected by the IPCC itself to, among other duties, provide guidance to the Panel on the scientific and technical aspects of its work. The selection of authors is a careful process that aims to reflect the range of scientific, technical and socio-economic expertise. Expert Reviewers and governments are invited at different stages to comment on the scientific, technical and socio-economic assessment and the overall balance of the drafts. The review process consists of hundreds of reviewers critiquing the accuracy and completeness of the scientific assessment contained in the drafts. Assessment Reports include a Summary for Policymakers that is prepared by the authors and approved line by line by a Plenary Session of the IPCC, with the final draft of the Assessment Report also accepted by participating governments.

[2] Climate Action Tracker: The Climate Action Tracker is an independent scientific analysis that tracks government climate action and measures it against the globally agreed Paris Agreement aim of "holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C." The CAT is a collaboration of two organisations, Climate Analytics and NewClimate Institute.

[3] Common but differentiated responsibilities: Common but Differentiated Responsibilities and Respective Capabilities is a principle within Article 3.1 of the United Nations Framework Convention on Climate Change (UNFCCC) which states that “Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof”.

[4] Effort Sharing Regulation (ESR): ESR is a regulation on greenhouse gas emission reductions, adopted by the Council of the European Union in May 2018. It establishes binding annual greenhouse gas emission targets for Member States for the periods 2013–2020 and 2021–2030. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and waste.

[5] Emissions pathway: The trajectory of annual greenhouse gas emissions over time.

[6] Emissions Trading Scheme (ETS): ETS, is a market mechanism that allows those bodies (such as countries, companies or manufacturing plants) which release greenhouse gases into the atmosphere, to buy and sell these emissions (as permits or allowances) amongst themselves.

[7] Equity: Equity is a central principle of the UNFCCC and the Paris Agreement. Equity in the context of climate change refers to issues including intergenerational fairness, the sharing of mitigation action, responsibility for the impacts of climate change and questions of fairness in how the impacts and responses to climate change, including costs and benefits, are distributed between countries, in and by society in more or less equal ways. It is often associated with ideas of equality, fairness and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society,

generations, and gender, and in the sense of who participates and controls the processes of decision-making. This report considers the estimates from the equity literature and uses a method consistent with the notion of "Common but Differentiated Responsibility".

[8] Equity literature: This relates to the scientific literature on how emissions reduction efforts can be equitably divided among countries. A wide range of methods, grounded in different ethical considerations, exist with the aim of dividing the level of responsibility countries have to achieve emission reductions. Scientific literature that analyses these approaches is referred to here as "equity literature".

[9] Fair share: What a country's total contribution would need to be, to make a fair contribution to global efforts to implement the Paris agreement, in line with equity and "Common but Differentiated Responsibility".

[10] Greenhouse gas (GHG): The atmospheric gases responsible for causing global warming and climatic change. The major greenhouse gases are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Less prevalent, but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

[11] IPCC (Intergovernmental Panel on Climate Change): The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. It is composed of 195 governments that are members of the UN or World Meteorological Organisation. IPCC scientists volunteer their time to assess the thousands of scientific papers published each year to provide a comprehensive summary of what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks. An open and transparent review by experts and governments around the world is an essential part of the IPCC process, to ensure an objective and complete assessment and to reflect a diverse range of views and expertise. Through its assessments, the IPCC identifies the strength of scientific agreement in different areas and indicates where further research is needed. The IPCC does not conduct its own research.

[12] LULUCF (Land Use, Land-Use Change and Forestry): A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land use change and forestry activities. This includes emissions and removals from such activities as: afforestation, reforestation, deforestation, revegetation, forest management, cropland management, grazing land management, natural disturbances, and wetland draining and rewetting. It does not cover emissions from agriculture. This report is limited to anthropogenic emissions reductions (i.e., outside of the LULUCF sector).

[13] National Energy and Climate Plan (NECP): To meet the EU's energy and climate targets for 2030, EU Member States need to establish a 10-year integrated national energy and climate plan for the period from 2021 to 2030. The national plans outline how the EU Member States intend to address: energy efficiency, renewables, greenhouse gas emissions reductions, interconnections, and research and innovation.

[14] Negative emissions and CDR measures: Negative emissions refers to the reduction of emissions through the removal of carbon from the atmosphere. This process is called Carbon Dioxide Removal (CDR). CDR can done naturally (e.g. afforestation), or technologically (such

as through direct air capture). For a country to be 'net negative', it would need to capture more carbon than it produces.

[15] Paris Agreement: The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in December 2015 in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. The agreement, adopted by 196 Parties to the UNFCCC, entered into force on 4 November 2016 and as of October 2020 has 197 Signatories and was ratified by 189 Parties. The long-term temperature goal of the Paris Agreement is 'Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels', recognising that this would significantly reduce the risks and impacts of climate change.

[16] Primary energy consumption: It measures the total energy demand of a country. It covers consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users. It excludes energy carriers used for non-energy purposes (such as petroleum not used for combustion but for producing plastics).

[17] PRIMES 2007 Scenario: The PRIMES model is an EU energy system model which simulates energy consumption and the energy supply system. It is a partial equilibrium modelling system that simulates an energy market equilibrium in the European Union and each of its Member States. The Baseline scenario finalised in November 2007 (PRIMES 2007) gives an update of the previous trend scenarios, such as the "Trends to 2030" published in 2003 and its 2005 update.

[18] RES (Renewable Energy Sources): Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, waste energy, hydro, wind, geothermal, solar, wave and tidal energy.

[19] United Nations Framework Convention on Climate Change (UNFCCC): The UNFCCC was adopted in May 1992 and opened for signature at the 1992 Earth Summit in Rio de Janeiro. It entered into force in March 1994 and as of October 2020 has 197 Parties (196 States and the European Union). The Convention's ultimate objective and that of any related legal instruments that the Conference of the Parties adopt, is the 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.' The provisions of the Convention are pursued and implemented by two treaties: the Kyoto Protocol and the Paris Agreement.

[20] Working Group III: The IPCC is divided into three Working Groups (WG) and a Task Force. WG III focuses on climate change mitigation, assessing methods for reducing greenhouse gas emissions, and removing greenhouse gases from the atmosphere.

Executive Summary

The Paris Agreement defines its long-term temperature goal as well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. This report assesses the contribution of the Italian State towards meeting the Paris Agreement's long-term temperature goal, in line with the principles of equity and common but differentiated responsibilities as enshrined in that agreement, so that its climate commitments represent a "fair share" towards achieving that goal.

Thus far, Italy has made some progress in reducing its emissions. After a continued gradual increase, Italy's total greenhouse gas (GHG) emissions peaked in 2005 and have fallen considerably since (-27% below 2005 levels in 2018). Prior to the COVID-19 pandemic, emissions in 2020 were projected to reach 19% below 1990 levels under current policies. While lower emissions levels were observed during 2020 through pandemic-related reductions in carbon-intensive activities, European emissions levels from energy consumption rebounded by the end of 2020 to within ~5% of those observed prior to the pandemic. Much of the pre-pandemic reduction in emissions so far has coincided with economic decline and the outsourcing of productive sectors. Under current policies – and with resumed but modest economic growth – the government's emissions projections to 2030 show a markedly slower rate of reduction than in previous years.

Following Italy's current policy scenario, 2030 emissions are expected to be 26% below 1990 levels. Under these government projections, Italy will not achieve its modest implied 2030 emission target of a 29% reduction below 1990 levels[1] [37% below 2005 levels] without additional measures. Additional policies planned by the Italian government, as outlined in Italy's Integrated National Energy and Climate Plan (NECP), are only projected to reduce emissions in 2030 by 36% below 1990 levels.

In recent decades, Italy's transport and buildings sectors have performed comparatively poorly in terms of emissions reductions, with 2018 emissions in both sectors sitting above 1990 levels. The commercial buildings sector in particular has seen a significant increase in natural gas consumption since 1990. Emissions projections under current policies show that the transport and buildings sectors will continue to underperform, leading Italy to miss its 2030 emissions reduction target for sectors not covered by the EU Emissions Trading Scheme. A large proportion of the additional emissions reductions implied by Italy's planned policies are in these sectors, as well as from the energy sector.

The electricity sector will continue to be a substantial source of emissions in Italy based on current policies. While Italy has committed to phase out coal use by 2030, it plans to do so by switching generation primarily to natural gas. Among European countries planning a coal-to-gas switch, Italy has the highest planned gas consumption in the 2020s. While Italy is targeting a 30% share of renewable energy in gross final energy consumption by 2030, it does not currently have the policies in place to achieve this target. Such substantial and continued dependence on unabated natural gas strongly contradicts the fuel consumption trends shown in 1.5°C scenarios assessed in the IPCC's Special Report on 1.5°C (IPCC SR 1.5C).

Considering Italy's policies and targets for reducing emissions, the country is **far from making a fair contribution** to the emissions reductions needed by 2030 to meet the Paris Agreement long-term temperature goal.

[1] Quantified by calculating the emissions level represented by both Italy's stated targets for sectors under the EU ETS and the ESR, see "Country-specific targets and compliance"

We compare Italy's emission target against the global emission trajectories identified by the IPCC in its 2018 Special Report on 1.5°C that would limit the temperature increase by the end of the century to 1.5°C with at least 50% probability while allowing minimal overshoot of this limit throughout the century. The median of these pathways can be characterized as an indicator of the average level of mitigation required across all countries in order to stay below 1.5°C by the end of the century. If starting from 2020 Italy were to mitigate emissions consistent with this global median pathway, it would need to reduce its emissions by 63% compared to 1990 levels by 2030 – far below its target and current emission trajectory. Importantly, this assessment does not take into account the principles of equity and common but differentiated responsibilities (CBDR) as laid down in the UNFCCC (Article. 3.1) and the Paris Agreement (Article 2.2), on the basis of which Italy needs to "take the lead" in achieving emission reductions. Italy would thus need to do more in order to do its "fair share" in line with these principles.

From an equity-based perspective, Italy's emission reduction target for 2030 lies outside the ranges assessed for 1.5°C in the literature. In its 5th Assessment Report (AR5), the IPCC assessed the available interpretations of 'fair share' contributions that have been assessed in the scientific literature. We use the same methodology as presented in AR5 to group these estimates and assess Italy's 2030 targets. While different interpretations of a country's fair share exist, Italy's **current domestic emission reduction target places its 2030 emissions target well outside any interpretation found in the literature of its "fair share" contribution** to meeting the Paris Agreement's long-term temperature goal (**Figure ES 1,** see the dark red horizontal line). Even taking into account **Italy's projected 2030 emissions under planned policies**, as outlined in its National Energy and Climate Plan, its projected emissions still **lie above even the upper range of the results in the fair share literature** for both 1.5°C and 2°C (**Figure ES 1,** see the red horizontal line**)**. As illustrated in Figure ES1, Italy's emission reduction target and projected emissions reductions for 2030 (the horizontal lines) do not intersect with any interpretation of Italy's fair share (the blue, and yellow vertical axes) for either 1.5°C or 2°C.

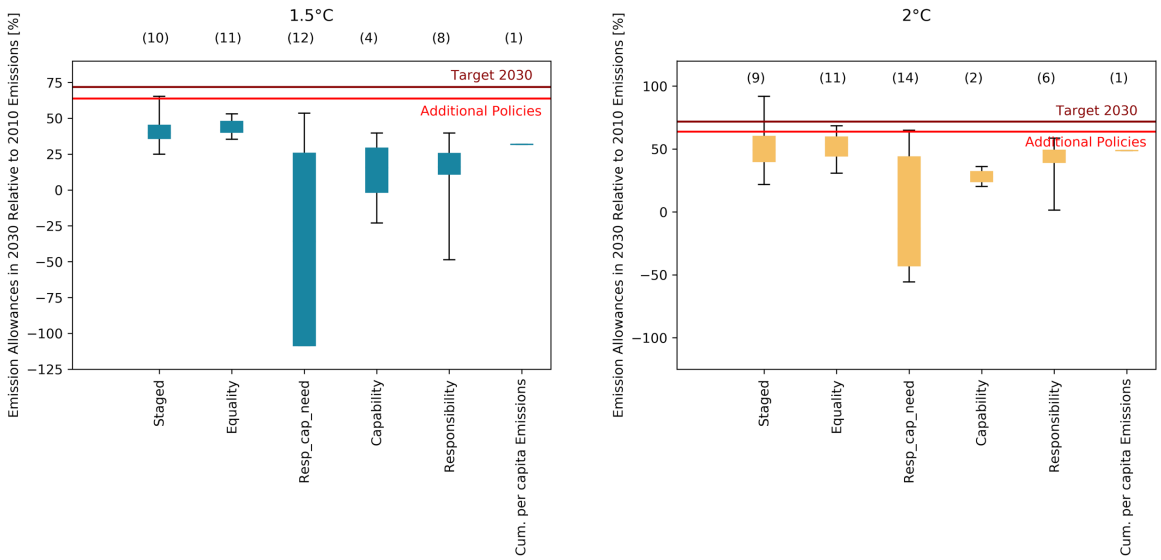

Figure ES1: *Emission allowances in 2030 for 1.5°C and 2°C temperature levels, based on the categorization method used in the IPCC's 5th Assessment Report. The vertical axis shows the emission allowances in 2030 as percentage compared to its 2010 levels. The blue and yellow bars show the range of results for Italy's fair share allowances for the different interpretation in the literature. The horizontal lines present the emission levels on the basis of current policy projections (dark red) and the additional policies projections (red) by the Italian government.*

This report considers the estimates from the equity literature and uses a method consistent with the notion of "Common but Differentiated Responsibility" to identify an emissions target in 2030 within the Italian fair share range to meet the Paris Agreement long-term temperature goal expressed as limiting end-of-century warming to 1.5°C with 50% or higher probability. The report further shows that if all countries were to lower their emissions to the level proposed in the literature that is most preferable to them, this in itself would not result in a contribution sufficient to achieve the Paris Agreement long-term temperature goal. On the contrary, this study assesses that if all countries were only to adopt the interpretation most preferable to themselves, global average temperature would rise to higher than 3.0°C by 2100. This report therefore identifies the fair share emissions level *within* the entire range of interpretations in the equity literature that *would be* consistent with meeting the Paris Agreement long-term temperature goal.

The analysis of Italy's required reduction of emissions is premised on the notion that other countries also set a reduction target that, with respect to their own fair share ranges, matches the ambition level of Italy's action. If Italy were to set a reduction target that is *above* its Paris-compatible fair share level, still meeting the Paris Agreement long-term temperature goal would require greater effort on the part of other countries above and beyond their own "fair share" to compensate for Italy's failure to do so. The results of our analysis are shown in Figure ES2 and Table ES1. The vertical-coloured bar shows the entire range of fair share results for Italy that is presented in the scientific literature, with each coloured section indicating the range of emission reductions for Italy in 2030 that would be compatible with different temperature levels.

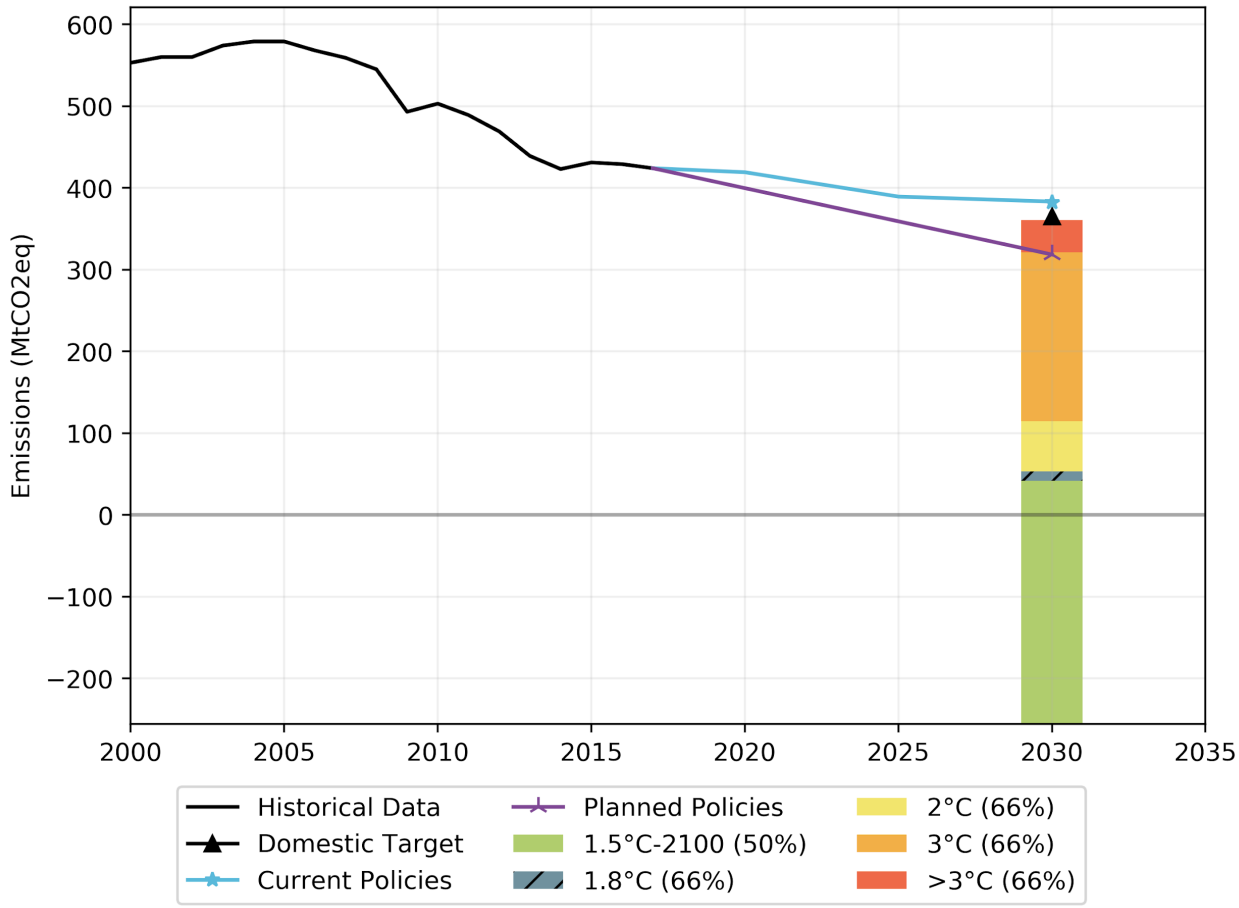

Figure ES 2: *1.5°C, 1.8°C, 2°C and 3°C compatible fair share ranges for Italy. The green bars represent the 1.5°C Paris compatible fair share range. The hatched blue bar represents the range corresponding to keeping warming below 1.8°C throughout the century. The yellow and orange bars correspond to the emission levels that would result in keeping*

warming below 2°C and 3°C respectively throughout the century with a 66% probability.

Table ES1: *Minimum emissions reduction below 1990 levels needed meet the Paris Agreement long term temperature target and emissions gaps between domestic target under fair share consideration*

Temperature	Absolute emission allowance in 2030	Minimum 2030 Emission Reduction (% below 1990 levels)	Emission Gap from Domestic Target (2030)	Emission Gap from Emissions under Planned Policies (2030)
1.5°C Paris compatible	41 Mt $MtCO_2e$	92%	323 $MtCO_2e$	276 $MtCO_2e$

Italy's fair share contribution to achieve the Paris Agreement long-term temperature goal - of limiting warming to 1.5°C in 2100 - would be an **emission reduction of 92% by 2030 compared to its 1990 emission level** (shown in the graph as the border between green and the hatched blue bar). As is shown in Figure ES2, even taking into account planned policies, Italy's emissions in 2030 would lie at the top end of the emission range that is compatible with a likely warming of more than 3°C. **Italy's current target represents such a low level of ambition that, if other countries were to follow it, it would likely lead to unprecedented warming of more than 3°C by the end of the century.**

Italy's remaining emission budget between 2020 and 2030 that is compatible with its fair share contribution to the Paris Agreement long-term temperature goal **amounts to nearly 2.09 $GtCO_2eq$ at most**. If the current levels of emissions were to continue, **Italy would exhaust its fair share of allowances for the period between 2020 and 2030 already in 2025.**

1. Introduction

Italy's economy, with a 2019 GDP of US$2 trillion, is the world's eighth largest, and the fourth largest in Europe (World Bank, 2020). Despite its economic clout and relative wealth, however, Italy has failed to keep up with the climate commitments of its fellow major European economies. Italy's lack of a 2050 net zero emissions target makes it the only large European economy without one, while the UK and Germany have 2030 emissions targets more stringent than and equal to, respectively, the EU domestic emission reduction target of a 55% reduction in total greenhouse gas (GHG) emissions below 1990 levels. Recent events also imply the adoption of an EU-wide net zero GHG target by 2050.

In contrast, Italy has defaulted to the emissions reductions required of it under the EU's Effort Sharing Regulation (ESR) and committed to the same level of overall emissions reductions required from sectors covered by the EU Emissions Trading Scheme (ETS). Both of these targets were derived using Italy's requirements under the EU's previous 2030 target of a 40% reduction below 1990 levels. Together these targets constitute a 29% reduction in GHG emissions by 2030 below 1990 levels [37% below 2005 levels], well below the EU's new 2030 target of a 55% reduction below 1990 levels. Italy's modest targets will make achievement of the EU's stronger 2030 target more difficult.

This report seeks to assess Italy's climate target against the Paris Agreement's long-term temperature goal of holding global average temperature increase to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. In order to

accurately assess whether Italy's climate target is an adequate contribution towards achieving this goal, this report assesses the entire range of scientific literature which apportions emissions to countries based on various equity considerations to derive a "fair-share" range of emissions for Italy. This report then locates the emission level for Italy in 2030 within this range such that global warming is limited to 1.5°C with consistent effort across nations.

2. Italy's Emissions Profile

2.1 Historical and Projected Emissions

Italy's total greenhouse gas (GHG) emissions peaked in 2005, and fell rapidly over the period 2008-2014 due to ongoing economic difficulties underscored by three recessions across these years. After an uptick in 2015, emissions fell only marginally over the subsequent three years. Emissions data from 2018, the last available year of historical data, puts Italy's overall emissions at 428 $MtCO_2e$ (excluding LULUCF), roughly 17% lower than 1990 levels. Italy's 2017 level of GHG emissions (431 MtCO2e) constituted approximately 0.9% of global emissions for that year (Gütschow, Jeffery, & Gieseke, 2019).

Based on current policies, Italy's emissions are projected to be 384 $MtCO_2e$ by 2030 (Government of Italy, 2019b), which equates to a reduction of 26% below 1990 levels. Total emissions in 2020 under current policies are projected to be 19% below 1990 levels. While emissions reduced globally in 2020 due to the COVID-19 pandemic, emissions in many economies have steadily increased to near-or-above pre-pandemic levels by the end of the year[2]. European energy-related CO_2 emissions rebounded by December 2020 to within 5% of December 2019 levels, aligned more to reductions in carbon-intensive activity than structural changes in European economies.

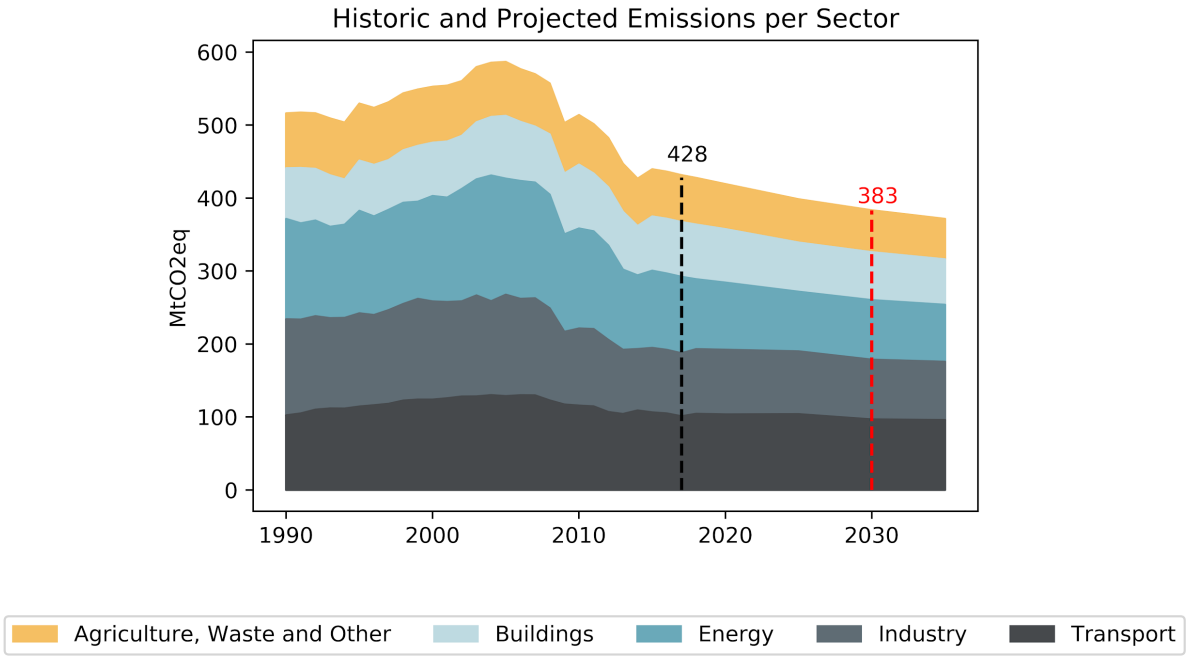

Figure 1: *Historic and projected emissions under current policies per sector for Italy.*
Source: *Own visualisation based on data from (Government of Italy, 2019a, ISPRA, 2020)*

[2] https://www.iea.org/articles/global-energy-review-co2-emissions-in-2020

2.2 Key Emissions Contributions

A country with a historically prominent industrial sector, Italy has since the early 2000s seen it become a source of contraction in average annual value added (Clementi, Gallegati, & Gallegati, 2015). This has coincided with a drop in both absolute emissions levels from industry over this period, as well as in industry's share of total emissions (ISPRA, 2020). This process intensified during the period of economic downturn during and following the 2008/09 global financial crisis. Significant gains made in the uptake of renewable energy sources have led energy emissions to mirror the story of those from the industry sector, also declining in absolute and relative terms since the beginning of the century.

Italy's transport, buildings and agriculture sectors contributed a combined 51% of emissions in 2018, up from 41% in 1990. Emissions from both the transport and buildings sectors have risen over this period as other sectoral emissions have declined, with transport increasing its overall share of emissions from 20% in 1990 to 24% in 2018 (Government of Italy, 2020). Agriculture emissions have declined over this period, but only marginally (-12%). Transport GHG emissions were 2.1 $MtCO_2e$ higher (+2.0%) in 2018 than in 1990, while buildings GHG emissions were 5.5 $MtCO_2e$ higher (+7.9%) in 2018 than in 1990.

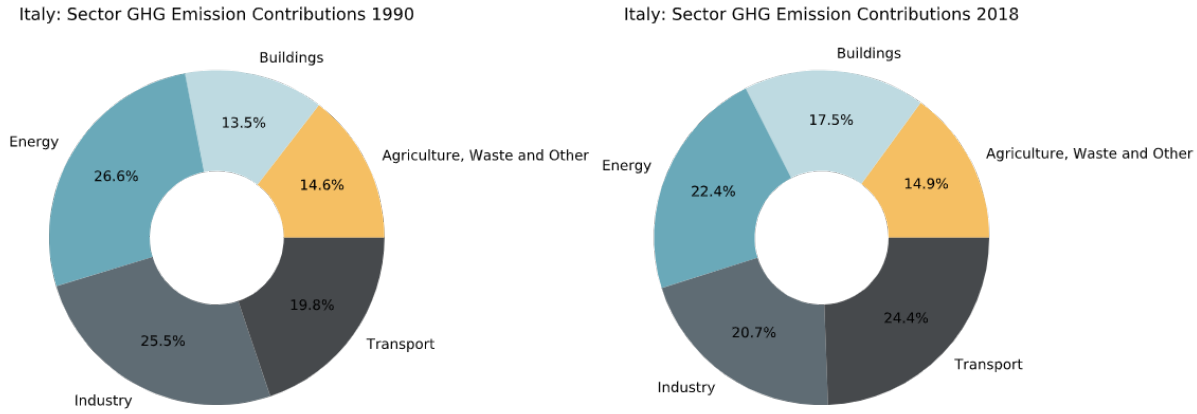

Figure 2: *Comparison of sectoral contribution to emissions (1990 and 2018).*
Source: *Own visualisation based on data from (Government of Italy 2020)*

Drivers of Power Sector Emissions

Italy has made progress in reducing emissions from its power sector, with electricity generation from renewable energy sources reaching 34% of total generation in 2017 (Government of Italy, 2019a). This has coincided with a decline in electricity generation from coal, (-28% between 2009-2018), however generation from natural gas combustion has risen from a dip in 2014, to be roughly in line with 2012 levels in 2018 (Eurostat, 2020).

Italy's commitment to phase out coal use in the power sector by 2030 makes it one of eleven EU countries planning to do so. However, it is also one of only four of these eleven countries that aims to achieve a coal phase-out by substantially increasing generation from natural gas, and of these four countries (Italy, Ireland, Greece, Hungary), Italy plans to increase gas generation the most (Ember, CAN Europe, 2020). Italy projects higher natural gas consumption in the power sector than the average consumption in 2016-2018 in every year until 2029, peaking in 2025 at more than 20% above 2016-2018 levels.

While Italy is targeting a 30% share of renewable energy in gross final energy consumption by 2030, it does not currently have the policies in place to achieve this target (Ember, CAN Europe, 2020). If the planned additions to gas generation capacity proceed as scheduled in the early 2020s, this will provide a strong incentive to the gas industry to prevent such policies from eventuating in order to maintain a strong role for gas in Italy's power sector beyond 2030. This contradicts scenarios meeting the Paris Agreement as assessed in the IPCC's Special Report on 1.5°C which show unabated gas consumption reducing drastically, especially in OECD countries (Climate Action Tracker, 2017).

Drivers of Industry Emissions

Industry emissions in Italy remained relatively constant between 1990 and 2007, before falling significantly between 2008-2014 and remaining stable thereafter (Government of Italy, 2020). This fall in emissions coincided with a drop in total energy consumption from industry, falling 31% between 2000-2017 due to an economic downturn-related drop in activity (44% of gross decline), as well as the realisation of energy savings (56% of gross decline) (ODYSSEE, 2018). The reduction in energy consumption over this period was spread across all energy sources except for renewables which increased 121% from a small base, with oil (-60%), and gas and coal demand (-50%) contributing most to the overall decline (National Agency for Energy Efficiency, 2018). Under current policies, industry emissions are expected to fall just 7.6% between 2018 and 2030, while under planned policies they are expected to fall 11.2% over the same period (Government of Italy, 2019a).

Substantial energy savings from Industry have been realised as a result of the Energy Efficiency Certificates program, with 61% of the 102 TWh of total energy savings from the program between 2013-2016 resulting from measures in the industry sector (Government of Italy, 2017). However, while the annual energy saving from industry in 2016 was just 26.5 TWh, targeted annual reductions by 2020 under Italy's latest Energy Efficiency Action Plan (2017) are 83 TWh, suggesting a greater level of effort will be needed in order to meet this target.

Italy introduced mandatory energy audits for large companies as well as those with high energy consumption starting from 2015 and then every four years thereafter, which will be enforced with the use of financial penalties for non-compliance (QualEnergia, 2014).

Drivers of Transport Emissions

Emissions from the domestic transport sector in Italy peaked in 2004, roughly in line with the peak in total economy-wide emissions, and declined by 20% between 2004 and 2013. Since 2013, however, emissions have not declined further, with 2018 emissions surpassing 2013 levels. This has been driven primarily by a steady increase in light duty vehicle kilometres travelled over this period, sending overall vehicle kms travelled to a record high of 84.1 billion km in 2018, up from the 2013 low of 75.1 billion km (AISCAT, 2013, 2018). A 6.5% reduction in total road freight traffic across Italy between 2013 and 2017 has acted to partially offset the increasing vehicle traffic from light duty vehicles, falling from 8.3 to 7.8 billion km (ANFIA, 2019).

A factor that appears to have been key in helping to prevent emissions from rising in recent years despite increasing light vehicle and total vehicle kms travelled is the EU mandatory emission reduction targets for new cars. This regulation stipulates an average emission level for new cars of 130 grams of CO_2 per kilometre between 2015 and 2019, lowering further to 95 grams of CO_2 per kilometre from 2020 onwards (European Commission, 2020b). In Italy, average emissions per passenger km from new passenger cars sold has steadily declined from the start of the century, but the rate of decline increased after 2010, leading to a record low of 113.3 g CO_2/km in 2016 (European Environment Agency, 2017; ISPRA, 2017).

Drivers of Buildings Emissions

The buildings sector is arguably Italy's worst performing sector with regard to its emissions trajectory, with emissions in 2018 sitting 8% higher than 1990 levels (Government of Italy, 2020). This is primarily due to increasing emissions from commercial buildings, as residential building emissions remained roughly constant between 1990 and 2010 before declining thereafter. Emissions from commercial buildings peaked in 2010 at a level 140% above 1990 levels, declined by roughly 14% in 2011 before remaining relatively constant until 2018. This increase has been driven mainly by rising natural gas consumption, with emissions from combustion of "gaseous fuels" in commercial buildings rising by 113% between 1990 and 2010. After dropping in 2011, commercial building gas combustion emissions have not declined further, with 2018 emissions higher than 2011 levels.

3. Country-specific targets and compliance

In December 2019, Italy submitted its Integrated National Energy and Climate Plan (NECP) as required under the EU regulation on the governance of the energy union and climate action (European Commission, 2020a). Outlined in the plan are Italy's 2020 and 2030 emission reduction targets for different sectors, which do not deviate from those stipulated under the overall reduction target of the EU Emissions Trading Scheme (EU ETS), which covers emissions from the power and industry sectors, and under the EU's Effort Sharing Regulation (ESR) which covers those sectors not covered by the EU ETS. Despite Italy not explicitly outlining an economy-wide 2030 GHG emission reduction target, an implied target can be quantified by calculating the emissions level represented by both Italy's stated targets for sectors under the EU ETS and the ESR. These targets and other sector specific targets outlined in Italy's NECP are shown in **Table 1** below.

Table 1: *Sector specific climate targets*

Source: *Government of Italy, 2019a*

Sector	Target 2020	Target 2030
Implied economy wide target (EU ETS and non-EU ETS sectors, excluding LULUCF)	6% reduction in GHG emissions below 1990 level [16% below 2005 level]	29% reduction in GHG emissions below 1990 level [37% below 2005 level]
Non-EU ETS sectors	13% reduction in GHG emissions below 2005 level	33% reduction in GHG emissions below 2005 level
EU ETS sectors	21% reduction in GHG emissions below 2005 level	43% reduction in GHG emissions below 2005 level
Energy	17% share of energy from RES in the gross final consumption of energy 24% reduction in primary energy consumption compared to the PRIMES 2007 scenario 8% electricity interconnectedness	30% share of energy from RES in the gross final consumption of energy 43% reduction in primary energy consumption compared to the PRIMES 2007 scenario (indicative)

		10% electricity interconnectedness
Transport	10% share of energy from RES in the gross final consumption of energy in the transport sector	22% share of energy from RES in the gross final consumption of energy in the transport sector
Heating and Cooling		+1.3% per year in share of energy from RES in the gross final consumption of energy for heating and cooling

3.1 How well is Italy complying with its targets?

Italy achieved its 2020 GHG emission reduction targets for both the EU ETS and non-EU ETS sectors in 2012. In contrast, under current policies, government projections show Italy missing the overall 2030 emissions reduction target implied by its EU ETS and non-EU ETS sector targets (383 $MtCO_2e$ vs 366 $MtCO_2e$) (Government of Italy, 2019a).

The 2030 emissions target for non-EU ETS sectors requires a strong deviation in current emission reduction trajectories. Government projections for emission reductions under current and planned policies for both EU ETS and non-EU ETS sectors are shown in **Table 2**.

Table 2. *Targeted vs. Projected Sectoral Emission Reductions. Red text indicates that the projected emissions do not meet the target emission levels in 2030.* ***Source:*** *(Government of Italy, 2019a, 2019b)*

Sector	Target 2030	Projection to 2030 with Current Policies	Projection to 2030 with Planned Policies
Economy wide excl. LULUCF (implied)	29% below 1990 level [37% below 2005 level]	26% below 1990 level [34% below 2005 level]	36% below 1990 level [44% below 2005 level]
EU ETS sectors	43% below 2005 level	45% below 2005 level	56% below 2005 level
Non-EU ETS sectors	33% below 2005 level	26% below 2005 level	35% below 2005 level

Table 2 shows that additional policies targeted at non-EU ETS sectors are needed to ensure Italy meets both its non-EU ETS emission reduction target, and the economy-wide GHG emission target implied by its ETS and non-ETS targets. A comprehensive list of policies planned for future implementation can be found in Italy's NECP (Government of Italy, 2019a), which will be referred to in the following as "planned policies".

These planned policies are targeted primarily at the four largest emitting sectors of the Italian economy: energy, industry, transport, and buildings. Additional emissions reductions from the transport and buildings sectors are projected to enable Italy to achieve its 2030 non-EU ETS emissions target. **Figure 3** provides a sectoral breakdown of emissions reductions projected under current policies and planned policies.

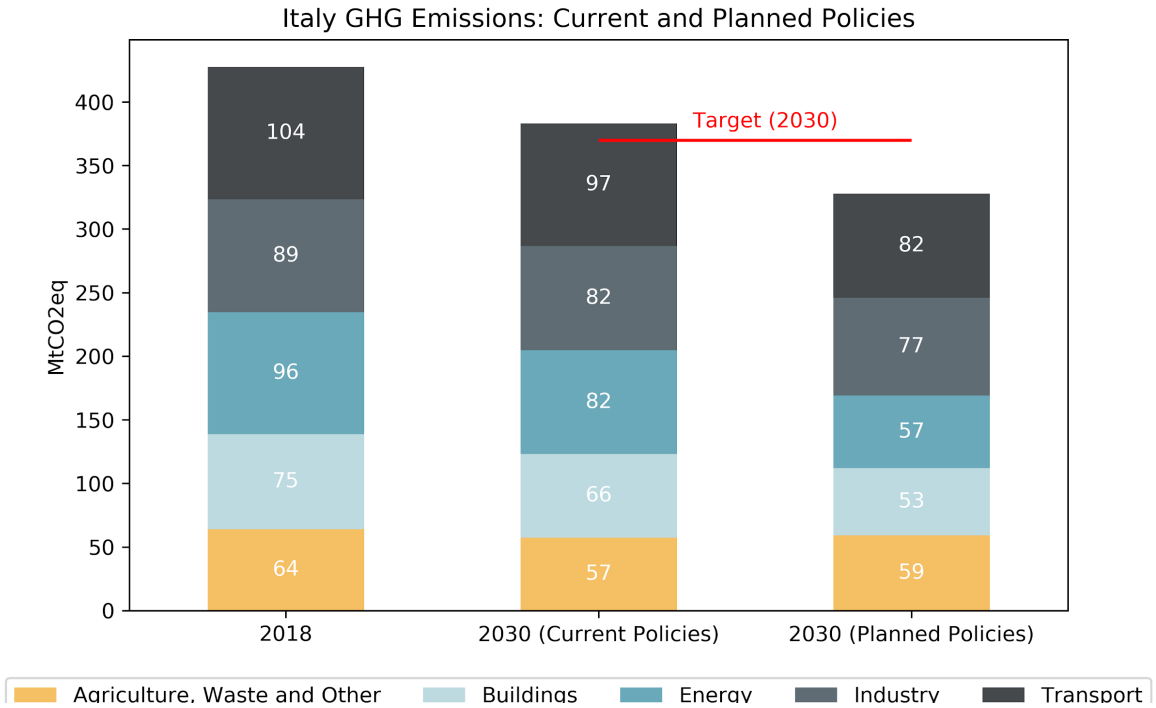

Figure 3: *Sectoral breakdown of projected emissions in 2030 under current and planned policies.*
Source: *Own visualisation based on data from (Government of Italy 2019a)*

3.2 Long-term climate strategy and EU targets

Italy currently does not have emissions reduction targets for 2040 or 2050.

In early 2021, Italy submitted its long-term climate strategy to the European Commission, as required under the regulation on the governance of the energy union and climate action (European Parliament and the Council of the European Union, 2018). The strategy outlines two scenarios to 2050, a 'reference scenario', which projects emissions under planned policies and which results in an emissions reduction of 57% below 1990 levels by 2050, and a 'decarbonisation scenario' which achieves a 90-92% reduction below 1990 levels by 2050 (both excluding LULUCF). The decarbonisation scenario assumes that net zero emissions can be achieved by abatement from the LULUCF sector (Ministry of the Environment and Protection of the Territory and the Sea, 2021).

Of the four largest economies in Europe, only Italy has not yet legislated a 2050 net zero GHG emissions target, with Germany, the UK, and France all recently codifying their targets in law. Other European countries have also legislated ambitious 2050 targets, with Denmark adopting net zero emissions by 2050, while the Netherlands has legislated a target of a 95% reduction below 1990 levels (European Commission, 2020b).

The European Council has endorsed a 2050 net zero target for the EU, while the EU Parliament has expressed support for such a target. In March 2020, the EU Commission put forward a proposal to enshrine the 2050 net zero target in law (European Commission, 2020b). The European Climate Law

proposes to set a 2030-2050 EU-wide emissions trajectory to measure progress and accountability over this period, with five-yearly assessments of EU and national measures against the climate neutrality objective and the 2030-2050 trajectory. The Commission will be empowered to issue recommendations to Member States whose actions are not compatible with the 2050 target. The Member States will be required to take account of these recommendations or explain their reasoning for a failure to do so.

In 2020, the EU strengthened its previous 2030 emissions target of a 40% reduction below 1990 levels, to at least a 55% reduction below 1990 levels (European Commission, 2020c). The EU's new 2030 target will now lead to a more stringent level of emissions reductions for individual member states than those upon which Italy's 2030 is formulated. Consequently, Italy's current target will be insufficient to achieve the proposed higher level of EU-wide ambition.

4. Interpretation of the Paris Agreement Long-Term Temperature Goal

Determination of the Long-Term Temperature Goal under the UNFCCC

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) defined the goal of the Convention to "*achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*." Since 1992, the State Parties to the UNFCCC have determined the long-term temperature goal (LTTG) that aligns with the prevention of dangerous climate change, in light of best available science. There are two key periods of development of the LTTG:

- From 2010 – 2015 (prior to the Paris Agreement): State Parties to the UNFCCC defined the LTTG as "below 2°C";
- Following scientific developments and since the adoption of the Paris Agreement in 2015: State Parties to the UNFCCC have defined the LTTG as "*well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C*" (article 2.1(a) Paris Agreement,).

The decision at the Conference of the Parties (COP) to the UNFCCC in Cancun in 2010 determined that urgent action needed to be taken to hold global average temperature to below 2°C above pre-industrial levels, establishing "below 2°C" as the LTTG (Decision 1/CP.16, "Cancun Agreement"). In the same decision, it was decided to set up a review to consider the necessity of strengthening the LTTG "on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5°C."

The so-called 2013-2015 Periodic Review of the adequacy of the LTTG, conducted under the UNFCCC conducted an extensive science-policy dialogue process known as the Structured Expert Dialogue (SED), in which 70 top scientists participated. The SED concluded in its summary report that based on the extensive evidence reviewed, "*the 'guardrail' concept, in which up to 2°C of warming is considered safe, is inadequate and would therefore be better seen as an upper limit, a defence line that needs to be stringently defended*", and that efforts should be made to "*push the defence line as low as possible"*, noting that a warming limit of 1.5°C would come closer to a *"safer guardrail*" (UNFCCC, 2015b).

Following the outcome of the 2013-2015 Periodic Review, in 2015 the State Parties to the UNFCCC adopted the Paris Agreement. The Paris Agreement defined a *new* LTTG in Article 2.1(a), as follows:

> "*Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change*;" (UNFCCC, 2015a).

The LTTG in Article 2.1(a) constitutes a single temperature goal ('*the long-term temperature goal*' as specified in Article 4.1 Paris Agreement) rather than "well below 2°C" and 1.5°C constituting separate goals (Thorgeirsson, 2017; Rajamani and Werksman, 2018).

The LTTG delineates the permissible space for future warming. The temperature goal caters for two interpretations: establishing a 1.5°C limit as a ceiling that should not be exceeded; or allowing for a temporary exceedance (overshoot) of the 1.5°C limit, while warming should always remain "*well below 2°C*" (Mace, 2016).

Legal opinion on States' obligations under the Paris Agreement has also interpreted Article 2.1(a) as a mandate for striving to limit warming to 1.5°C. The judgment of the Supreme Court of the Netherlands in 2019 in *Urgenda Foundation v The State of the Netherlands* (ECLI:NL:HR:2019:2007) highlights the Netherlands' obligation to 'endeavour to limit warming to 1.5°C'. Similarly, the Irish High Court in *Friends of the Irish Environment v The Government of Ireland* ([2019] IEHC 747) found that scientific understanding of the 'safe temperature rise target' sought by the Paris Agreement has increasingly gravitated towards 'a lower figure … in the region of 1.5°C'.

4.1 Emission scenarios in line with the LTTG

The reports of the Intergovernmental Panel on Climate Change (IPCC) provide the best available science for the determination of emissions reduction pathways that are in line with the LTTG under the Paris Agreement.

Due to inherent uncertainties linked to feedback mechanisms in the climate system (such as from clouds, oceans or the global biosphere), the climate response to greenhouse gas emissions (in the form of temperature increase) is subject to inherent uncertainty (IPCC, 2014). Linking emissions reduction pathways to temperature limits thus always implies different probabilities of exceeding this warming limit.

The science that informed the 2013-2015 Review and the adoption of the Paris Agreement was the Fifth Assessment Report (AR5) of the IPCC. In the AR5, and the wider scientific literature, the "below 2°C" goal of the Cancun Agreement was interpreted as a 66% probability of holding temperature increase to this level (or "likely" probability in IPCC terminology). This is reflected in decisions taken by the Conference of the Parties to the UNFCCC prior to the Paris Agreement: based on the "below 2°C" LTTG, the decisions referred to emission pathways with a likely (66%) chance of staying below 2°C. Such pathways would thus have a 33% probability of exceeding 2°C and even a non-negligible probability of exceeding 2.5°C of warming (6%) (IPCC, 2018).

Such emission pathways with a likely (66%) chance of staying below 2°C are therefore *not* in line with Article 2.1(a) of the Paris Agreement which sought to significantly strengthen the "below 2°C" LTTG by holding the temperature increase "*well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C*".

Following IPCC terminology, a 'very likely' (or 90%) chance of not exceeding 2°C is the plausible interpretation of holding warming to 'well below 2°C' following the concept of a line to be stringently defended.

The IPCC Special Report on Global Warming of 1.5°C (SR1.5) authored by more than 91 scientists and policy experts drawn from 44 nationalities, provides the most comprehensive assessment to date of greenhouse gas emission pathways that would meet the LTTG of the Paris Agreement. Emissions trajectories used in this report are derived from numerous modelled scenarios reflecting different evolutions of global energy demand and consumption and non-energy emissions. The scenario pathways relevant for the interpretation of the Paris Agreement LTTG are:

- 1.5°C no or low overshoot pathways;
- 1.5°C high overshoot pathways; and
- lower 2°C pathways.

The lower 2°C pathways have a (66%) chance of staying below 2°C (SR15 Table 2.SM.11) and are therefore not in line with LTTG as defined in the Paris Agreement. The so-called 'high overshoot 1.5°C' pathways are in fact above 1.5°C pathways with a 33% or worse chance of remaining below 1.5°C. These pathways resemble 'lower 2°C' pathways before achieving extreme amounts of negative emissions by deploying large-scale carbon dioxide removal (CDR) efforts to extract CO_2 from the atmosphere and reduce temperatures again to below 1.5°C in 2100 after a temporal 'overshoot' of the temperature limit. Both 'lower 2°C' and 'high overshoot 1.5°C' have similar peak warming characteristics (SR15 Table 2.SM.12).

The IPCC notes that the feasibility of achieving large-scale deployment of CDR measures is "uncertain and entails clear risks" (IPCC, 2018). In addition to sustainability concerns of deploying CDR measures at large scale, pathways that allow for a high overshoot have a much larger likelihood of triggering irreversible tipping points, such as the melting of the permafrost, which would lead to further temperature increase. The 1.5°C high overshoot pathways identified in SR15 are therefore not a permissible interpretation of the Paris Agreement LTTG.

The only emissions pathways from the IPCC SR1.5 report that are in line with the Paris Agreement LTTG are those categorised as "no or low overshoot 1.5°C pathways" that are "as likely as not" to limit warming to below 1.5°C throughout the 21st century (with a probability of more than 33%) and to limit warming to below 1.5°C in 2100 with at least 50% chance. Pursuing such an emission reduction pathway would also give a 'very likely' (>90%) probability of not ever exceeding 2°C, in line with the interpretation of 'well below 2°C' as a '*defence line that needs to be stringently defended*' UNFCCC, 2015b), as outlined above.

In conclusion, emission pathways with a likely (66%) chance of staying below 2°C are not in line with the Paris Agreement LTTG. Due to feasibility and sustainability concerns and increased climate risks, the 1.5C high overshoot pathways identified in SR15 are also not a permissible interpretation of the Paris Agreement LTTG. The UNEP GAP report series include a pathway category labelled "below 1.8°C" (with 66% chance), but such pathways still include a considerable risk (about 1-in-5 chance) of exceeding 2°C and are therefore not in line with the Paris Agreement LTTG. Emission mitigation benchmarks for Paris Agreement compatible pathways are available from the IPCC SR1.5 as 'no or low overshoot 1.5°C' pathways that limit warming to 1.5°C with 50% or higher probability. This report will use these 'no or low overshoot 1.5°C' Paris compatible pathways for the determination of Italy's fair share emission allowance that is in line with the Paris Agreement.

4.2 Italy's reduction target compared to 1.5°C compatible global emissions reductions

The models used by the IPCC in SR1.5 which generate trajectories that are consistent with different temperature levels generally use a framing of 'cost-effectiveness' or 'cost-optimality'. These models mitigate emissions in the sectors and geographic locations where the models determine it is cheapest to do so. However, the IPCC does not classify cost-effectiveness as an 'equity-based' model of emissions reductions (IPCC AR5, see also section 5.1 below). Thus, although the planned emission reductions by Italy can be compared with these global 'cost-effective' emissions reductions, these emission reductions are not in line with equity considerations that can inform a 'fair share' emission level for Italy.

As outlined in section 4.1, only the "no or low overshoot 1.5°C pathways" in IPCC SR1.5 are in line with the Paris Agreement LTTG. The SR1.5 finds that in these pathways, global total GHG emissions need to be reduced by 2030 to 45% (40-60% interquartile range, IPCC, 2018) below 2010 levels, or in emission terms to between 25-31 $GtCO_2e\ yr^{-1}$. The median estimate of 27 $GtCO_2e\ yr^{-1}$ equates to a reduction of 42% below 2015 levels globally (IPCC, 2018, Gütschow et al, 2019). All "no or low overshoot 1.5°C pathways" reach net zero GHG emissions levels. Global anthropogenic CO_2 emissions reach net zero around 2050 (2046-2055 interquartile range, IPCC, 2018), as shown in **Figure 4**.

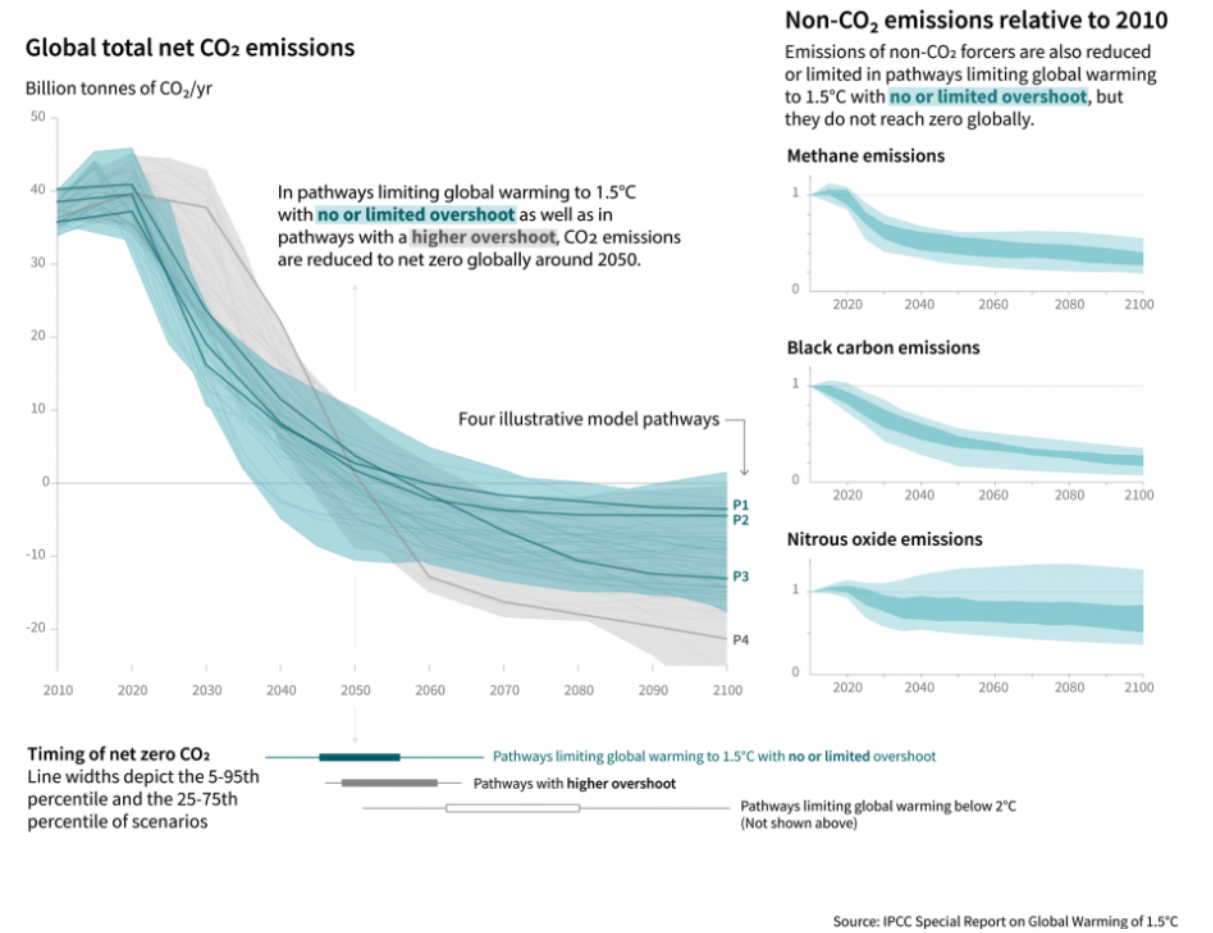

Figure 4 *Global emissions reduction pathways from SR1.5 Summary for Policymakers*

The emissions reductions planned by Italy can be compared with the global emissions reductions achieved by "no or low-overshoot pathways" in the IPCC SR1.5. These global emission reductions

represent the global average of necessary emissions reductions that countries collectively need to achieve in order to meet the Paris Agreement LTTG. **Figure 5** shows the median of such pathways globally (left panel). The right panel compares this trend using percentage reductions to determine an Italian emission pathway which is in line with the global average pathway starting from 2020. In 2030, current Italian policies would result in reductions of 26% compared to 2010 (or 1990 given they happen to be roughly equivalent) levels, planned policies would result in reductions of 36%, and the reductions implied by the median global IPCC pathway would require a reduction of 63% in 2030 compared to 1990 levels. Therefore, Italian policies do not even meet the required 1.5°C Paris compatible mitigation level implied by the reduction rate from global "least-cost" pathways (which, as indicated above, are not consistent with the principle of equity in the UNFCCC and the Paris Agreement).

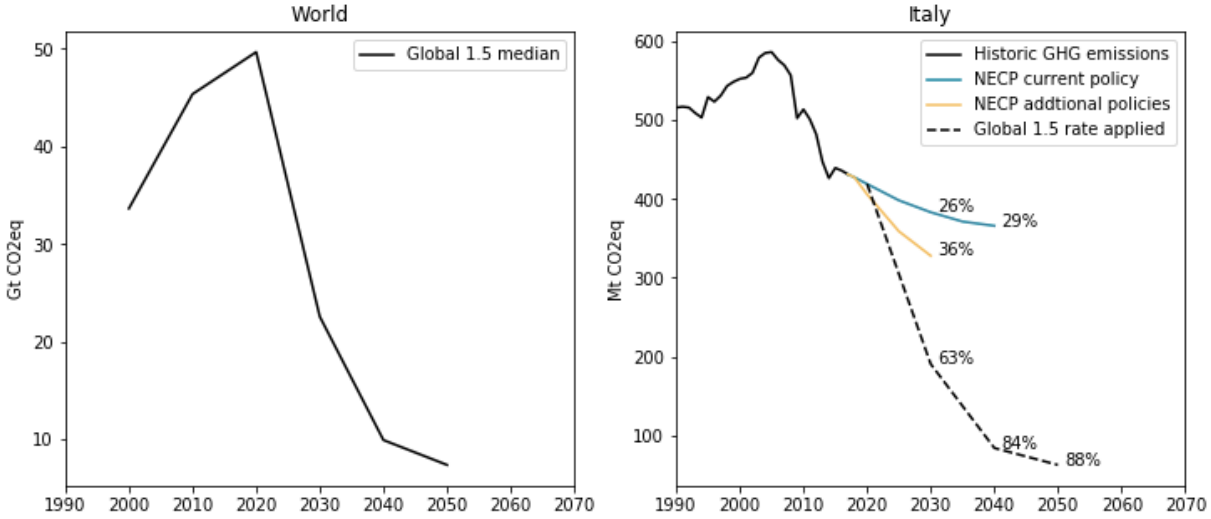

Figure 5 *Global emissions reduction pathways from SR1.5 applied to Italy's current policy emissions in 2020. The percentages shown in the right panel are the percentage reduction compared to 1990/2010 emission levels (the two values are within 3Mt of each other and thus provide similar percentage reductions).*

The 1.5°C scenarios with "no or low-overshoot" in IPCC SR1.5 provide a range of least-cost mitigation pathways that are considered compatible with achieving the Paris Agreement LTTG at a global level. They are based on a cost-effective allocation of emissions, and, for many developed countries this cost-effective allocation lies above their fair share allowances. Hence, they not only have to reduce emissions *at least* at this rate but also need to support emission reduction in developing countries to be in line with the principle of Common But Differentiated Responsibilities. This principle informs how the burden of emissions reductions should be distributed, such as by taking into account the historical responsibility for climate change and capacity to act of individual countries.

When equity is considered, it becomes clear that Italy is responsible for doing more than what would be required if Italy were to follow the global average of necessary emission reductions as set out in this chapter. The following chapter will determine the necessary emission reduction level for Italy that is in line with global equity considerations.

5. Italy's Climate Targets Under Global Equity Considerations

This section presents Italy's fair share of emissions trajectories consistent with limiting warming to 1.5°C and 2°C. First, the findings on equitable emission allocation schemes from the IPCC's 5th Assessment Report are reviewed and complemented with an assessment of the literature that has been published since. Further, section 5 highlights the methodology used to obtain the "fair share" of allowed emissions for Italy, taking into consideration the methodology used in the IPCC's 5th

Assessment Report (AR5) and finally concludes with a comparison of Italy's fair share of allowed emissions against its current 2030 emissions target and the projection of its 2030 emissions level with the implementation of the planned policies provided in the NECP.

5.1 IPCC assessment of equitable effort sharing methodologies

In 1992, within the United Nations Framework Convention on Climate Change (UNFCCC), all countries agreed to pursue efforts to *"[…]stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*" and to do so *"[…] on the basis of equity and in accordance with their common but differentiated responsibilities*" (United Nations Framework Convention, 1992). However, there has been no agreement on how the notion of "equity" and "common but differentiated responsibilities" translates into concrete emission reduction targets for countries. A large number of "emissions allocation" schemes (also referred to as "effort-sharing approaches"), grounded in different ethical considerations, have been suggested by policy analysts and researchers (Klinsky & Dowlatabadi, 2009; Rao, 2014). These allocation schemes do not express where emissions need to be reduced, but rather what level of responsibility countries have to achieve emission reductions, based on different equity interpretations. The allocation schemes are based on the presumption that countries may also fulfil their emission reduction responsibility by contributing to emission reductions outside their own territory. To provide means to compare the emissions reduction targets implied by these allocation schemes, Höhne et al. (2014) propose a categorisation method to allow for comparison (**Figure 6**).

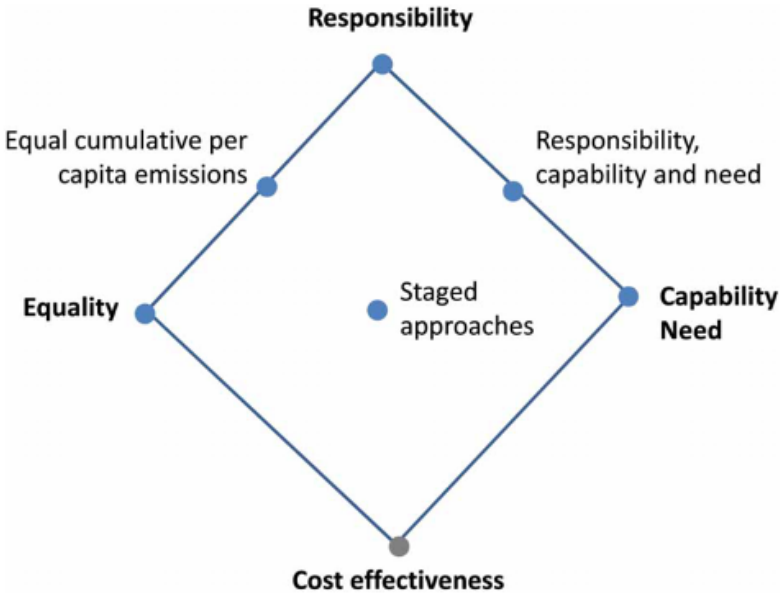

Figure 6 *Categories of effort-sharing approaches suggested by Höhne, den Elzen and Escalante (2014)*

This categorisation method of Höhne (2014) provided the basis for the analysis of equitable emissions allocations presented in Chapter 6 of Working Group III of the IPCC 5th Assessment Report (Clarke et al., 2014). The IPCC 5th Assessment Report provided an assessment of all available interpretations in the literature on how emissions reduction efforts can be equitably divided among countries. These emission allocation schemes are also referred to as "equity approaches" in the literature. Scientific literature that analyses these approaches is referred to here as "equity literature".

Cost-effectiveness is not considered as an equity-based allocation scheme by the available literature as assessed by AR5 (represented as a grey dot in **Figure 6** and equivalent to the equal marginal abatement costs category in **Figure 7** below). **Figure 7** is taken directly from the IPCC 5th Assessment

Report and presents the results of emissions allowances in 2030 (relative to 2010 emission levels) for all the different equity approaches. The figure illustrates the large range of results both across and between clusters of equity approaches. It is important to note that the estimates presented are for equity approaches that reach an end-of-century global warming between 1.5 and 2.0°C[3]. Another key element of the analysis presented in this chapter of the IPCC report is that the estimates are grouped at the "R5 region" level[4], providing limited guidance on the emission allowances for individual countries.

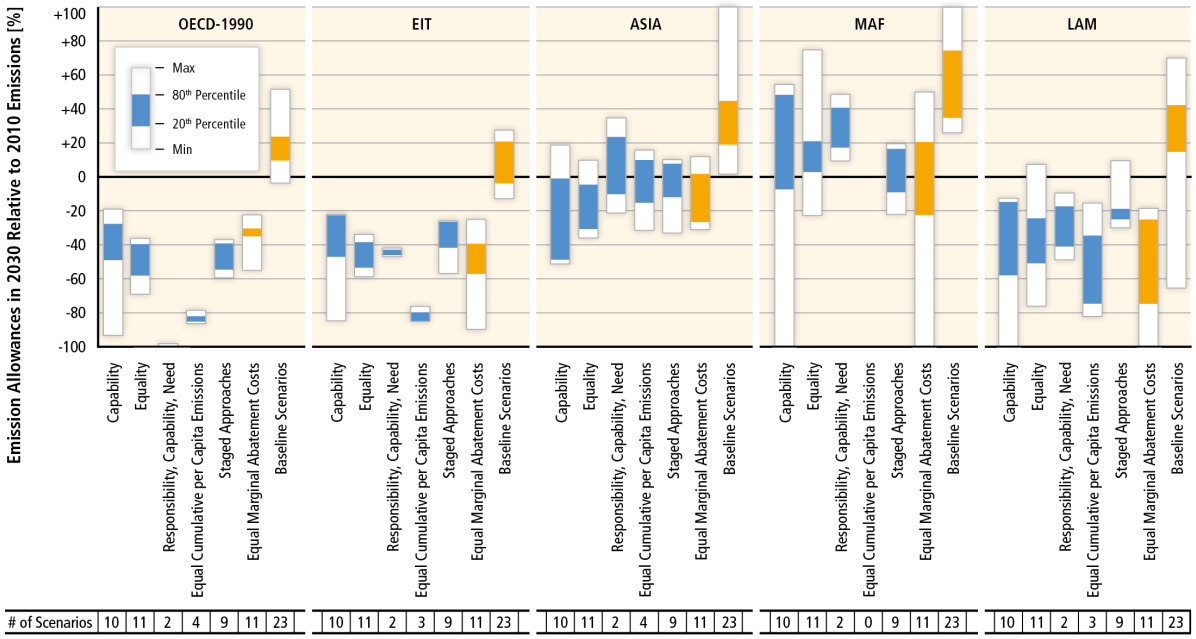

Figure 7 *Emission allowances in 2030 (relative to 2010 levels) assessed in the 5th Assessment Report. Source: IPCC (2014). Blue bars denote equity-based approaches, and yellow bars denote results for cost-effective mitigation models. Note that the 'equal marginal abatement costs' and 'baseline' scenario is included here only as a reference to the equity results.*

5.2 Applying the IPCC effort sharing methodology to Italy

To conduct an updated country-level evaluation for Italy, the emission allowances dataset of the Climate Action Tracker is used. This dataset contains the emissions allowances presented in a variety of peer-reviewed publications, including the studies assessed in the IPCC 5th Assessment Report and the literature that has been published since its publication in 2014. Climate Analytics developed a tool to quantify equity approaches found in the literature with updated historic data and more up-to-date compatible emissions pathways[5] (regarding a given temperature target). The literature data was combined with these additional estimates to overcome data scarcity in the literature, for certain countries and categories.

Figure 8 and Table 3 provide the range of results of emissions allowances in 2030 (relative to 2010 emission levels) for Italy that are represented in the equity literature for two end-of-century

[3] Scenarios categories by the AR5 report are 430-480ppm:
https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

[4] For more details on the region definitions see:
https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about#regiondefs

[5] Scenarios form the Special Report 1.5 database:
https://data.ene.iiasa.ac.at/iamc-1.5c-explorer

temperature targets (1.5°C and 2°C). In Figure 8 the short horizontal lines or "whiskers" represent the full range of results from the literature. The box represents the 20th – 80th percentile range of the emission allowance results. The bracketed numbers above each figure represents the number of study results present for each category. Some of the equity interpretations lead to negative emission allowances for Italy by 2030, which could only be achieved by contributing to emission reductions in developing countries or reaching negative emissions domestically, for instance through technical carbon-dioxide removal (CDR). The figure also shows Italy's current reduction target (29% reduction from its 2010 level – indicated by the dark red line) and reduction implied from its planned policies (36% reduction from 2010 levels, indicated by the red line).

The figure shows that neither Italy's current 2030 target nor its reduction level when all its planned policies are implemented are compatible with any of the equity approaches that are represented in the literature for both 1.5 and 2°C temperature limits. **Table 3** shows the results per equity approach for each temperature level as depicted in **Table 8.**

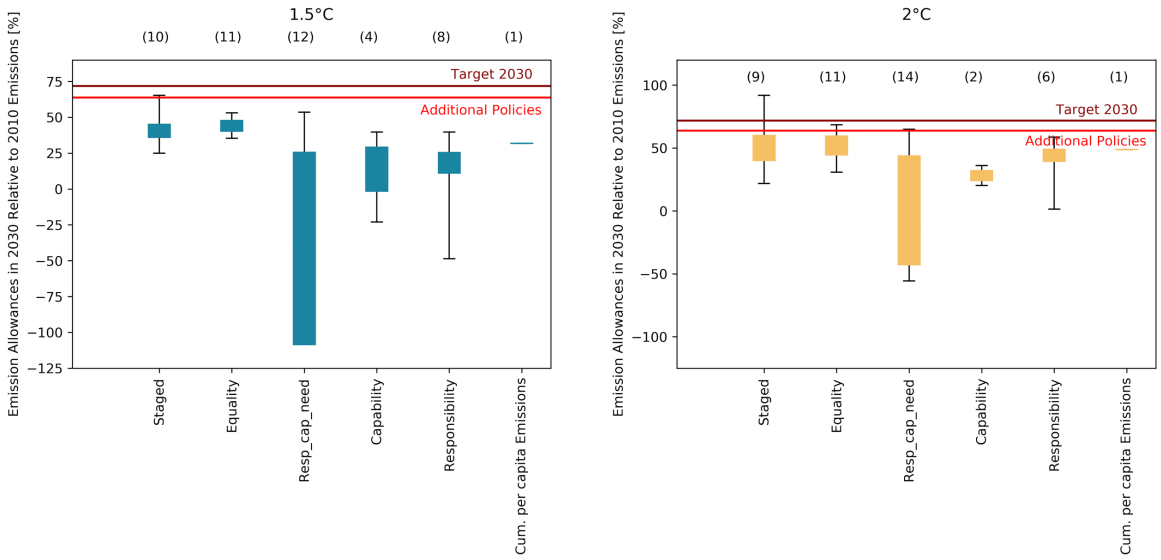

Figure 8: *Emission allowances in 2030 for 1.5°C and 2°C temperature levels, based on the categorization method used in the IPCC's 5th Assessment Report. The vertical axis shows the emission allowances in 2030 as percentage compared to its 2010 levels. The blue and yellow bars show the range of results for Italy's fair share allowances for the different interpretation in the literature. The horizontal lines present the level of emission on the basis of current policy projections (dark red) and the additional policies projections (red) by the Italian government.*

Table 3: *Comparison of emissions allowances in 2030 (compared to 2010 levels) for Italy according to the categorisation method used in the 5th Assessment Report. For Italy, 1990 and 2010 emissions levels are very similar, meaning these figures also apply to % of 1990 levels. Values are provided from the 20th percentile (most stringent) to the 80th percentile (least stringent).*

Equity approach category	1.5°C compatible emission allowances in 2030 (% of 2010 levels) [20th, 80th percentile]	2°C compatible emission allowances in 2030 (% of 2010 levels) [20th, 80th percentile]
Equality	[40%, 48%]	[39%, 62%]
Staged	[34%, 46%]	[39%, 61%]
Responsibility Capability Need	[-100%, 41%]	[-34%, 54%]
Capability	[-6%, 31%]	[23%, 32%]
Responsibility	[5%, 27%]	[36%, 49%]
Cumulative per capita emissions	[32%, 32%]	[49%, 49%]

This analysis has limited utility due to the range in the emission allowances for each temperature level being quite large, and the results for the same equity approach between different temperature levels often overlap. The reasons for this are discussed in Höhne, den Elzen and Escalante (2014) and include, among other reasons:

- The choices underlying the quantification of the equity principle. We will explain this using the equity approach of 'Responsibility' as an example. The premise of 'Responsibility' is that countries that have emitted more historically (and are hence considered developed countries today) should be responsible for more mitigation, or, should have less access to the remaining allowed emissions. There are differences in implementation of this in the literature, which include the scope of gases that a country can be considered responsible for (for instance, calculating the allowances based on responsibility for energy CO2 emissions only versus calculations based on total greenhouse gas emissions) as well as the timeframe for responsibility (only from 1990 - present, or 1850 - present, for example). Each of these choices would lead to very different numerical results.
- The starting year of allowance allocation. Studies that start allocating allowances later have an element of grandfathering (i.e. more generous allowances for high emitters), in that they do not penalize countries (especially developed countries) for their continued trend of growing

emissions. This is another key reason why the same equity approach, when implemented with different base years, can lead to very different results.

Differences in when and how studies on equity approaches were implemented and variations in input data thus lead to a large variation in results, both within and across the equity approaches. For the underlying assumption of this study that all equity approaches are equally valid, the range of allowable emissions (the 'full' equity range) becomes even bigger. Thus, such an analysis based on the range of literature estimates does not provide useful guidance on what a "1.5°C compatible" level of emissions is for a particular country. It merely indicates that this level in 2030 for Italy should be within -100% to 48% of 1990 emission levels (-513 to 246 $MtCO_2e$ in 2030 excl. LULUCF). The constructed range based on multiple equity approaches does not in fact accurately represent the underlying emission budget required to limit global warming as we will illustrate in the following example.

So far, the analysis has shown that the current targets lie outside of the full range of equitable emissions levels to reach 1.5 or 2.0°C warming. But even if that would be the case, a target within the full range of the available equity literature will not by itself lead to Paris Agreement compatible warming levels. The following simple example will explain why the fair share range needs to be further limited to achieve a desired global warming level.

A synthetic example shown in **Figure 9** illustrates why the upper range of the emission allocation, or budget of each country (i.e., the most generous allocation for the country) is exceeding the actual emission budget and the respective limit of warming. It comprises a three-country example with three equity approaches to split a remaining emission budget of 8 parts under equity consideration. Country names are only selected to better illustrate properties like population, historic emission and economic potential. Assuming the first equity approach of "Equality" (equal per capita emissions) would allow "China" to emit 5 parts, attributing its large population, while the small state of "The Gambia" would need to limit itself to 1 part. Switching to the second equity approach of "Responsibility" would shift the emission allocation. "China" and "The Gambia" would end up with more generous emission allowances while the United Kingdom would need to reduce its emission to 0 Mt due to its long industrial history and related emissions. The third equity approach of "Capability" focuses on the economic feasibility and would again lead to a different split. In all approaches any higher or lower allowance of one country is compensated by the other countries since the total budget is the same (8 parts).

Assuming that all three equity approaches are valid, this would lead to an equitable range for China of 3-6 parts, 0-3 parts for England and 1-2 parts for The Gambia. However, this range in itself is insufficient to represent the level of emissions that each of the countries would need to achieve to stay within the budget in each study individually.

If all countries would choose the equity approach that is most preferable to it, thus emitting at the top of their range, this would lead to total emissions that go beyond the available emission budget. In the example set out in Figure 9 the upper bound would allow the three countries 6 + 3 + 2 and a total of 11 parts. At this upper bound, all countries' allowances are at the maximum, but no country is compensating for this additional budget (as it is the case in the individual equity approaches). Similarly, if all countries achieve their most strict equitable level, the total emissions would be less than the available budget. In the example set out in Figure 9, total emissions in this scenario would be 4 parts, half of the available budget. In other words, looking at the full range across the different equity approaches mixes the different approaches for individual countries and therefore violates the initial budget limitation.

	China - High population - Medium historic emissions	United Kindom - Medium population - High historic emissions	The Gambia - Small population - Few historic emissions	**Sum of Emissions (Budget)**
Equal per capita emissions				8
Historic responsibilty				8
Capability				8
Upper range	6	3	2	11
Lower range	3	0	1	4

Figure 9 *presents a simplified example to illustrate equity mechanisms in a hypothetical three country world. It illustrates that equity principles re-distribute a given emission budget. It illustrates that the upper and lower bounds of the range do lead to different emission budgets than in the individual equity approaches.*

In other words, merely looking at the "total range" or "full fair share range" of an individual county does not take efforts of other countries into account and neglects the interactions of all nations in the individual equity studies.

The full fair share range combines the results of all the individual equity studies. Each study is calibrated to lead to a particular warming level assuming that all countries adopt the reduction levels that are the result of the particular study. If a country were to reduce its emission to a lower level than indicated by the study, this would need to be compensated for by more stringent emissions levels for another country if warming were still to be limited to 1.5°C.

Section 5.3 will show in fact that if every country would commit to reduce emissions to the upper end of its own "full fair share range" of "equitable" allowances, thus choosing the equity approach that is most preferable to itself, global temperature would likely exceed 3C of warming, far exceeding the 1.5°C warming limit of the Paris Agreement.

The next section will illustrate the additional steps that will allow us to derive specific emissions reduction levels for individual countries that lead to Paris compatible 1.5°C warming that are located in the individual fair share ranges.

5.3 Determining Paris compatible fair share emission reduction levels

Section 5.2 showed that Italy's planned emissions reductions towards 2030 are incompatible with equity approaches that are represented in the literature. The following section will present an analysis to determine the fair share reduction level for Italy in line with the Paris Agreement LTTG. In order to arrive at this result, two steps will be taken. The first step is to aggregate all the results of the different

equity approaches (outlined in the previous section) for individual countries. As a second step the emissions reduction level for Italy will be determined by its fair share of limiting warming levels in line with the Paris Agreement LTTG, assuming that all other countries adopt the same level of ambition. To determine this, we create a "full fair share range" for each country then place each country level in the same relative position within this range. Agreeing on this definition of the same level of ambition, based on the equity literature range, we further find the exact levels that all countries would need to be placed to achieve an aspired level of global warming.
Applying this methodology to the simplified example above, we would find the relative position within the individual ranges of the three countries which when summed up would result in a total budget of 8 parts.

The analysis follows the Climate Action Tracker's methodology[6] and IPCC equity considerations (Ganti et al., submitted). It provides a consistent framework of comparing emission targets with the many interpretations of what is considered "fair". Similar to the example in section 5.2, first all quantified equity approaches from the literature for all countries are combined in a comprehensive dataset. This dataset represents the entire range of the interpretations in the literature of what is considered to be a "fair share" for each country. Different from the presentation in section 5.2, we combine the results of achieving a warming level of 1.5°C and 2°C in one data set. This allows for a more rigorous analysis that takes into account a wide spectrum of interpretation of what is a fair contribution based on what is available in the literature to achieving a particular temperature goal. In a second step, the data is used to construct a country-specific range of equitable emissions levels for all countries individually.

Lastly we derive global pathways corresponding to different temperature outcomes that would result if all other countries were to put forward emissions reduction targets with the same relative ambition level within their country-specific range.

As we outlined in section 4.1, the emission pathways described by the IPCC in its SR1.5 which are compatible with the long-term temperature goal of the Paris Agreement are categorized as 'no or low overshoot 1.5°C pathways.' In this report we categorize these pathways as 1.5°C Paris compatible pathways. In addition, we also provide fair share emission reduction levels for global warming levels of 1.8°C, 2°C and 3°C. As was outlined in section 4.1, pathways that reach these temperature levels are not in line with the Paris Agreement LTTG. These temperature levels are provided as benchmarks in order to assess the global temperature level that would occur if all countries adopt a similar ambition level to that of Italy.

5.4 Aggregating equity approaches into a single fair share range per country

Multiple considerations are included in the creation of the fair share range in order to provide an agnostic assessment that gives equal weight to all the different equity approaches in the literature (as described in section 5.1 above)":

- As shown in **Figures 6, 7 and 8**, the equity literature can be grouped into different kinds of equity approaches. In order to account for all of the equity approaches equally, we introduce a weighting scheme that ensures the contribution of each approach is equal.

- Scientific literature taken up by the IPCC (5th Assessment Report and SR1.5) provides different global pathways compatible to 1.5°C and 2.0°C and a variety of plausible Business As Usual (BAU) scenarios (here RCP8.5 is used). Each pathway has different underlying assumptions regarding population growth and when emissions peak. Therefore, where possible, each

[6] See https://climateactiontracker.org/methodology/comparability-of-effort/

equity approach is quantified for a range of baselines and compatible pathways in order to derive a best estimate.

Due to the huge variety and sources of equity estimates additional steps are required to reduce the possible effect of single extreme values (outliers). To account for outliers and ensure a robust measure, the resulting full range is stripped of extreme values by limiting the range between the 5th and 95th percentile.

The resulting range provides a robust upper and lower limit of what is considered as "fair" given available literature and equity approaches. The upper level relates to the least stringent emissions level from the country perspective (most allowed emissions) and the lower limit relates respectively to the most stringent emission reductions (least allowed emissions). This range is constructed for all countries individually.

5.5 Constructing a global fair share range

As was shown in section 5.3 the "full fair share ranges" for individual countries in themselves are insufficient to determine the level of emissions reductions that a country must reach in order to contribute its fair share towards limiting warming to 1.5°C.

The primary reason for this is that if all countries choose to reduce emissions on the basis of the equity approach that is most preferential for them individually, this would lead to a higher level of cumulative emissions than is allowed to stay below the temperature target.

We run a climate assessment, to assess the results of a scenario in which all countries would reduce emissions to the level implied by the top of their full fair share range. In this "global worst case" warming would reach ~3.1°C above the pre-industrial period by 2100. Thus, despite the fact that individual studies apply equity approaches that allocate emissions allowances so that total emissions do not violate their individual budgets for 1.5°C or respective 2.0°C limit, the aggregated fair share ranges are not compatible with these warming limits.

On the other hand, the "global best case" scenario would be if each country chooses to reduce its emissions at the most stringent lower range of equity approaches presented in the literature.

Figure 10 illustrates the emission pathways until 2030 of both the "global worst case" and "global best case" scenarios, compared to the Paris compatible emission scenario (the median of the 'no or low overshoot 1.5°C' emissions scenario reported by the IPCC in SR1.5 and shown in **Figure 5**). The emissions gap between the "global worst case" and the SR1.5 IPCC 1.5°C scenario median, which is considered Paris compatible, is 26.6 Gt in 2030. On the contrary, the "global best case" is much lower than the Paris compatible scenario (**Figure 10**) and therefore would over-achieve the 1.5°C warming target.

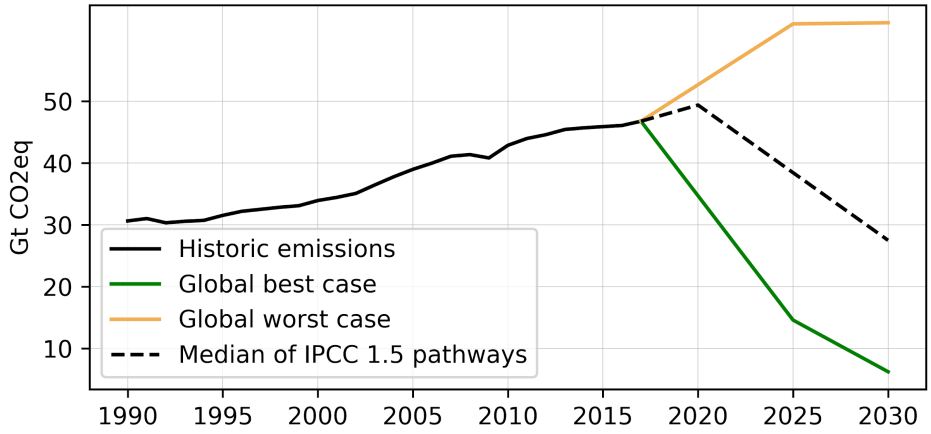

Figure 10: *Global GHG emissions based on effort sharing levels. The "global worst case" results in all countries going to the individual upper bound of their fair share range. The "global best case" would be the outcome if all countries go to the lower bound of their fair share range.*

On the basis of these results, we can now determine the relative level of effort within the full fair share range for each country that would be sufficient to achieve the Paris Agreement LTTG.

5.6 Identifying the 1.5°C Paris compatible ambition level within the fair share range

As stated in section 5.5 and in **Figure 10**, the "global worst case" in which all countries reduce emissions to a level as implied by the top of their full fair share range would lead to a warming of ~3.1°C while the "global best case" would result in warming of below 1.5°C. In this section we identify the ambition level of emission reductions for each country, which collectively would lead to achieving the Paris Agreement LTTG. We do this by determining the level of ambition that each country would need to achieve within its own "full fair share range" in order for the collective efforts of all countries to be sufficient to stay below a certain temperature level. This methodology thus takes as a basis the full range of equity approaches in the literature, which allows for differentiation of efforts between countries in line with the principles of equity and CBDR. The full equity ranges provide a common scale for all individual countries within which an "equal level of ambition" for mitigation efforts can be determined that is based in the equity literature. It then takes the additional step of determining which equal level of ambition within each country's fair share range would lead to a temperature increase in line with the Agreement LTTG.

We will define the "global worst case" (in which all countries are relying on the most generous end of their fair share) as an 'ambition level' of 0% within the full fair share range and the "global best case" (in which counties are relying on the least generous end of their fair share range) as an ambition level of 100% of the full fair share range. This allows us to determine the ambition levels consistent with different temperature levels, including the Paris Agreement LTTG. We do this by constructing emissions pathways consistent across countries at different ambition levels. For example, a global emissions pathway at a 50% ambition level within the full fair share range will be constructed from the halfway point of every country-specific full fair share range. For each constructed ambition level, a simplified climate model is applied to estimate the resulting median global warming levels for the remaining century.

The full assessment of the global warming level at the end of the century requires a set of different additional steps. Since the global fair share range only extends until 2050, pathways need to be extended until 2100 and supplemented by global contributions of international shipping and aviation to facilitate the temperature assessment. The Constant Quantile Extension method as described in

Gütschow, Jeffrey, Schaeffer and Hare (2018) is used to extend the emissions pathways until 2100. A more detailed explanation of the method and its use to facilitate temperature assessment of emissions pathways consistent with the emissions levels implied by countries' emissions targets that were adopted in the context of the Paris Agreement can be found in Geiges et al. (2019).

Each ambition level leads to a global emission pathway that is used to derive the cumulative emissions between 2011 and 2100. A linear relation as presented in Gütschow et al. (2018) and shown below can be used as a rough estimate of the median average global warming level in 2100.

$$T_{md} = E_{cum}\ 0.466°C/TtCO_2eq + 0.801°C$$

where,
T_{md} = Median end of century temperature
E_{cum} = Cumulative emissions (excl. LULUCF) between 2011 and 2100

For finding the exact median global warming levels in 2100 or peak warming levels, the full resulting global emissions pathway is used as an input to the reduced-complexity carbon cycle and climate model MAGICC (Model for Assessment of Greenhouse Gas Induced Climate Change) (Meinshausen et al., 2011). Using an appropriate search routing, we determine that to limit global warming in line with the Paris Agreement LTTG (defined in section 4.1 as 50% chance of stay below 1.5°C in 2100) requires an ambition level of 48% within each fair share range. The related emissions pathways are presented in **Figure 11** for both global emissions and Italy[7].

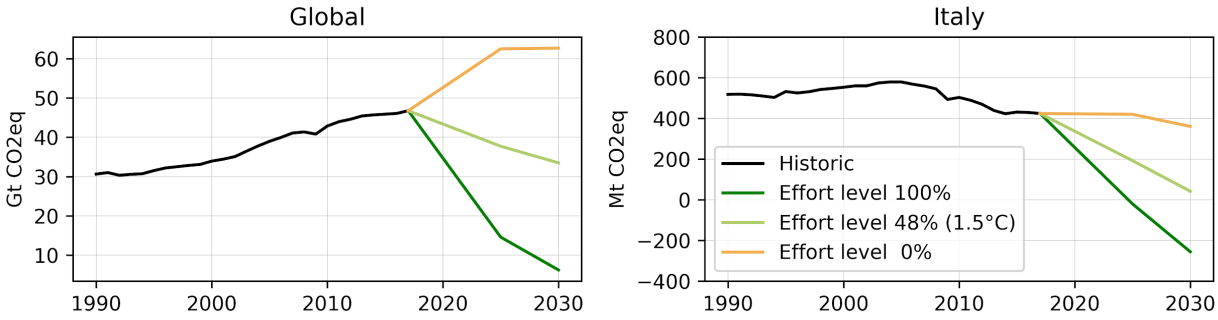

Figure 11: *Effort levels calculated for different temperature targets (i.e., where in the mitigation burden distribution temperature thresholds are found)*

5.7 Equity based 1.5°C Paris Compatible emissions levels in 2030 and 2050 for Italy

In section 5.6 we determined the necessary ambition level within the country-specific fair share range that would limit global warming in line with the Paris Agreement LTTG, if adopted by all countries. On the basis of this analysis, we can now determine the level of emissions for Italy and the allowed emissions for 2030 and 2050 that would be in line with its fair share of meeting the long-term temperature goal of the Paris Agreement. The 1.5°C Paris compatible fair share emissions reduction ranges for Italy for 2030 and 2050 are shown as the green bar in **Figure 12**. This range is formed by the minimum level of ambition identified in section 5.6 (a 48% ambition level within the full fair share

[7] Note that an effort level of 100% corresponds to the global "best case" emission level and an effort level of 0% corresponds to the global "worst case" emissions level

range) and the maximum level of effort (best case scenario, i.e., 100% ambition level) of the full fair share range.

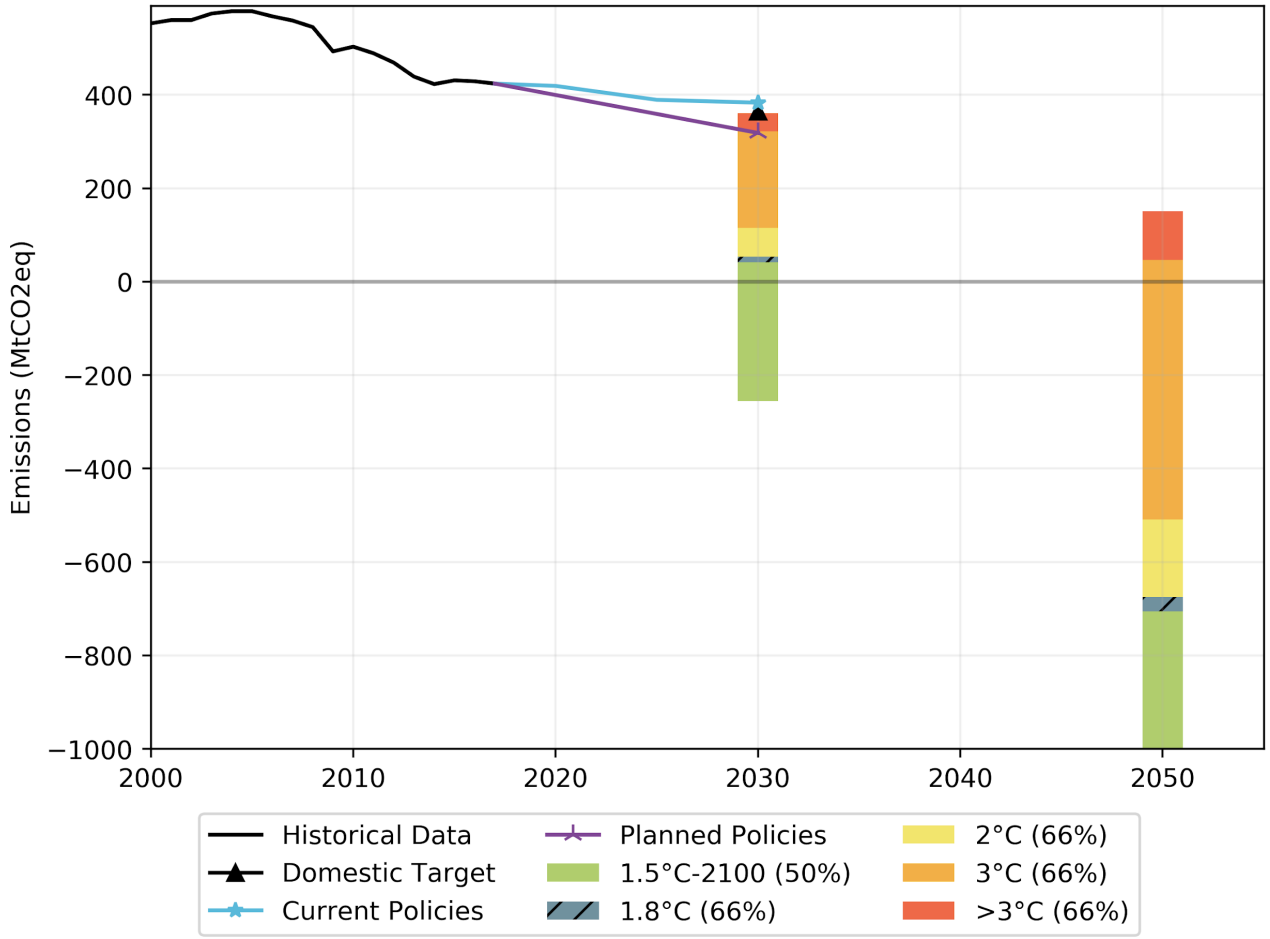

Figure 12: *1.5°C, 1.8°C, 2°C and 3°C compatible fair share ranges for Italy. The green bars represent the 1.5°C Paris compatible fair share range. The hatched blue bar represents the range corresponding to keeping warming below 1.8°C throughout the century. The yellow and orange bars correspond to the emission levels that would result in keeping warming below 2°C and 3°C respectively throughout the century with a 66% probability.*

In order to do its fair share for meeting the Paris temperature goal, Italy would need to reduce its emissions in 2030 at a minimum to 42 $MtCO_2e$, 92% below 1990 levels. For 2050 this level would lie at a minimum of -705 MtCO2e, implying that by this date Italy's total contribution to emission levels (domestic and international) would need to be net negative. The figure also shows Italy's fair share ranges for a warming level of 1.8°C (blue dashed) and 2°C (yellow). These fair share ranges can be compared to the present domestic emissions reduction target (29% below 1990 by 2030), and to its projected emissions level in 2030 with the implementation of additional policies as outlined in the NECP (36 below 1990 levels by 2030).

Italy's 2030 emissions reduction target falls entirely outside the range of equitable mitigation allowances considered in this study, which accounts for outlier data points exceeding both the 5th and 95th percentile of all available studies. Italy's target is thus inconsistent with the vast majority (>95%) of equity studies defining what can be considered a fair mitigation responsibility. Moreover, as can be inferred from Figure 12, the ambition level that is expressed in both the domestic target as well as the level that would be achieved if all planned policies were executed, lies at the top of the full fair share range, thus close to the "global worst case" scenario described in section 5.5. It can thus be inferred

that if all other countries would follow the ambition level of Italy, global temperature would rise to above 3°C by the end of the century.

The minimum emission reduction levels and the corresponding emission gaps between Italy's domestic target and the fair share levels for different warming levels are summarized in **Table 5.**

Table 5: *Minimum emissions reduction below 1990 levels needed to limit warming to different temperature levels and emissions gaps between domestic target under fair share consideration*

Temperature	Absolute emission allowance in 2030	Minimum 2030 Emission Reduction (% below 1990 levels)	Emission Gap from Domestic Target (2030)	Emission Gap from Emissions under Planned Policies (2030)
1.5°C Paris compatible	42 Mt $MtCO_2e$	92%	323 $MtCO_2e$	276 $MtCO_2e$
1.8 peak (66%)	53 $MtCO_2e$	90%	311 $MtCO_2e$	265 $MtCO_2e$
2.0 peak (66%)	114 $MtCO_2e$	78%	250 $MtCO_2e$	203 $MtCO_2e$
3.0 peak (66%)	321 $MtCO_2e$	38%	45 $MtCO_2e$	-

5.8 Emissions budget for Italy based on fair share calculations

On the basis of the results presented in section 5.7 we can calculate a remaining cumulative emissions budget for Italy. Both the AR5 and SR1.5 reports of the IPCC presented global carbon budgets of allowable emissions for different temperature levels. Different from emissions pathways, the concept of the carbon budget describes the total cumulative emissions over a certain time span, without prescribing at which point in time these emissions can take place. Whereas the carbon budgets reported by the IPPC in its AR5 and SR1.5 report only describe total cumulative CO_2 emissions, an emissions budget derived from the fair share methodology presented in this report includes all greenhouse gases and take into account the level of negative emissions that are reported in the IPCC global emission trajectories in SR1.5 (see also section 4.1).

The cumulative emissions allowance between 2020 and 2030 for Italy for the 1.5°C warming target is presented in **Table 6.**

Table 6: Cumulative allowed emissions for Italy between 2020 and 2030 for different temperature levels

Temperature	Cumulative Emissions 2020 - 2030
1.5°C Paris compatible	2.10 $GtCO_2e$
peak 1.8°C (66% chance)	2.18 $GtCO_2e$
peak 2.0°C 66% chance	2.64 $GtCO_2e$

Italy's emissions in 2018 amounted to 427 $MtCO_2e$ excluding LULUCF (Government of Italy, 2020). Assuming Italy's annual emissions level stays the same in the near future, Italy would exhaust its Paris compatible fair share emissions allowance in around 4.9 years.

6. Conclusion

Italy has so far failed to commit to a clear, unambiguous economy-wide emissions reduction target for 2030. Its target for the EU ETS and non-ETS sector implies emissions reductions of 29% by 2030 compared to 1990 levels. This target is related to the EU's previous 2030 target of 40% below 1990 levels. Based on current policies, Italy's emissions are projected to achieve a reduction of 26% by 2030 below 1990 levels. Italy has put forward additional planned policies in its National Energy and Climate Plan (NECP), which if all implemented would achieve a reduction of 36% below 1990 levels by 2030.

This report has sought to demonstrate that Italy's efforts are insufficient to achieve the Paris Agreement temperature target of 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels', assessed here as limiting end-of-century warming to 1.5°C with a 50% or higher probability.

Italy's emissions reduction target fails to match the level of global effort required to meet the Paris Agreement long-term temperature goal. Adopting the same level of effort as is required at the global level entails an emissions reduction level for Italy in 2030 of 63% below 1990 levels. Both Italy's current and planned policies (as expressed in its NECP) fall far short of this. Further, this level of effort does not take into account principles of equity and "common but differentiated responsibilities" (CBDR) on the basis of which Italy needs to "take the lead" in reducing its emissions. Italy is a developed country with a far greater capacity to implement policies and technologies to reduce emissions than many developing nations, and has a significant level of historical responsibility for cumulative emissions to the present day. When principles of equity and CBDR are taken into account, the insufficiency of Italy's emission reduction efforts for 2030 become even more apparent.

The scientific literature has proposed a broad range of interpretations of a "fair share" contribution towards meeting the 1.5°C and 2°C temperature goals. Applying the methodology presented in the IPCC's 5th Assessment Report (AR5), we assess that Italy's current emissions reduction target lies well outside the upper bound (Figure ES 1) of the range of estimates in the literature for the country's "fair

share" contribution to emissions mitigation. Italy's emission reduction target for 2030, even when considering its planned policies described in the NECP, is thus not compatible with the vast majority of interpretations of fairness as represented in the literature when considering mitigation required to meet the Paris LTTG. Furthermore, reducing emissions to the upper bound of the fair share range in the literature would, however, *not* suffice to achieve the Paris Agreement long-term temperature goal, but rather would lead to a warming of higher than 3°C in 2100, if all countries follow suit.

Assuming an equal level of ambition for each country within the full range of results from the equity literature, Italy would need to reduce its emissions by 92% by 2030 compared to 1990 to be in line with the Paris Agreement long-term temperature goal. This is very far off from the 36% reduction in 2030 compared to 1990, which would be achieved if Italy implements all its planned policies outlined in the NECP. The emissions gap between a Paris comparable emissions reduction for Italy and the planned policy emissions reduction amounts to ~280 $MtCO_2e$ in 2030. Closing this emissions gap requires a rapid scaling up of mitigation measures and a rapid transition towards a carbon-free economy within Italy. In addition, Italy may close part of the gap by concrete commitments to aid mitigation in developing countries, if these mitigation actions were truly additional, contributing to an overall mitigation in global emissions, and not counted towards those countries' own reduction targets.

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