The COP29 Net Zero Atlas

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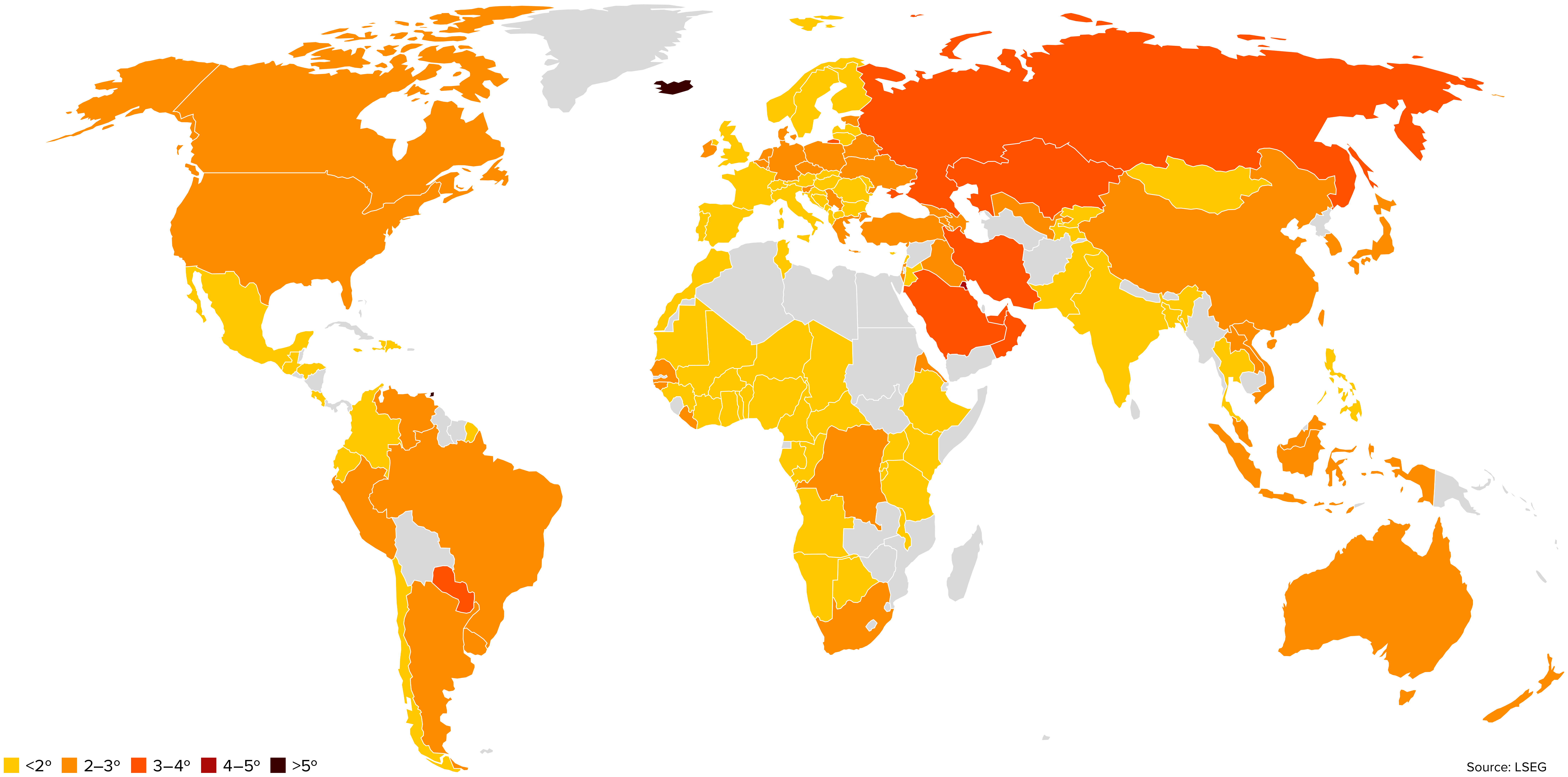
Figure 01: Implied Temperature Rise of every country with a quantifiable NDC target



Source: LSEG

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Foreword

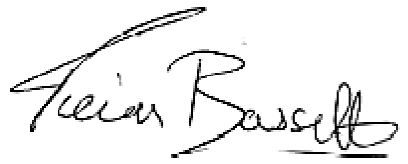
COP29, which will get underway in Baku in just a few weeks' time and COP30 next year in Belém, will shape how our climate changes for years to come.

The next wave of national climate commitments – so-called 'NDCs 3.0' – will be critical in determining the speed at which the global economy decarbonises, whether the goals of the Paris Agreement are met, and where trillions of dollars of future investment will flow.

As our latest edition of the Net Zero Atlas shows, however, the outlook remains challenging. G20 countries will have to set ambitious new 2035 targets to accelerate the pace of the transition and limit warming to well below 2°C by the end of the century. This is also the clear policy signal many companies and investors are looking for as they take steps to mobilise long-term investment in greening the global economy.

The Atlas also highlights the cost of inaction, as physical effects of climate change intensify across the globe. The devastating hurricanes Milton and Helene in the US this autumn were one among many stark reminders of this. Looking ahead, our research shows that cities – nerve centres of the global economy and home to over half of the global population – will be particularly affected, requiring large scale adaptation measures and financing.

The analysis and data in this report provide investors with a valuable and timely analysis of physical and transition climate risks across the G20.



Fiona Bassett
CEO, FTSE Russell

Executive Summary

Transition Risk: All eyes on "NDCs 3.0" as policymakers gather in Baku for COP29

The next round of 2035 emissions targets – dubbed 'NDCs 3.0' and due early next year – are a critical juncture in global climate negotiations. These national commitments will be key to signalling what post-2030 emissions pathways G20 governments are envisaging.

They are also important for investors, as they will shape the trajectories of G20 economies in the 2030s – and determine transition and physical risk levels that companies will face over the coming decades.

Our latest edition of the Net Zero Atlas explores the level at which each G20 country could set these targets (see our country profiles). We show that global emission cuts are almost certain to accelerate post-2030, but only the most ambitious scenario would limit warming to the well below 2°C. Leveraging our updated sovereign climate assessment framework, we focus on three stylised scenarios:

- **'NDCs 2.0 ambition'** – assumes that the G20 set 2035 targets in line with the current 2030 ("2.0") NDCs. Emissions would decline at 2.1% p.a. between 2030-35 and aligns with c. 2.4°C warming by the end of the century, putting the Paris goals out of reach. Transition risks are modest but physical risks progressively escalate.
- **'Long term commitment (LTC) ambition'** – assumes that the G20 set targets in line with their mid-century net-zero commitments. Emissions decline at 3-4% p.a., aligning with 2.0°C. Transition risk increases materially, while physical risks also become more pronounced.
- **'Paris ambition'** – assumes G20 countries focus on front-loading emissions cuts to meet the Paris goals. Decarbonisation accelerates to 7.7% p.a., aligning to 1.8°C warming. Transition risks are greatest, however physical risks are lessened compared to other scenarios.

Pathways to limit global warming to 1.5°C would require more aggressive near-term reductions than those implied by existing 2030 NDCs. However, further substantial enhancements of these 2030 targets appears increasingly unlikely. Indeed, in the last 12 months only one G20 country, Brazil, has made minor updates.

This is even though many G20 governments are gradually getting closer to achieving their NDCs, with our latest current policy projections showing G20 emissions in 2030 to be only 5.2% above target (aligning with 2.6°C warming).

Physical risk: Intensifying hazards put major cities at risk across the G20.

As temperature records have continued to tumble in 2024 and forecasts suggest that annual climate change damages could reach $38 trillion under a 2°C warming scenario, we also expand our physical risk analysis. We focus on major cities across the G20 – a critical vector for physical climate risk to materialise.

Using analytics from Sust Global, we assess how four key climate hazards (floods, cyclones, heatwaves and water stress) could impact 49 of the world's largest cities – home to almost 440 million people and responsible for almost 20% of global GDP – between now and 2050. Our research finds that:

- **The share of major cities with high-risk exposure would increase from less than one in five (18%) to almost one in two (47%)** under a high emission scenario. The average number of days of extreme heat is expected to more than double across major cities from an average of 14 to 36 days in 2050.
- **Even in a low emissions scenario, large-scale resources are required to adapt cities** to shifting physical climate risk profiles – ranging from establishing monitoring and early warning systems, to developing more hazard-resilient buildings and infrastructure, and updating city planning and building codes.
- **Adaptation efforts in G20 cities are particularly urgent in the Middle East and Southeast Asia**, where elevated exposure to climate hazards can intersect with rapid urban expansion, high inequality, large informal settlements and limits on the provision of public services.

Chapter 1

Transition Risk

Methodology

Implied Temperature Rise (ITR) – summary and 2024 enhancements

The country-level temperature metrics (denoted in °C) presented in this report indicate the global Implied Temperature Rise (ITR) that would result if every country that has a commitment or set of policies with the same level of ambition as the studied country. However, they do not imply that those countries alone can have such an influence on global temperature.

Interpreting these temperature metrics, it is important to note that two countries with a Nationally Determined Contribution (NDC) or long-term commitments, which indicates the same level of emissions reduction, may not share the same ITR. As the methodology also considers historical cumulative emissions, a country that has already used a significant portion of its carbon budget will need to decarbonise at a faster rate than a target year (e.g. 2050) to remain in line with the Paris Agreement's objectives.

1. **First, we estimate the annual emissions of each country for NDCs, current policies, and for long-term commitments.** We calculate this based on the reductions implied by the announced NDCs and long-term commitments, assuming countries meet their goals. For the current policies, we use projections developed by the International Institute for Applied Systems Analysis (IIASA) and NewClimate Institute.[1] These projections operate under the assumption that no additional mitigation measures will be undertaken beyond the policies already in place.

2. **We then calculate each country's share of the global 'carbon budget' – the total available emissions budget consistent with a 1.5°C scenario.**

    a. **We first choose a future emissions pathway that gives a global carbon budget that aligns with a 1.5°C rise in global temperature.** The pathway used here is the Net Zero 2050 scenario from the MESSAGEix-GLOBIOM model as presented in the latest phase (Phase IV) of the Network for Greening the Financial Systems (NGFS)'s Climate Scenarios.[2]

    b. **We then distribute the annual global carbon budget between countries to obtain a carbon budget per country per year that would align with a 1.5°C trajectory.** To do this, we use LSEG's proprietary Climate Liabilities Assessment Integrated Methodology (CLAIM) model,[3] which estimates the budget using a statistical approach that factors in historical and current emission levels to determine the remaining GHG allowance for each country.

3. **Next, we determine the gap in cumulative emissions between a country's projected emissions for its commitments or current policies and its carbon budget under the 1.5°C scenario from the present until 2060.** This 'emissions gap' is the main variable in assessing the alignment of a country with a global warming target.

4. **Lastly, we calculate the ITR above pre-industrial levels for each country and scenario, respectively.** This calculation is based on an equation that effectively converts estimated future GHG emission volumes into an ITR for each country.

2024 enhancements

For this year's report we have made two significant methodological upgrades to the model.

We have updated the future emissions pathways (used in 2) to reflect the latest emissions pathways from the NGFS. We also update our approach to a cumulative emissions based model (used in 3) - from a point in time approach used last year.

Please see the Annex for further details.

In the 2030 NDCs, the Paris Agreement has delivered substantial emissions reduction commitments...

At the heart of the Paris Agreement is the idea of breaking down shared long-term objectives – holding the increase in the global average temperature to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C by the year 2100[4] – into short-term national plans. Each successive short-term plan, or Nationally Determined Contribution (NDC), would see more ambitious emissions reduction efforts than what had gone before. The result – a ratcheting up of individual, voluntarily determined national emission cuts over time.

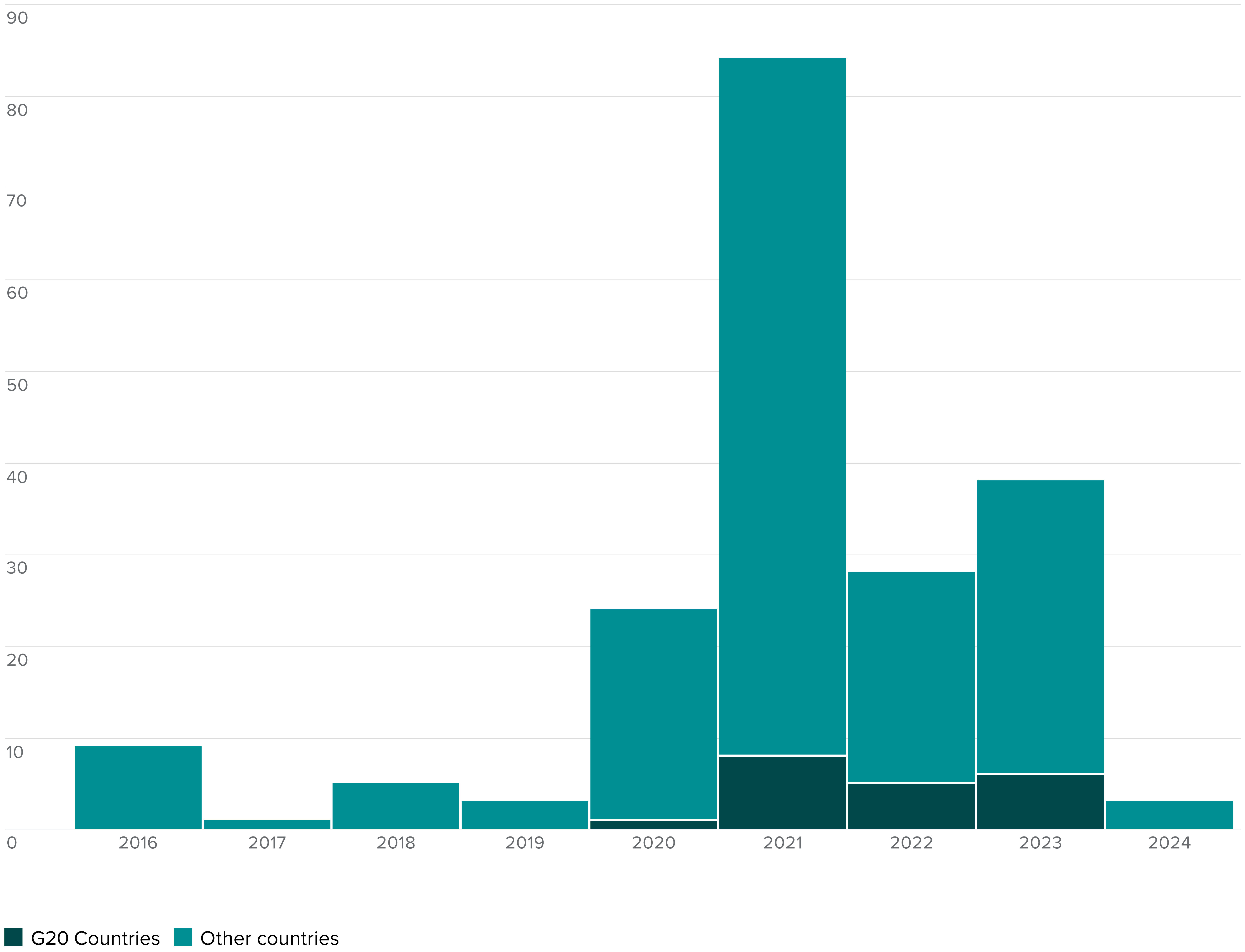
The Paris Agreement has been remarkably successful in unblocking previously deadlocked international climate negotiations. Not only did all 195 parties submit initial 2030 emissions reduction targets (NDCs 1.0), but 174 out of the 195 parties have enhanced these once or more since Paris, resulting in substantial additional commitments.[5] Compared to the initial NDCs 1.0, which would have resulted in global greenhouse gas (GHG) emissions increasing by 70% versus 1990 levels and continuing to rise beyond 2030, the NDCs 2.0 imply a substantially smaller 50% increase and a global emissions peak this decade, according to UN calculations.[6,7]

This success comes even though there is no mechanism in the Paris Agreement to enforce national emissions reductions, and that national climate ambitions continue to diverge significantly. Indeed, our analysis suggests that the latest NDCs align to below 2°C for countries like the UK and India; to 2.6°C for the largest emitters, the US and China; and to over 3°C for countries such as Russia and Saudi Arabia.

...though progress is slowing and new 2030 commitments are rare

However, as the deadline to achieve the 2030 NDCs draws closer, further substantial enhancements to these commitments appear increasingly unlikely. Despite the UNFCCC asking to further enhance 2030 commitments, Brazil is the only G20 country to have updated its 2030 NDC over the past 12 months (see Figure 2), resulting in only a 3% increase in its targeted emissions reduction by 2030.[8] By themselves, these 2030 commitments are insufficient to achieve the goals of the Paris Agreement. Our latest calculations suggest that, without further cuts, the collective NDC commitments of the G20 countries would align with 2.5°C global warming by the end of the century, potentially resulting in debilitating impacts on ecosystems and human societies.

Figure 02: No. of submissions of NDCs 2.0 (2016–2024)



G20 countries NDCs 2.0 submission year

2020	Russia
2021	Argentina Canada China Japan South Korea Saudi Arabia United States South Africa
2022	Australia United Kingdom India Indonesia Mexico
2023	Brazil Germany EU Italy Türkiye

Meeting the 2030 NDCs 2.0: within touching distance or out-of-sight?

To assess countries' progress towards the NDCs 2.0, we have worked with the New Climate Institute and the International Institute for Applied Systems Analysis (IIASA) to develop projections of G20 countries' 2030 GHG emissions based on currently enacted policies. The gap between these 'current policies' projections and the NDCs 2.0 can be interpreted as a useful measure of how close countries are tracking towards achieving their climate goals.

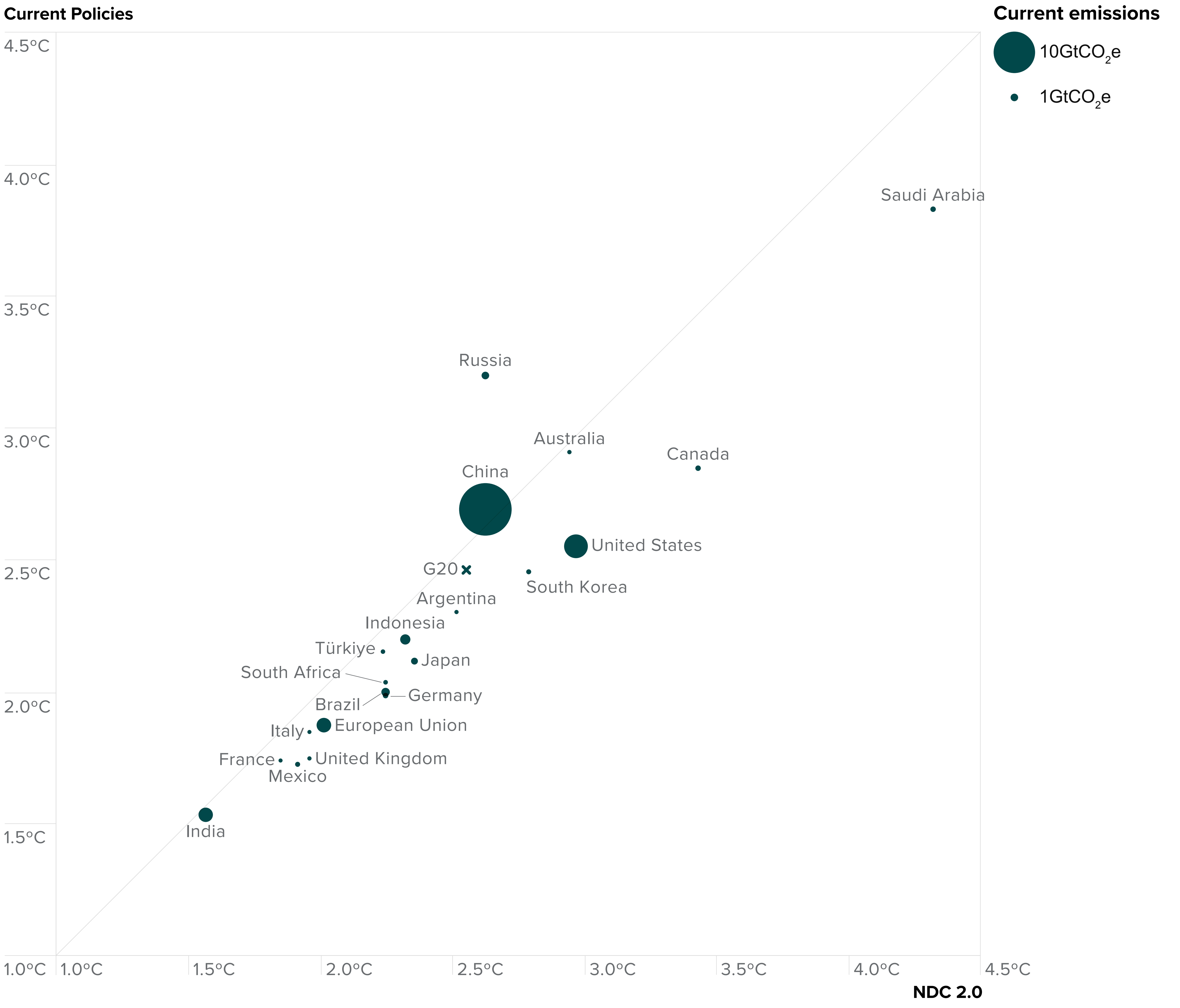
Meanwhile, it is important to stress that such projections are subject to significant uncertainty, as they depend not only on assumptions of how the policies that countries are implementing will impact their emissions, but also on other factors such as projections of future economic growth and emissions linked to land-use change.

With these caveats in mind, our data shows that in aggregate the G20 – while not yet on track to meet their 2030 emission targets – appear increasingly within striking distance. Our latest calculations imply that, without further policy action to reduce emissions before the end of the decade, G20 GHG emissions would exceed their combined NDC target by 1.7 $GtCO_2e$ (or 5.2%) – aligning with a 2.6°C trajectory compared to 2.5°C for the NDCs. Compared to last year's analysis projected emissions gap between NDCs and current policies for the G20 has narrowed by an estimated 0.5 Gt in 2030.

For individual G20 countries, the size of the gap between 2030 targets and projected emissions – as shown in Figure 03 – varies significantly and is determined by a combination of growth projections, policy actions and the ambition level of their targets. Our latest projections suggest that Russia and China might end up exceeding their NDC commitments.[9] Countries such as India and Australia currently appear broadly on track for their own NDCs, while others such as Canada, Saudi Arabia, and the US appear behind their commitments (by at least 0.4°C).

In the case of the US, emissions have fallen by 1.0 Gt from 2005 to 2022, largely due to replacement of coal-fired power generation with cheaper renewables and gas.[10] Policy measures like the Inflation Reduction Act are likely to contribute to further emissions reductions, which we estimate at 1.3 Gt by 2030.[11] However, the US would have to more than double the size of these cuts, delivering an additional 1.6 Gt in emissions reductions by 2030 to meet its targets.

Figure 03: Implied Temperature Rise for G20 NDCs and Current Policies



Policy progress in the G20 has been more incremental.

Since we last surveyed G20 members' climate policies in the COP28 Net Zero Atlas, policy progress has been more incremental, and mainly focused on implementing ambitious emission reduction commitments. In April, the US EPA finalised plans for a 90% reduction in emissions from coal and gas energy by 2032.[12] A month later, China's State Council issued a detailed plan to accelerate progress towards their 2025 energy efficiency targets, including a raft of measures to reduce energy consumption by 2.5%, carbon intensity by 3.9%, and energy intensity of large industrial enterprises by 3.5% in 2024.[13] China also hit its target to install 1,200 gigawatts of wind and solar power by 2030 6 years early.[14]

Despite geo-political dynamics between the world's two largest GHG emitters, China and the US also discussed methane and non-CO_2 greenhouse gas reduction efforts in September,[15] with hopes of new commitments to reduce methane emissions being agreed in November's COP29.

There have also been notable developments in Canada and Australia, among the most carbon intensive G20 members. In November 2023, Australia expanded its Capacity Investment Scheme (CIS) – designed to encourage new investment in renewable capacity as well as clean dispatchable capacity, such as battery storage - to deliver 32 GW of new capacity by 2030.[16] In Canada, the Electric Vehicle Availability Standard, updated in December 2023, now mandates that 60% of new cars must be zero-emissions by 2030 and 100% by 2035.[17]

All eyes on NDCs 3.0 – the next stop in the Paris process

In many ways, COP29 in Baku sounds the starting gun for that next stage of post-2030 global transition planning, with countries required to submit new 2035 targets by 2025. In the run-up to COP29, governments and climate negotiators are increasingly focused on these NDC 3.0 submissions:

In April, the European Commission proposed a 90% emissions reduction target for 2040 in February 2024 (vs. the current 55% for 2030[18]). If adopted by Member States, it is likely to inform ambitious 2035 NDCs for the bloc.

In August, the new government in the UK instructed an expert body to draw up recommendations for its 2035 NDC by the end of October at the latest.[19]

In September, on a visit to Beijing, US climate envoy John Podesta called on the Chinese government to set ambitious 2035 targets.[20]

Also in September, the host countries of COP28, COP29, and COP30, the UAE, Azerbaijan, and Brazil (the 'Troika') reiterated their commitment to submit new NDCs aligned with 1.5°C by the end of the year at the UN General Assembly, calling on other countries to do the same ahead of COP29 in Baku.[21]

The NDCs 3.0 are a critical signal for future transition trajectories and investment.

Compared to NDCs 2.0, investors have urged governments to provide more granular detail on the sectoral targets and underlying macroeconomic assumptions in their NDC 3.0 submissions to make them more 'investable'.[22]

NDCs 3.0 will be critical, because so far, many governments have not gone into detail on their post-2030 emissions reduction commitments. As part of the Paris process, the G20 along with over 100 countries have formulated 'long-term commitments' (LTCs) in addition to the NDCs. These strategies mostly aim to achieve 'net zero' emissions, in many cases by 2050, but in some cases earlier (such as Germany for 2045) or later (such as China, 2060[23]).

However, these net zero goals describe an endpoint, and governments have not set any interim milestones that outline the emissions trajectories between the 2030 NDCs and these long-term targets. This leaves significant uncertainty about the climate outcomes associated with these long-term targets. With climate change driven by cumulative emissions, rather than emissions levels at any specific point in time, this could result in different levels of global warming.

To illustrate this:

- We estimate that a constant rate ('straight-line') reduction between G20 countries' 2030 NDC commitments and their long-term goals would align to 2°C global warming by the end of the century.
- In contrast, an early decarbonisation pathway – where two-thirds of the reduction are achieved in the 2030s and only one-third of the reduction occurs in the 2040s – would align to 1.8°C warming.
- If emissions reductions to deliver 2030 NDCs were achieved and a similar rate of reduction continued until 2035, this would align to 2.4°C warming without further reductions.

Box 1. What would it take to keep 1.5°C in play?

We note that a post-2030 trajectory that takes the current 2030 NDCs as a starting point is very unlikely to be compatible with a 1.5°C warming scenario. Indeed, if G20 countries decarbonise throughout the 2020s on a trajectory towards the latest 2030 NDCs, the 1.5°C emissions budget would likely be exhausted shortly afterwards (by 2033 based on our estimates[24]). Realistic emissions pathways that limit global warming to 1.5°C would therefore almost certainly require more aggressive near-term emissions reductions than those implied by the latest 2030 NDCs.

Transition Risk

Diverging climate ambition in the G20?

For each country, the next stage of transition planning could therefore result in very different climate ambition levels – and will be critical to signalling which transition pathway major emitters are envisaging. This can be illustrated with the world's three largest emitters:

- **China:** In the case of China, emissions are projected to peak in the next few years ahead of the government's deadline of 2030.[25] However, the 2035 emissions target will be a critical signal on whether to expect rapid emissions reduction (particularly through accelerating a transition away from thermal coal in power generation) or whether reduction rates will be more gradual resulting in an extended 'emissions plateau'.

- **India:** In the world's most populous country, emissions continue to grow rapidly from very low per capita emissions levels. 2035 commitments will be critical to determining whether emissions growth will slow and eventually peak in the 2030s, or whether they continue to expand throughout the next decade and potentially beyond.

- **USA:** In the US, election outcomes will determine the direction of travel, with new 2035 NDCs signalling a further acceleration of emissions cuts or a withdrawal from the Paris process both in the realm of possibilities.

Figure 04: Projected cumulative emissions for the G20 under the NDC 3.0 scenarios

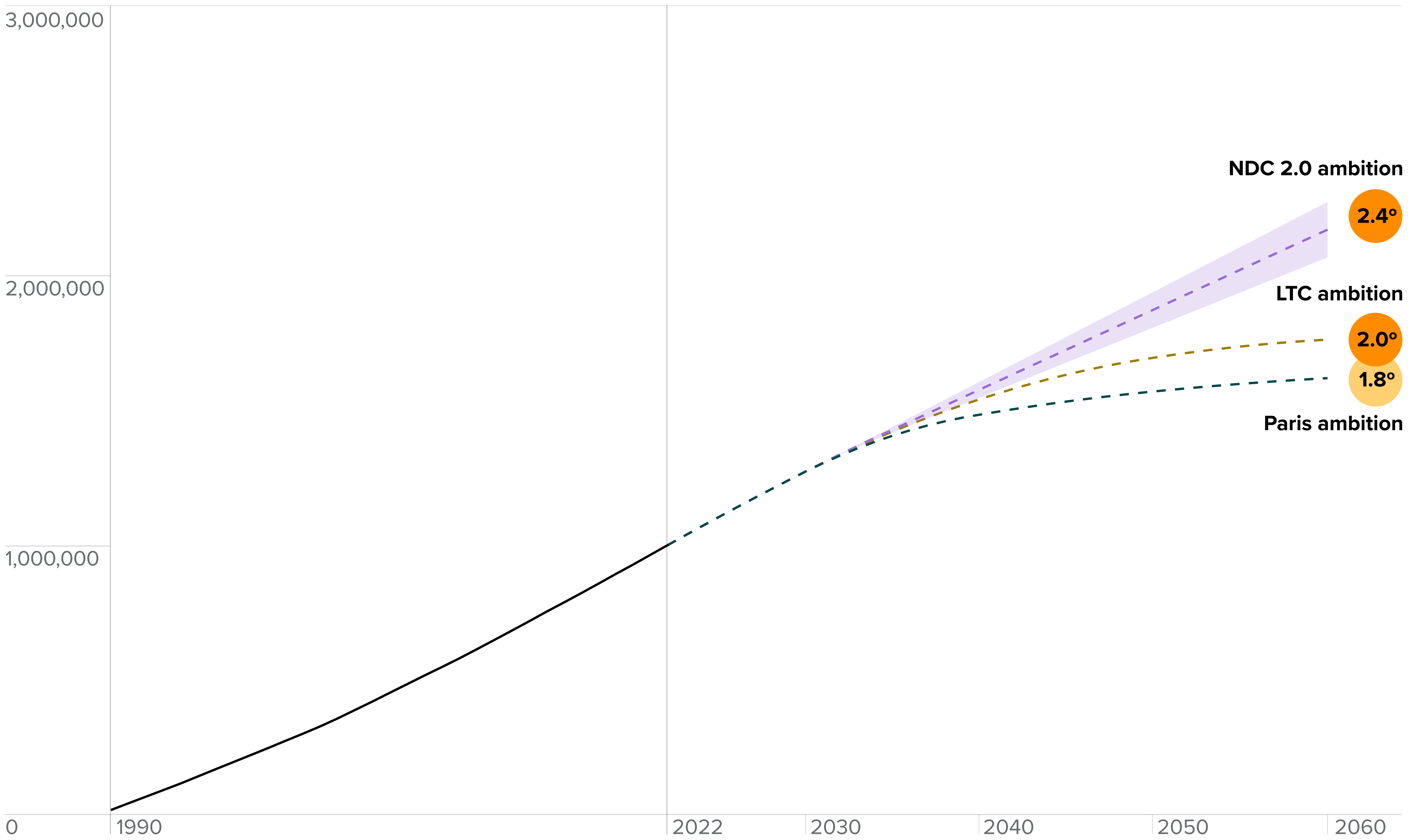
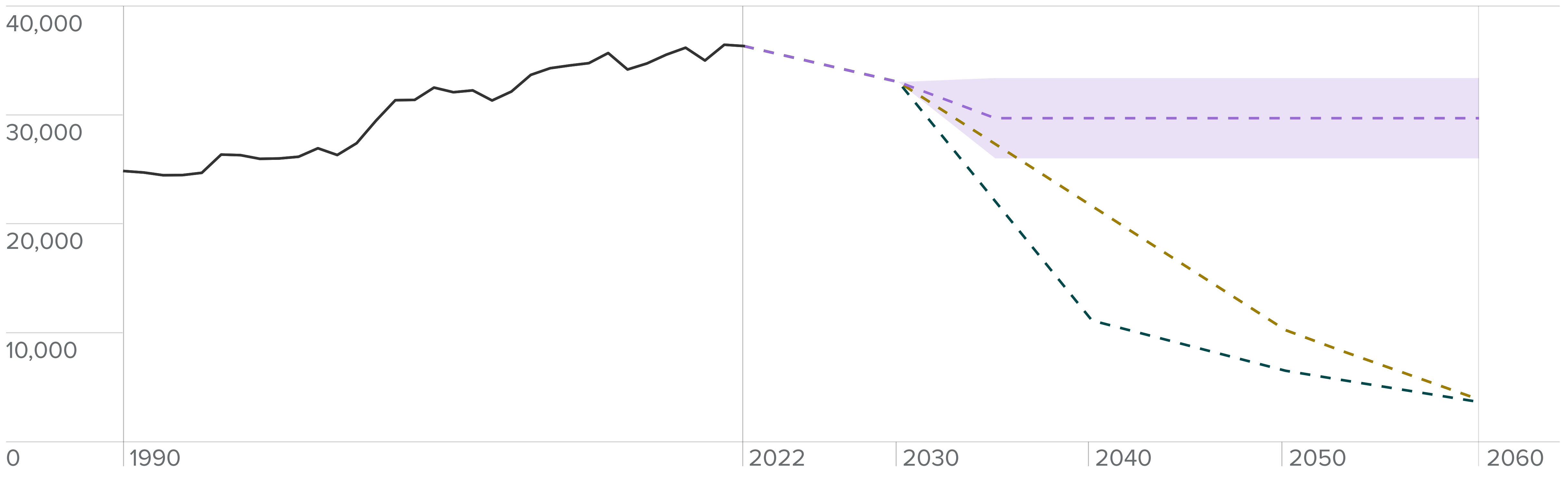


Figure 05: Historical and projected annual GHG emissions for the G20 ($MtCO_2e$)



Historical | NDC 2.0 ambition | Long-Term Commitment (LTC) ambition | Paris ambition

Projecting NDCs 3.0 for the G20

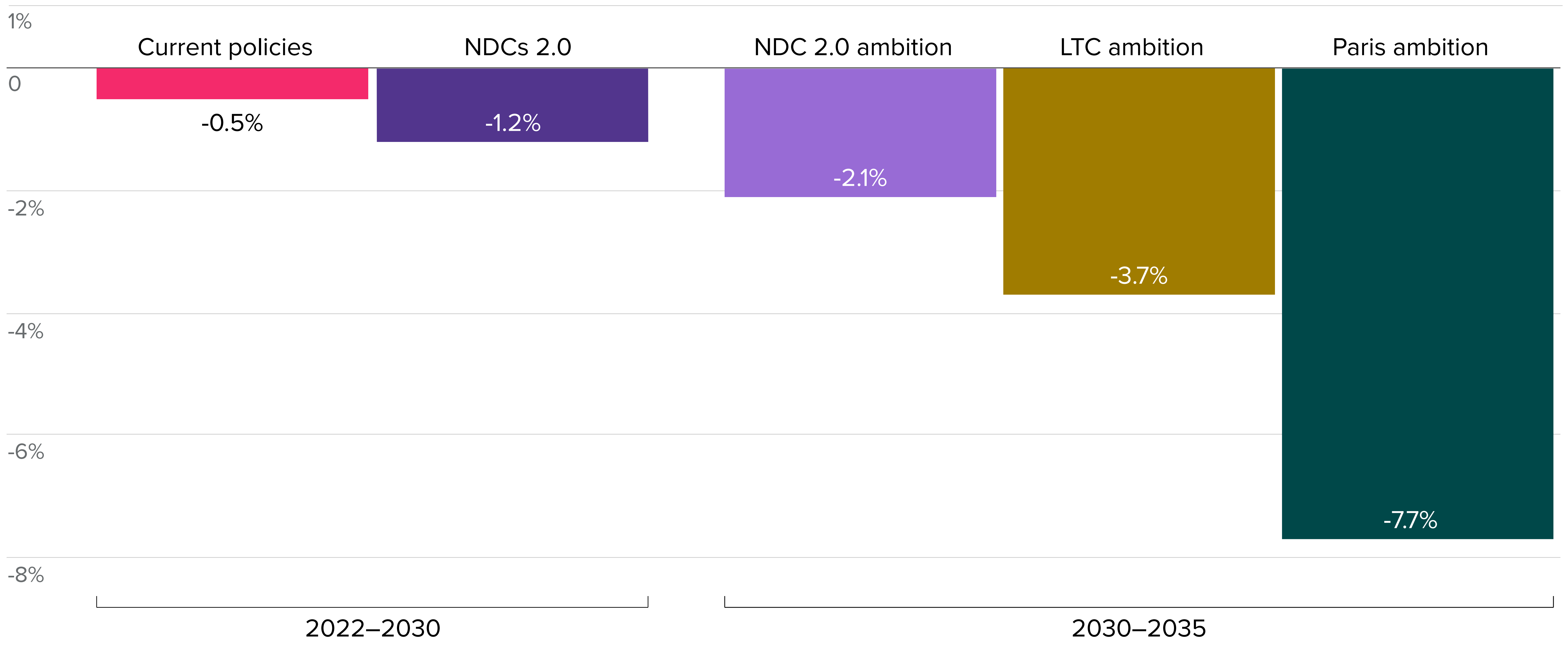
We develop a set of scenarios to systematically analyse potential outcomes for the NDCs 3.0. These outline plausible ranges for G20 countries' 2035 targets, resulting global climate outcomes, and associated physical and transition risks. These 'ambition scenarios' provide investors with a useful framework to benchmark actual commitments as they are announced by G20 governments over the coming months.

NDC 2.0 ambition	Long-term commitment (LTC) ambition	Paris ambition	
Assumes that countries' emission reduction ambitions remain at a broadly similar level as expressed in the current 2030 NDCs. In this scenario, countries are unable, or unwilling, to accelerate decarbonisation to a level that is consistent with their long-term commitments or temperature outcomes that are consistent with the goals of the Paris Agreement.	Assumes that in setting their 2035 NDCs, governments are primarily focused on setting targets that are consistent with meeting their midcentury net zero commitments (LTCs). This results in a material acceleration of decarbonisation trajectories from the late 2020s onwards.	In this scenario, we assume that governments are focused on limiting temperature rise by the end ofthe century to well below 2°C, in keeping with the Paris Agreement. This assumes a dramatic acceleration of decarbonisation trajectories in the 2030s.	**Ambition level**
We calculate the annual emissions reduction (growth) rate for 2015-30, based on the countries' latest NDC – see Country Profiles – and assume that its 2035 target will be set to reduce (grow) emissions at the same rate. Alternatively, we use the ITR associated with our current policies projections for 2030; and assume that countries 2035 targets will align to the same temperature outcome. We use the average of both as the estimate for a 2035 target that is consistent with the 2030 NDCs.	We assume a linear decrease in emissions from a country's 2030 NDC to its long-term commitment and assume that the 2035 NDC lies on this pathway.	We assume a level of ambition required to keep implied temperature rise in the G20 to approximately 1.8°C, however the rate of decarbonisation is specific to the long-term commitments made by G20 members. The decarbonisation trajectory results in 2040 emissions that are equivalent to a 90% reduction for countries with 2050 long-term commitments (LTCs), 70% reduction with 2060 LTCs, and a 30% reduction in emissions in 2040 for India, which has a 2070 LTC. We calculate a country's 2035 NDC from where it intersects this pathway.	**How we calculate it**

Transition Risk

	NDC 2.0 ambition	Long-term commitment (LTC) ambition	Paris ambition
Emissions pathway	In this scenario G20 emissions peak pre-2030, and then decline on average by 2% p.a. over the course of 2030-2035. For markets such as US and the EU, decarbonisation rates slow post 2030 as harder to abate sectors prove more challenging to decarbonise. For China, emissions begin to reduce gradually, and India sees largely flat emissions across the decade. The prospects for countries to achieve their mid-century net zero commitments fade, which we assume are not met in this scenario.	Emissions peak well before the end of this decade, and then decline by roughly a third throughout the 2030s (or 3-4% per annum between 2030 and 2035). This results in a combination of considerable cuts in developed markets (e.g. -50% in EU and US emissions in the 2030s) modest emissions declines in India and China (2% and 3% per annum respectively between 2030 and 2035).	Global emissions fall by two-thirds over the decade from 2030-2040. Rapid decarbonisation takes place across the G20 in both developed and emerging markets with 9% and 10% per annum reductions in the EU and US between 2030-2035, and 8% and 5% for China and India respectively.
Temperature outcomes	We estimate that (without further reductions post 2035) this scenario aligns with 2.4°C warming, putting the goals of the Paris Agreement well out of reach.	Whilst countries accelerate to a pathway consistent with their long-term commitments, we project that temperatures would still rise by 2.0°C by the end of the century, failing to reach the goals of the Paris Agreement.	We project that the Paris Ambition scenario would imply 1.8°C warming.
Transition and physical risk	Power generation and the autos sector continue to decarbonise steadily as low carbon technologies become the market standard. In the latter half of the decade, regulators begin to put growing pressure on real estate and other hard-to-abate sectors to reduce emissions and roll-out low carbon technologies. In contrast, physical climate risks materialise increasingly aggressively, placing a rapidly escalating burden on G20 economies and societies.	Physical risks become more pronounced. At the same time transition risks increase rapidly as governments push to generate large-scale emission reductions through substantially completing the transition in the power generation and autos sectors in the 2030s.	Transition risks spike. Major emerging economies rapidly decarbonise their power and transport sector in the 2030s, while advanced economies mostly complete the transition in these sectors in the second half of the decade. Governments particularly in advanced economies, increase regulatory pressure to develop low carbon solutions in sectors such as real estate, industrials and agriculture. Physical risks are lessened compared to other scenarios.

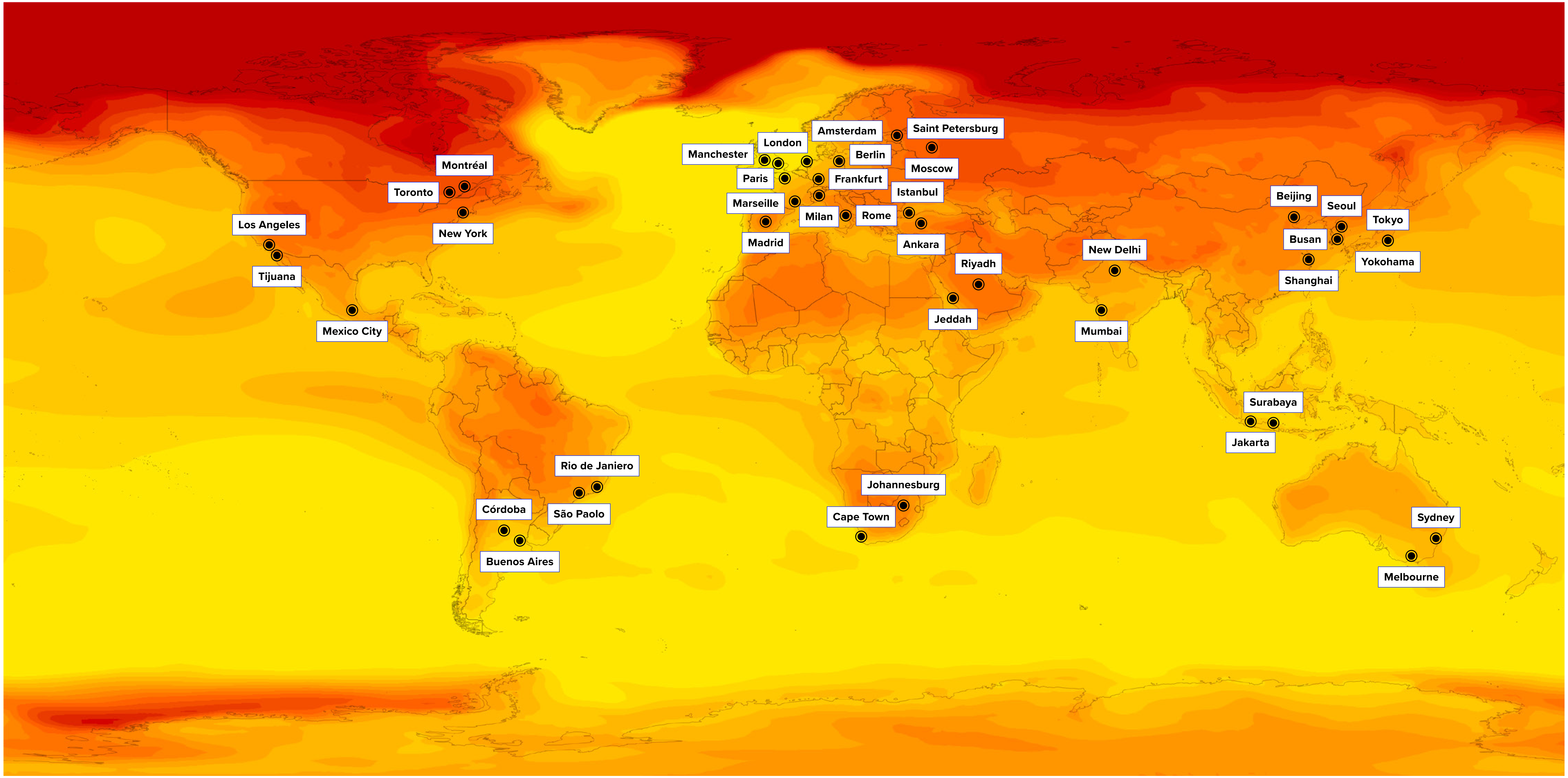
Figure 06: Compound annual growth rate (CAGR) in emissions for current policies, 2030 NDCs. Also shown are the CAGR needed for the three levels of 2035 ambition scenarios



Chapter 2

Physical Risk

Figure 07: Projected global temperature increase by 2050 (high emissions scenario), along with the cities used in our analysis



Source: LSEG

Physical Risk

The physical impacts of climate change are increasingly thrown into sharp relief...

Investor thinking on climate risk has been dominated by a focus on transition risk. But as temperature records continue to tumble and extreme weather events become more frequent and debilitating, the physical risk climate change poses to societies and portfolios is beginning to receive attention.

These impacts are asserting themselves faster than expected, with recent forecasts suggesting that annual damages attributed to climate change are likely to reach US$38 trillion by the mid-century under a 2°C warming scenario[1].

Although global temperature averages for the second half of 2024 are expected to be slightly below those in 2023. Nonetheless, record-breaking temperatures in the first half of the year make it highly likely that 2024 will again mark the hottest year ever recorded[2] (Figure 8).

Higher average surface air and sea temperatures across the planet are triggering longer, more intense heatwaves and droughts. A recent study estimated that climate change added, on average, 26 days of unusually warm temperatures worldwide, with over three quarters of the global population experiencing over a month of extreme heat in the period from May 2023 to May 2024[3].

...with no part of the globe left unaffected.

In the world's largest river system, the Amazon, intense droughts this year resulted in the lowest water levels since measurements began in 1902[4] – threatening to disrupt shipping and power generation in a region where hydropower is by far the most significant source of electricity.

Higher temperatures are also contributing to more intense wildfires, storms, rainfall and flooding, with far-reaching effects that are often difficult to capture with conventional risk models. In September and October 2024, unusually warm waters around the southeastern coast of the United States lent devastating power to back-to-back hurricanes Helene and Milton. Fierce winds and torrential rains triggered landslides, tornadoes and flooding killing hundreds, driving millions from their homes and caused damages that are estimated to be in excess of US$100 billion[5].

They have also knocked out mining operations in a region that supplies over 90% of global high-purity quartz until further notice – threatening to disrupt global semiconductor manufacturing supply chains, for which the material is indispensable[6].

Physical Risk

Despite increasing data and analytics, physical climate risk often remains poorly understood

This poor understanding of physical risk relates not only to changing exposures to damages and disruption from more frequent and more violent weather events. Critically, it also includes more subtle knock-on effects through pressure for regulatory interventions, technological innovation and behavioural change. Over time these will reshape competitive advantages, supply chains and profit pools across sectors and regions.

Since 2022, our Net Zero Atlas series has been exploring this emerging topography of physical risk. The COP27 Net Zero Atlas focused on surveying the exposure of different G20 economies to major climate hazards[7]. It showed that while acute hazards and chronic risks will be diverse and highly regionalised in scope, G20 countries are not immune to physical climate risks and will face increasingly complex adaptation challenges as climate change intensifies.

In last year's COP28 Net Zero Atlas, we examined how G20 governments are beginning to tackle these challenges through formulating national adaptation plans[8]. However, we found that adaptation strategies remain mostly in their infancy, and lack the systematic resourcing, implementation and monitoring required to adequately mitigate these emerging risks.

Figure 08a: Temperature anomaly for 12-month average compared to the 1850-1900 baseline. 2024 values are for the latest 12-month period (September 2023 to August 2024)

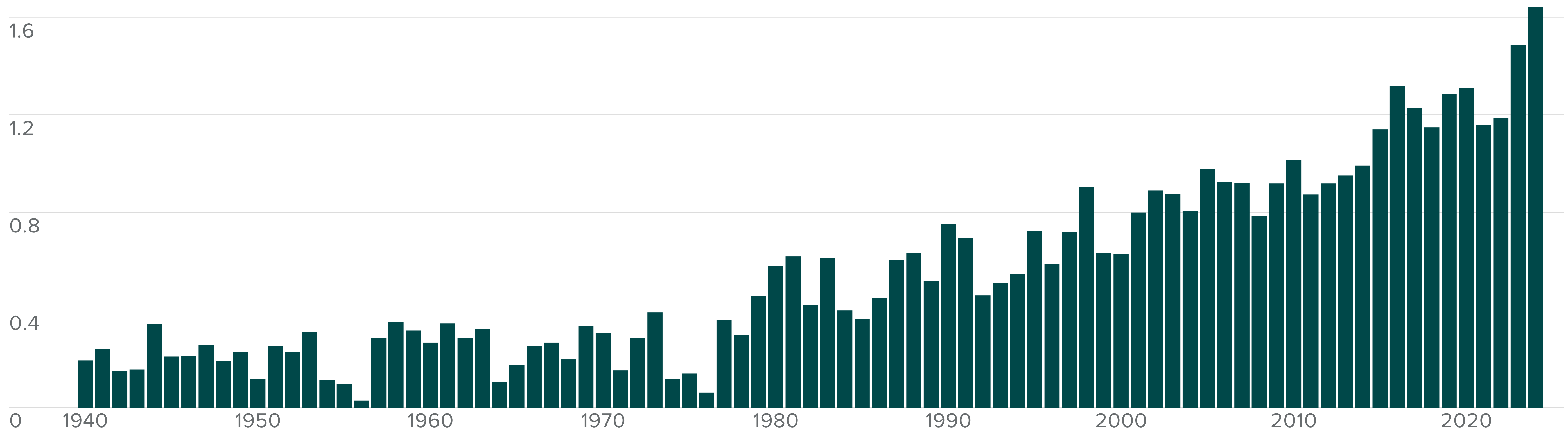
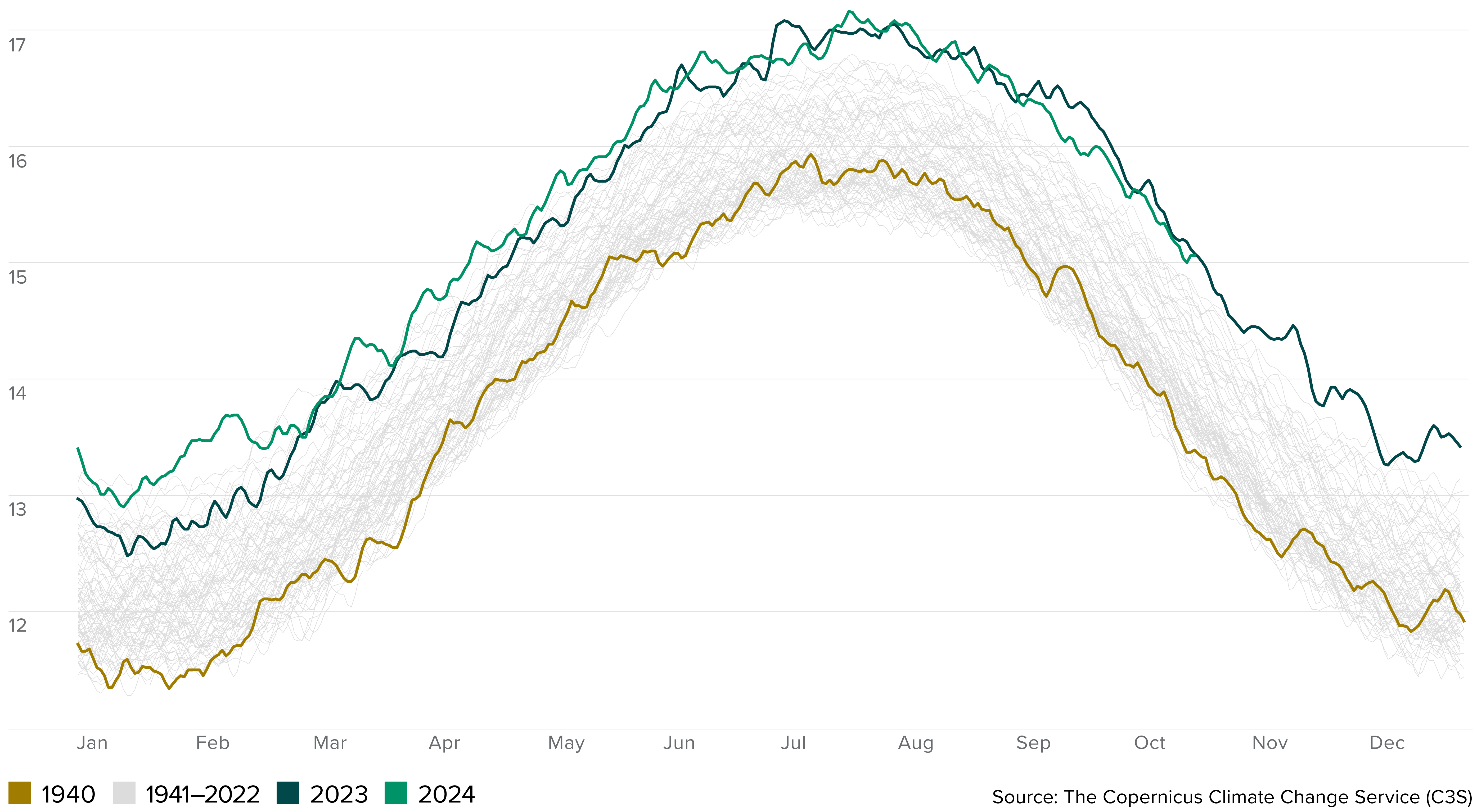


Figure 08b: Average daily temperatures from 1940 to the present



Source: The Copernicus Climate Change Service (C3S)

Physical Risk

Cities – the nerve centres of the global economy – are a critical risk vector.

In this year's COP29 Net Zero Atlas, we focus on how evolving climate hazards will affect cities, which are already home to over half of the global population[9] and generate over 80% of global GDP[10]. The exceptional concentration of real estate, critical infrastructure, economic activity, and human lives makes them a key vector through which physical risk will materialise – and impact investor portfolios – over the coming decades across G20 economies[11,12]. Features of the built environment can further exacerbate the impact of climate hazards in cities, whether it be raised air temperatures through 'the urban heat island effect'[13] or large impermeable ground surfaces that reduce the drainage of rain water and increase the risk of urban flooding.

We have partnered with Sust Global a specialised provider of climate hazard analytics to analyse how four key hazards – floods, cyclones, heatwaves and water stress – will impact 49 of the world's largest cities[14]. This provides investors with an analytical framework to explore absolute risk levels, and how risks will evolve for these cities, which are home to almost 440 million people (6% of the global population) and responsible for almost 20% of global GDP.

Box 2. Physical risk analytics for cities

The analysis of cities contained within this report are based on climate hazard analytics generated by Sust Global. For each hazard – floods, cyclones, heatwaves and water stress – a specific measure of risk is generated to describe the hazard's frequency or intensity. This may be an average or a maximum of risk exposure across a city; these outputs are also translated into a general classification of risk (high/medium/low/minimal). See Table 1 and the Annex for more details.

Physical risk estimates for each city are generated by:

1. Defining the city perimeter. This is achieved by creating a near-circular polygon forming a 5km radius around the city's central business district (CBD).
2. Building a detailed picture of physical risk exposure across the city up to 2050. This involves using high resolution observations from a wide range of public and private scientific datasets (see Annex), coupled with General Circulation Models (GCMs) from the latest international modeling efforts (CMIP6), to project how each climate hazard will evolve by 2050.
3. Aggregating risks across each location in the city to create a single aggregate hazard risk score for each hazard. For example, using the mean flooding risk of a city to depict the overall score.

Table 1. Risk methodology for different hazard categories.

Hazard	Risk Metric Methodology	Polygonal processing output
Flood	Annual probability of a flood with depth greater than 0.5 m at a location. This includes both precipitation-based inland flooding and coastal flooding.	Mean
Cyclone	Annual probability of a Category 1 or higher cyclone at a location.	Maximum
Heatwave	Total days in a given year exceeding the historic 98th percentile for temperature	Mean
Water stress	Unitless water stress score. Higher values indicate greater water stress, with values greater than 0.6 and 0.8 generally considered to be at high and severe water stress, respectively.	Mean

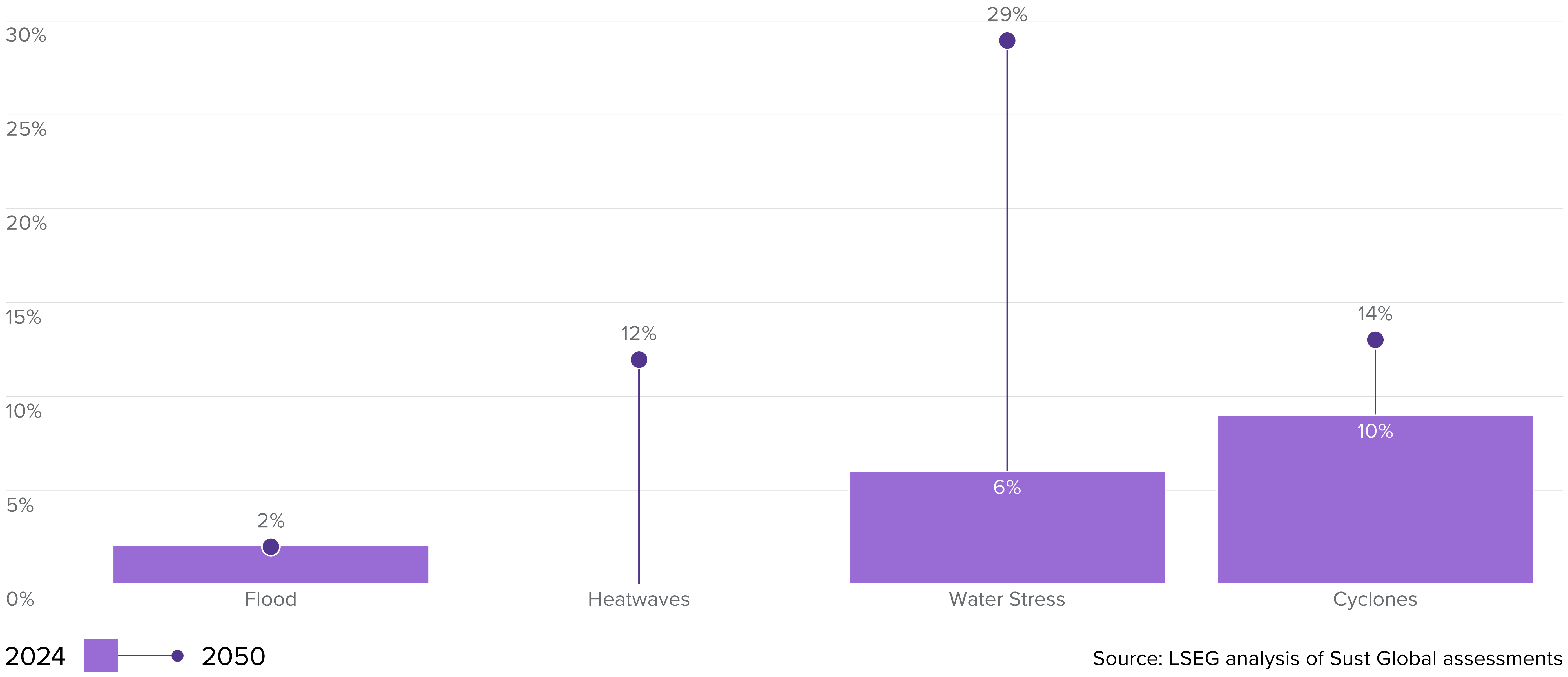
Intensifying climate hazards will impact all cities – though the effects will be uneven.

While cities have always faced the threat of natural disasters, our data shows that, in a high emissions scenario, major cities would be heavily affected by the impacts of climate change. By 2050, the number of major cities with high-risk exposure to one climate hazard increases from less than one in five (18%) to almost one in two (47%).

Climate change will primarily work to amplify pre-existing hazards facing cities. The average number of days of extreme heat, one of the deadliest climate hazards, is expected to more than double across major cities (from an average of 14 days currently to 36 days in 2050). Similarly, high levels of water stress, currently affecting approximately one in 20 major cities (6%), would affect one in four cities (29%) by 2050.

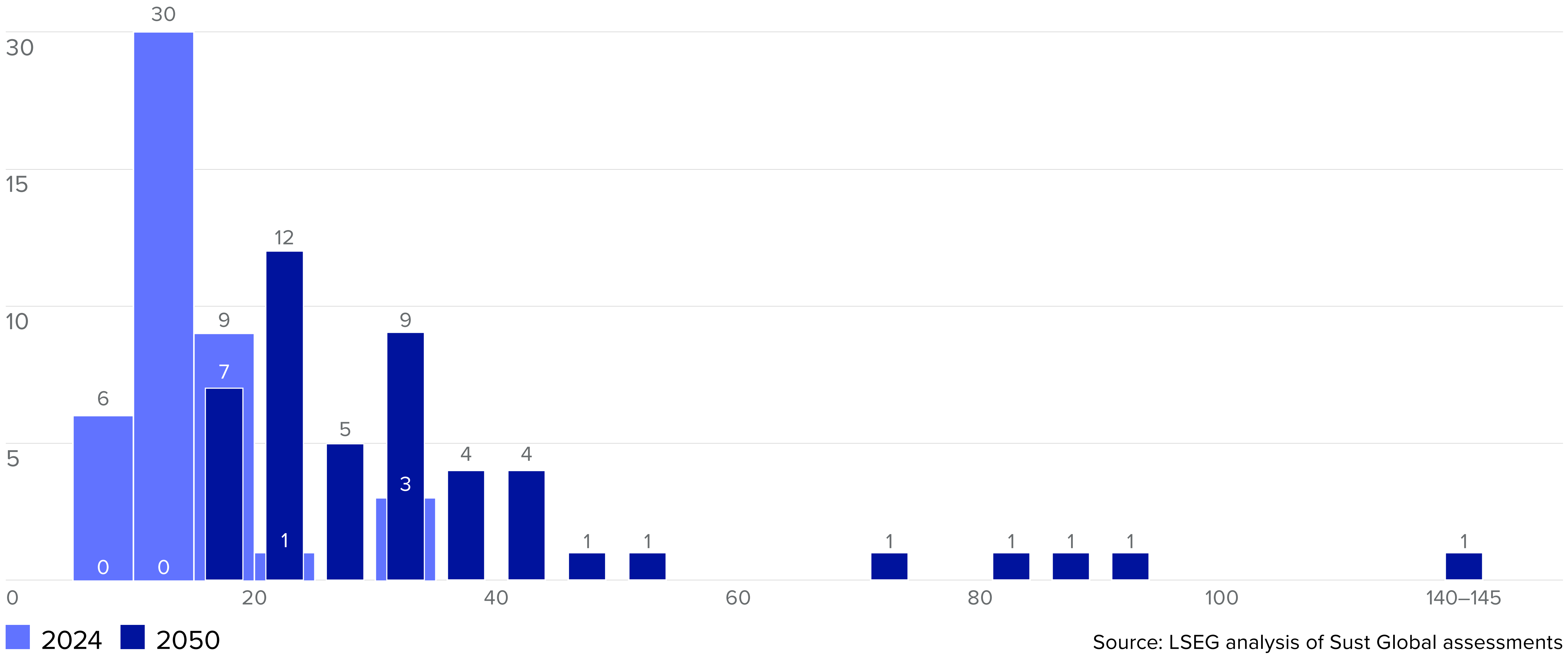
The most severely affected major cities will be in the Middle East and Southeast Asia, six cities in these regions are expected to experience more than 50 days of extreme heat a year. Indeed, five cities – Singapore, Surabaya, Dubai, Riyadh and Jeddah – would have to confront a combination of high risk for both water stress and heatwaves by 2050.

Figure 09: Proportion of cities with high-hazard risk



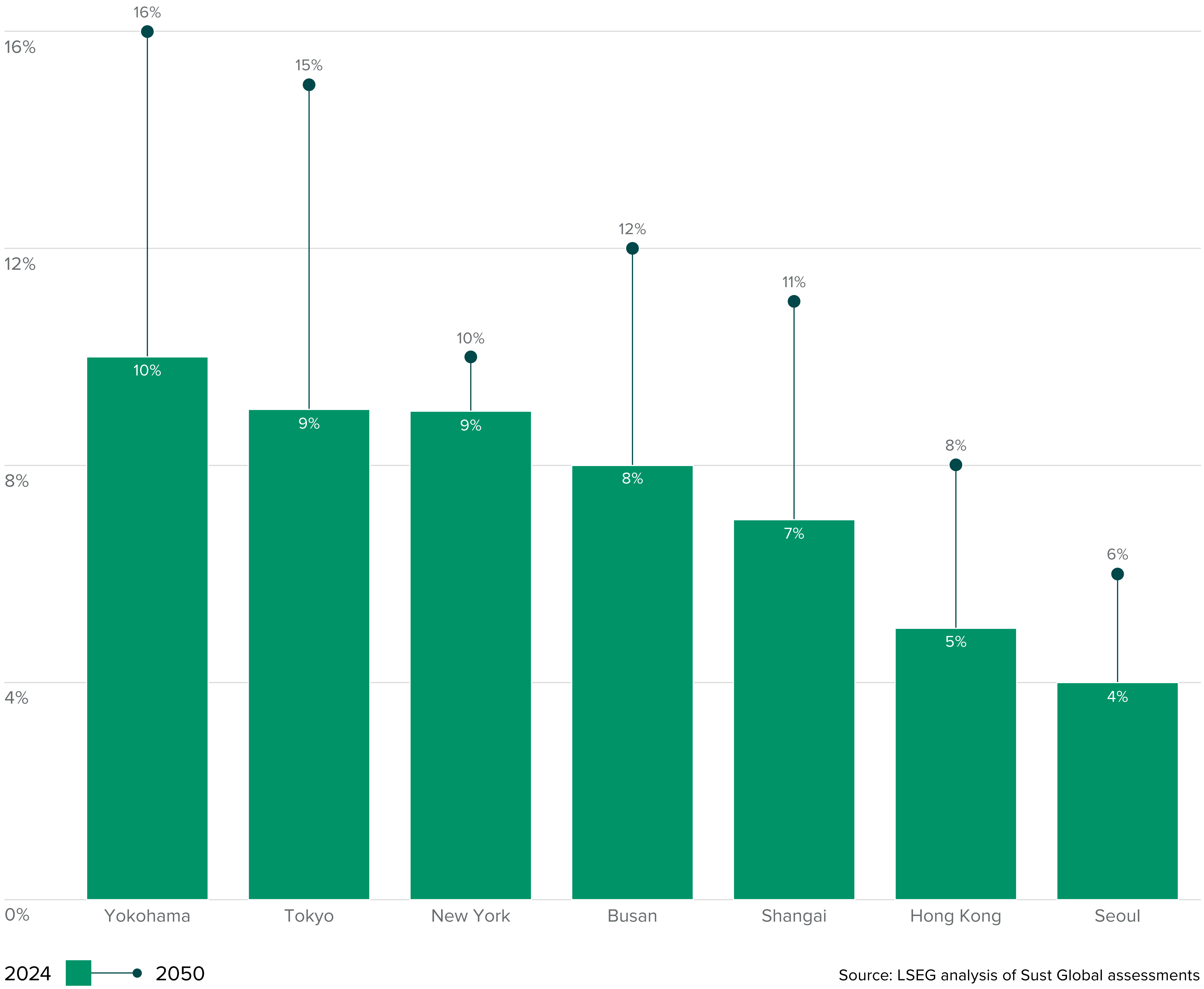
Source: LSEG analysis of Sust Global assessments

Figure 10: Evolution of heatwave days (2024–2050)



Source: LSEG analysis of Sust Global assessments

Figure 11: Evolution of cyclone risk days (2024–2050)



Source: LSEG analysis of Sust Global assessments

Risk of devastating flooding and tropical cyclones are also set to increase materially – although they will mainly impact a subset of cities that are already prone to these hazards. Amongst cities with cyclone risk, the average likelihood of a cyclone increases from an average of one every 16 years to one every 10 years – with Tokyo, for example, going from one event in 11 years in 2024 to one in seven by 2050.

Both storms and flooding can cause particularly large economic damages to cities due to their impact on real estate and infrastructure. In both New York City and Hong Kong, for example, authorities have assessed that hundreds of billion of US$ in real estate is at risk from flooding and storms[15,16].

Climate proofing G20 cities will require ramped up adaptation efforts.

Our analysis estimates climate impacts in a high emissions scenario, which could be significantly dampened through emissions reduction efforts. Nonetheless, even in a low emissions scenario rigorous efforts and large-scale resources are required to adapt cities to the shifting physical climate risk profile that they are facing. These range from developing robust adaptation plans, establishing monitoring and early warning systems, to developing more hazard-resilient buildings and infrastructure, and updating city planning and building codes.

These efforts are particularly urgent in many emerging economies, where elevated exposure to climate hazards can intersect with rapid urban expansion, high inequality, and large informal settlements and limited provision of public services. Considerably more resources will need to be directed to adaptation efforts going forward, if G20 countries are to climate-proof their cities. The UNEP Adaptation Gap Report 2023 estimated the cost of adaptation to be US$215 billion per year, of which urban adaptation will comprise a significant share[17].

These measures are costly and often require long-term planning, though experience shows that with the right levels of long-term investments, the worst impacts of escalating climate hazards can be successfully avoided.

Structures such as sea walls, levees, flood barriers and drainage systems can, for example, significantly lessen the impacts of storm surges, allowing cities like Amsterdam to thrive for centuries despite extreme levels of flood risk. In 2019, during Typhoon Hagibis, one the largest ever recorded, Tokyo's water management system successfully diverted over 12 million cubic meters of flood water, reducing the number of flooded homes in the river basin by 90% and preventing an estimated US$1.76 billion in damages[18].

Innovative nature-based solutions (NbS) can also make an important contribution to dealing with flooding and heatwaves. City authorities increasingly invest in green infrastructure like green parks, green corridors and wetlands to both manage floods and reduce the effects of the urban heat island. Examples include experiments with creating a 'sponge city' in Shanghai[19], or 'cool islands' in Paris[20], or roof gardens in Singapore[21] to help to reduce flooding and better manage extreme urban heat.

Early warning systems (EWS) and disaster response management (DRM) have proven results. Early warning systems can provide authorities with extra time to prepare the city for impacts and evacuate where necessary – with the World Meteorological Organization estimating that 30% of damages can be avoided by giving 24-hour notice of a disaster[22].

Chapter 3

Country Profiles

Argentina

Physical risk city insights

Buenos Aires

Urban population
15 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+74%
Water stress	Low	Low	Low	+22%

Located on the Río de la Plata near the Atlantic Ocean, the physical risk profile of Buenos Aires remains low even under a high emissions scenario. Although our 2050 projections forecast **heatwaves** will increase from 10 days to 18 days and a moderate increase in **water stress**, both hazards are deemed low risk for the Argentinian capital.

Córdoba

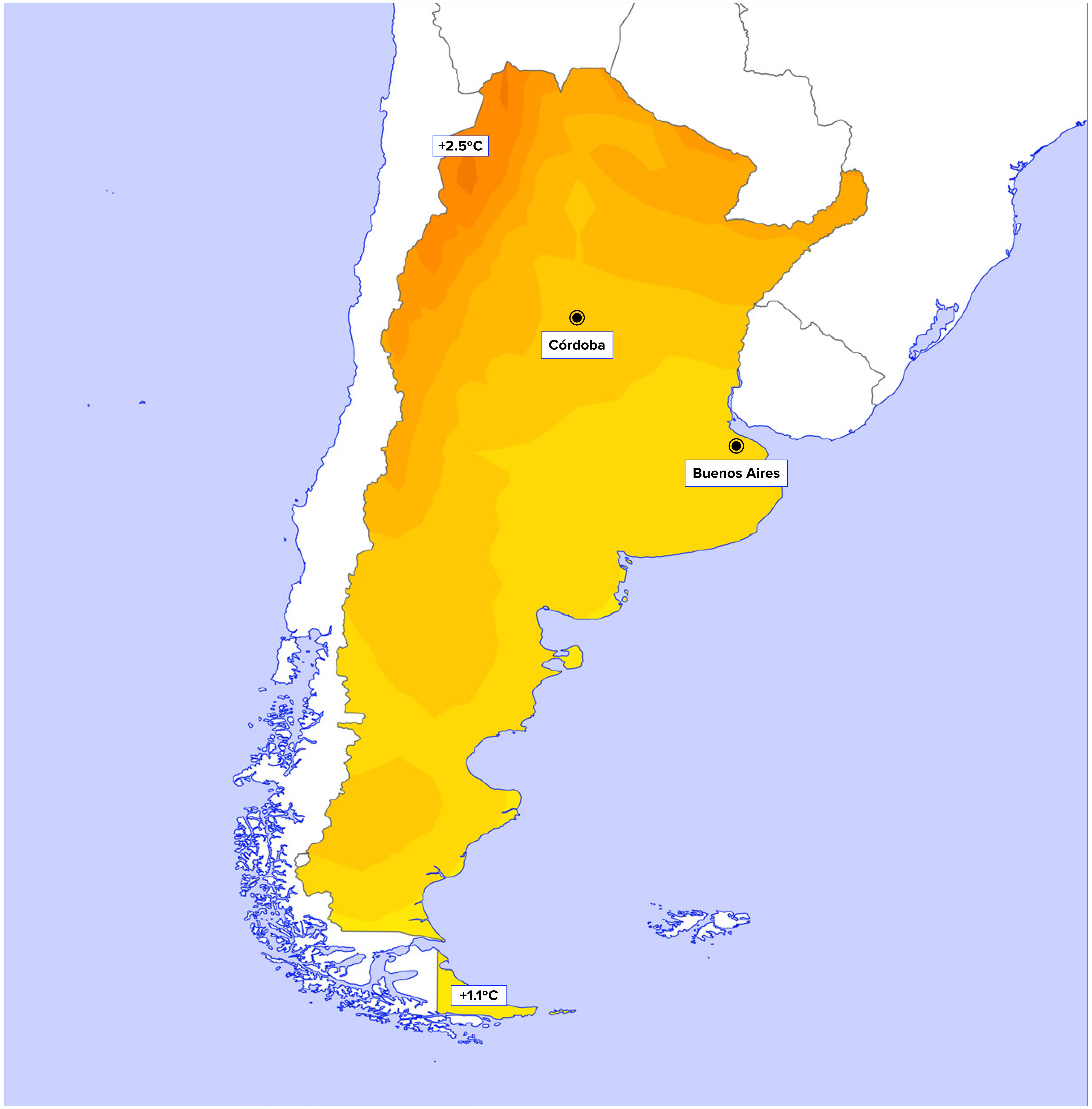
Urban population
1.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+102%
Water stress	Medium	Medium	Medium	+12%

Córdoba is situated in central Argentina in the foothills of the Sierras de Córdoba. It has a humid subtropical climate with dry winters and hot, rainy summers. **Water stress** is projected to increase slightly under a high emissions scenario remaining a medium risk until 2050.
The number of **heatwave** days are expected to double from 11 days to 22 days in 2050, staying at a low risk level.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C
+4.0°C



Argentina

We project that by 2030, Argentina's current policies will result in the country overshooting its NDC by 19%, or 69 $MtCO_2e$.

We also estimate that Argentina will surpass its 1.5°C emissions budget by 2031.

NDC 2.0[1]

Conditionality	Unconditional
Covers all sectors	✓

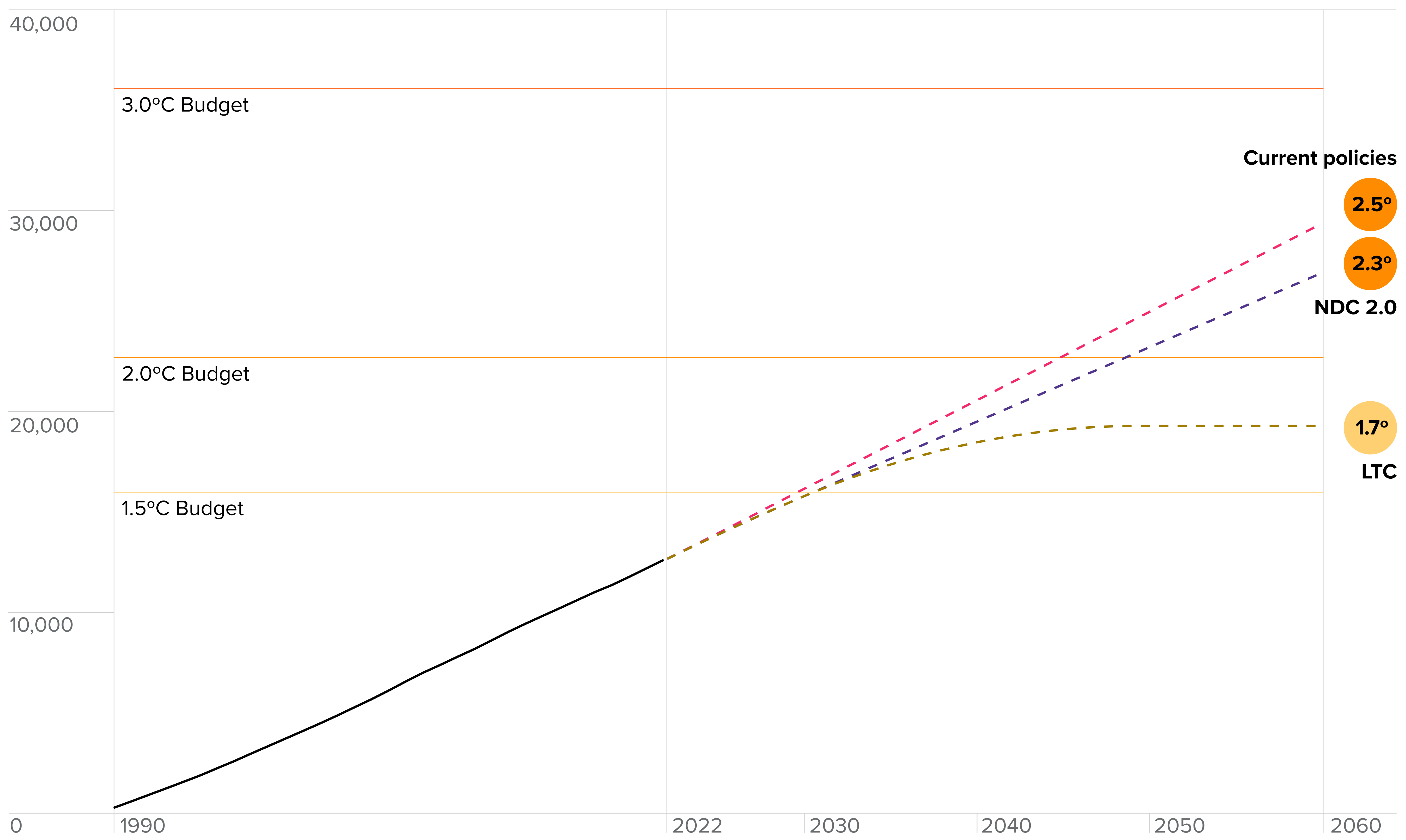
In its most recent (2021) NDC, Argentina has pledged to cap emissions at 349 $MtCO_2e$ in 2030. However, the absolute emissions target is based on Second Assessment Report (SAR) Global Warming Potential (GWP) values. We estimate Argentina's NDC to be 367 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[2]

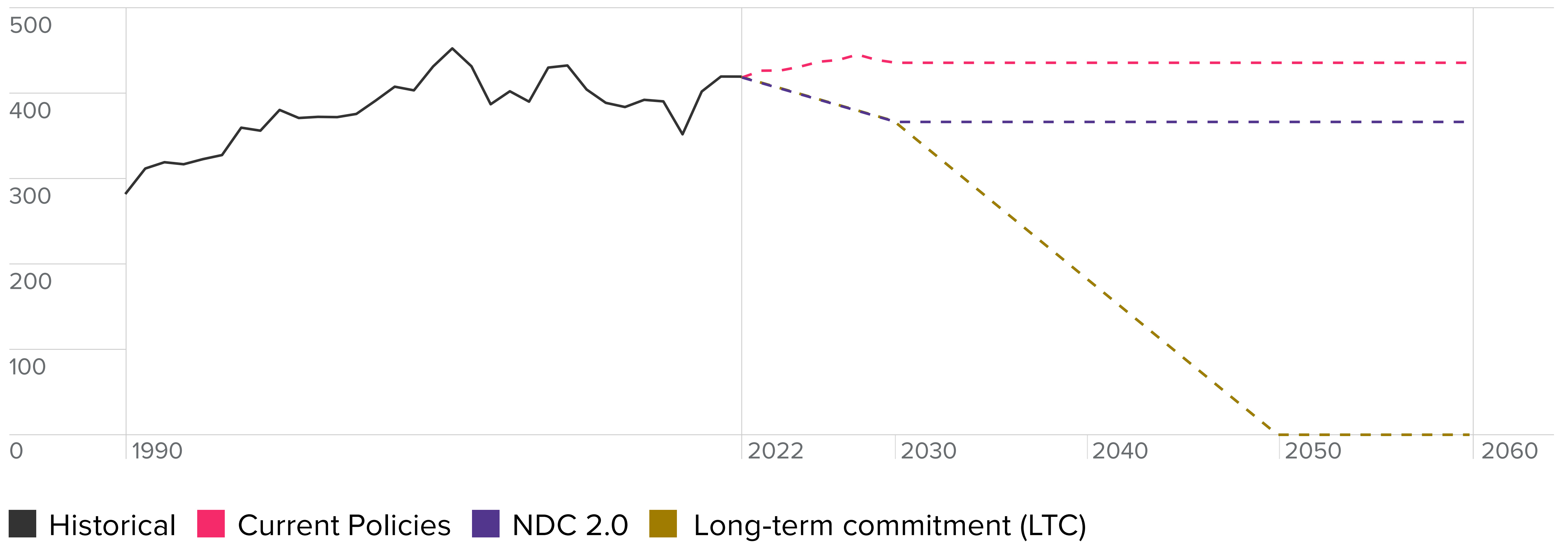
Covers all sectors	✓
Covers Kyoto gases[3]	✓

Argentina submitted its long-term strategy to the UNFCCC in 2022 with the target of achieving net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Argentina

Policies overview

✓ National adaptation plan[4]

Regular published risk assessments	✓
Monitoring and evaluating report	In development ✗
Part of a sovereign catastrophe risk pool	✗

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[5]	2.5% of GDP

✓ Carbon pricing system[6]

% of GHG emissions covered by carbon price	38%
Carbon price ($/t$CO_2$e)	0.81[5]
Aligned with the global carbon price corridor[7]	✗

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity
(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Hydroelectric[8]	9.81	4th[11]
Wind[9]	3.63	15th[9]
Solar[10]	2.29	15th[8]
Geothermal[11]	0	N/A[10]

Argentina

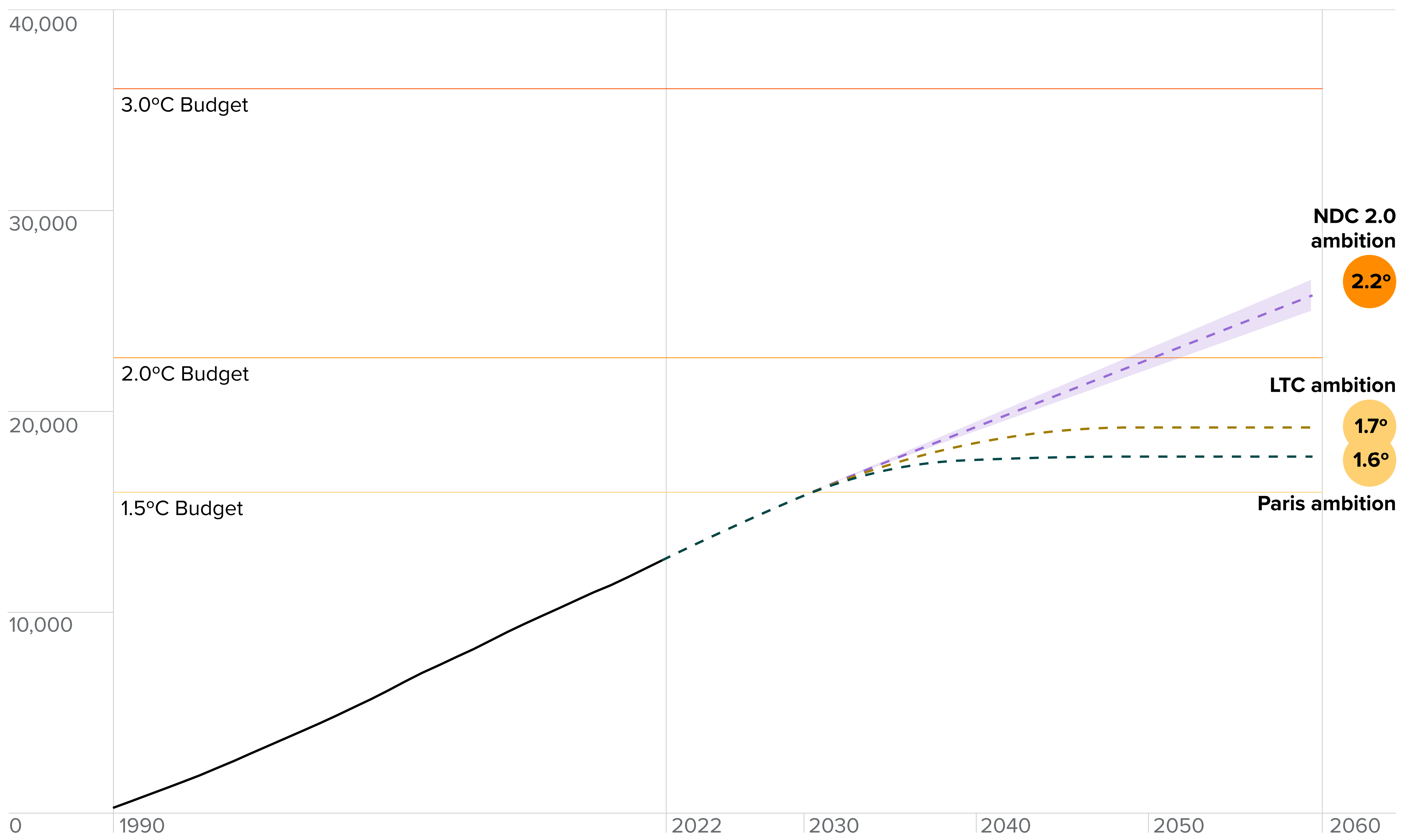
2035 targets

NDC 2.0 ambition: we estimate that if Argentina were to set targets based on the same ambition as its current NDC 2.0, it would set a target in the range of 300-360 $MtCO_2e$ for 2035. The median of this range would keep Argentina on a greater than 2°C decarbonisation pathway.

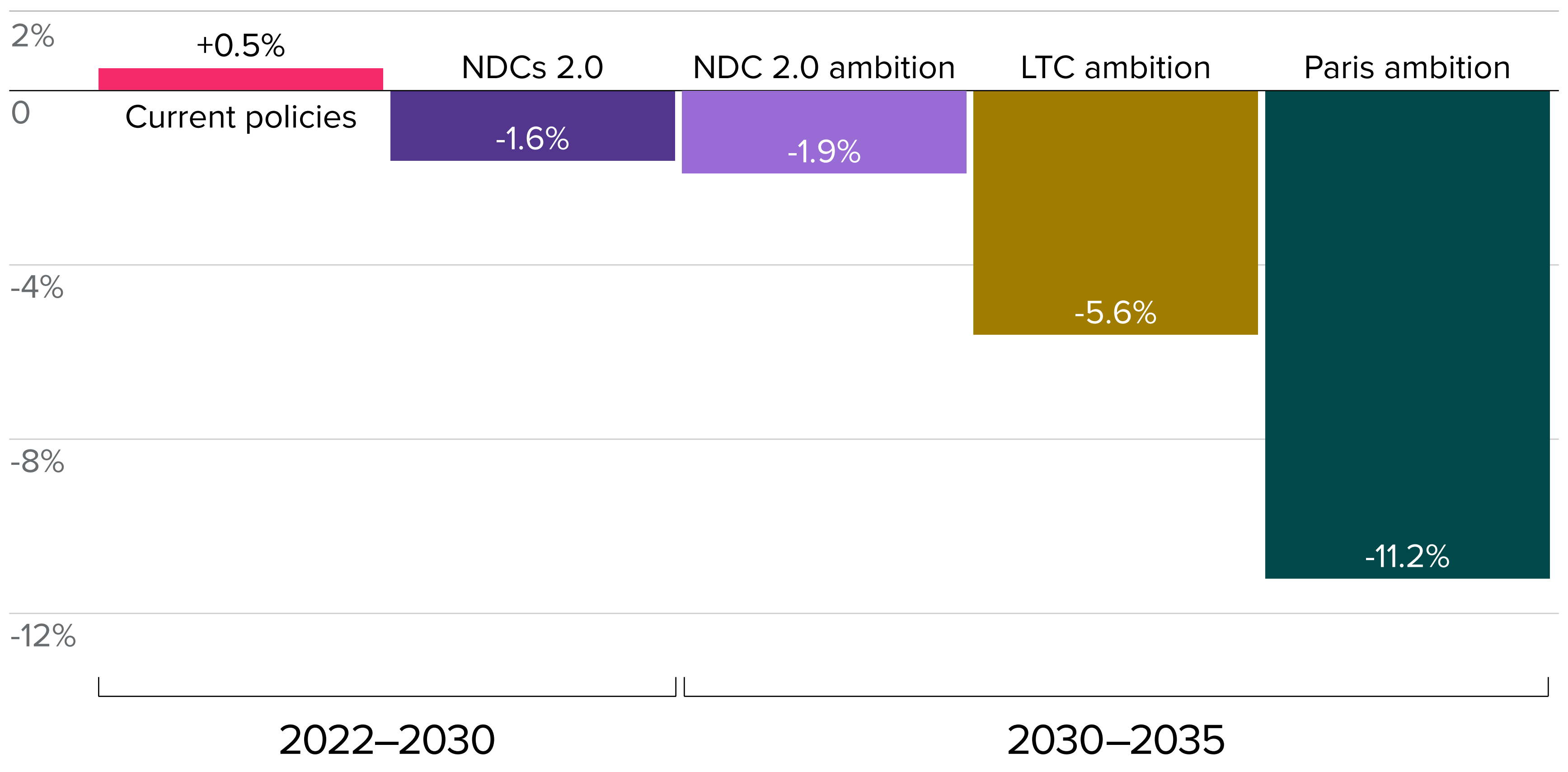
However, if Argentina sets a 2035 target that's less than 293 $MtCO_2e$ in 2035, then we project that it will be on a below 2°C pathway and have a reasonable chance of achieving its 2050 net zero target.

To achieve its LTC Ambition, Argentina will have to substantially ramp up its annual rate of decarbonisation from +0.5% under current policies from 2024-2030 to 6% year on year decarbonisation from 2030 onwards to reach its 2035 target under **LTC Ambition** and 11% under **Paris Ambition**.

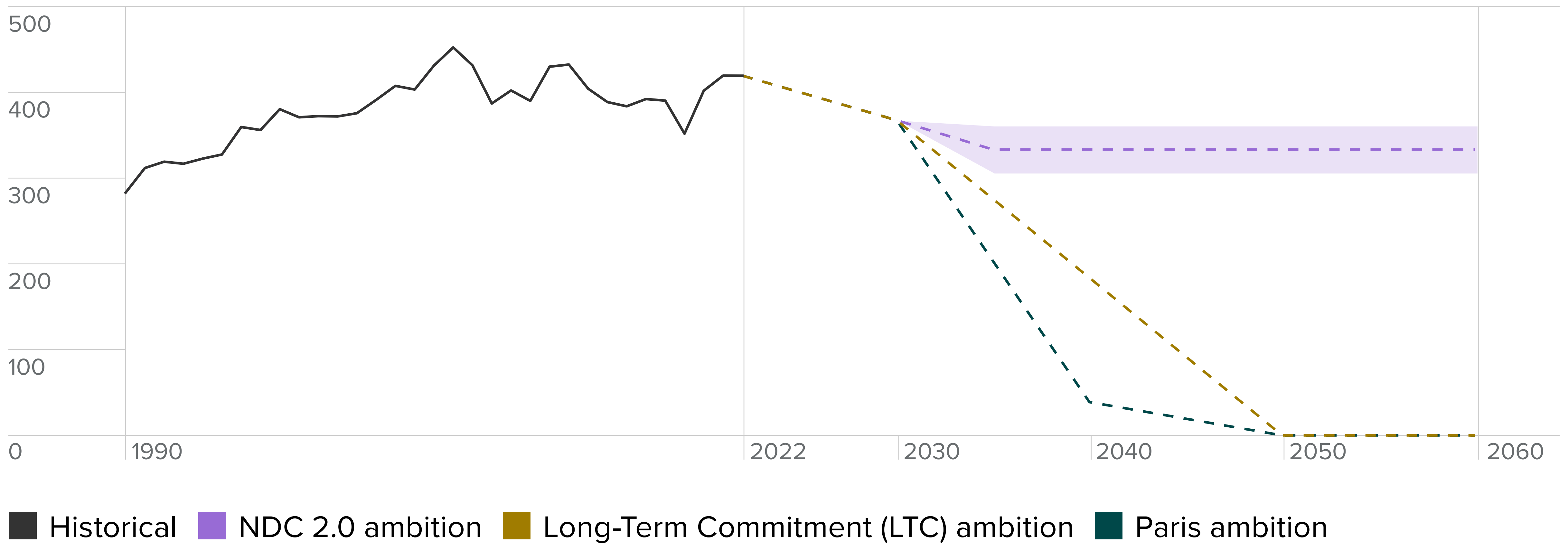
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Australia

Physical risk city insights

Melbourne

Urban population
5 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+37%
Heatwaves	Low	Low	Low	+73%
Water stess	Medium	Medium	High	+44%

Situated on the northern shore of Port Phillip Bay, Melbourne has a temperate oceanic climate with changeable weather. Its coastal location leaves it exposed to sea level rise. **Water stress** is projected to become a high risk in 2050 under high emissions scenarios due to expected longer and drier periods. The number of **heatwave** days are anticipated to grow from 8 to 14 days.

Sydney

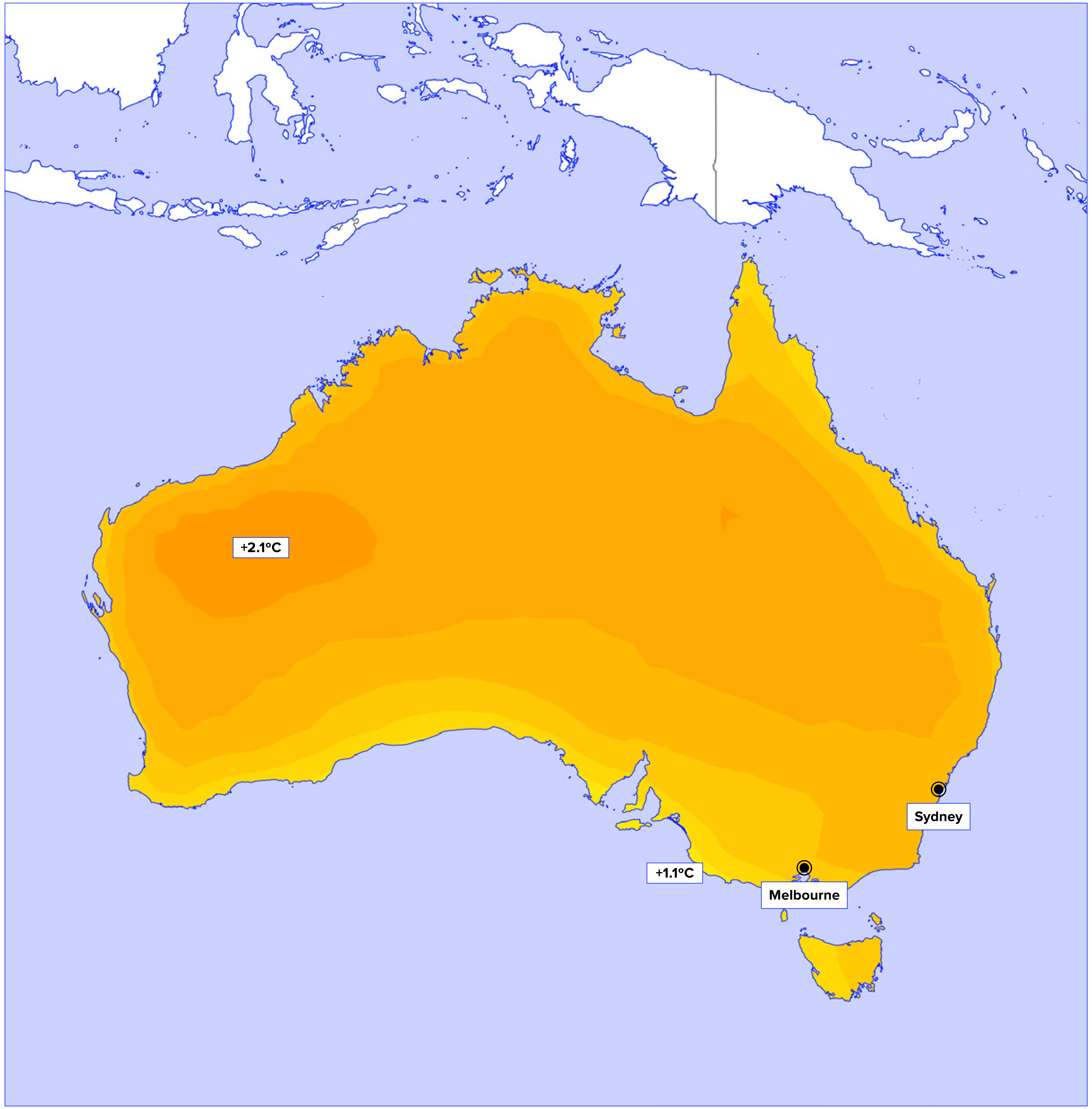
Urban population
5 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+2%
Heatwaves	Low	Low	Low	+75%
Water stress	Medium	Medium	Medium	+24%

Sydney sits on Australia's southeastern coast near the Pacific. It has a humid subtropical climate with warm summers, mild winters. Less predictable rainfall has resulted in medium risk of **water stress** for Sydney, which is anticipated to remain at the same level in 2050 under high emissions scenarios. The number of **heatwave** days is anticipated to grow from 10 to 18 days per year.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C +4.0°C



Australia

We project that Australia's current policies mean that it will reach, and be 2% or 8 $MtCO_2e$ under, its NDC by 2030.

We also estimate that Australia will surpass its 1.5°C emissions budget by 2027.

NDC 2.0[12]

Conditionality	Unconditional
Covers all sectors	✔

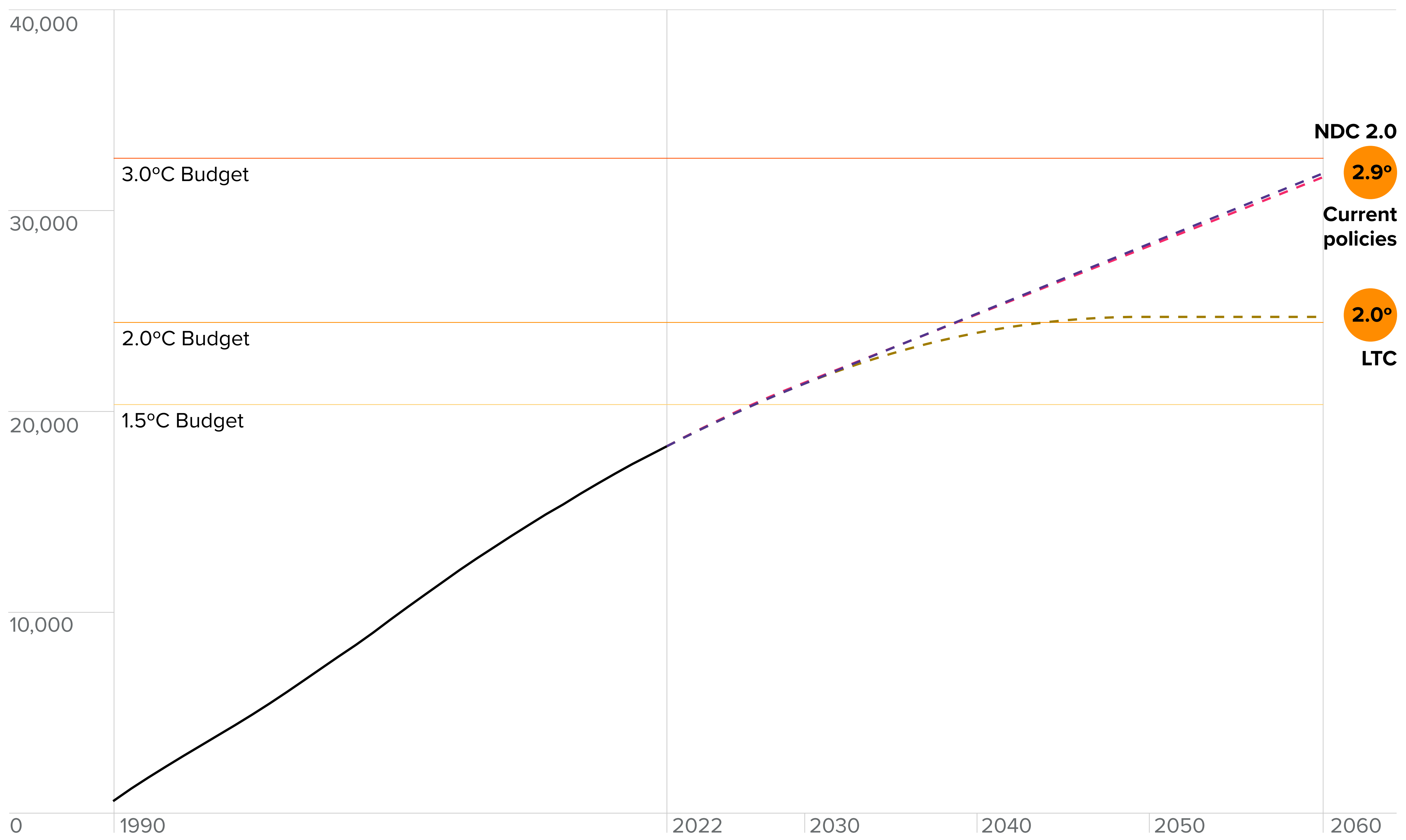
In its most recent (2022) NDC, Australia has pledged to reduce GHG emissions by 43% compared to 2005 levels by 2030. We estimate Australia's NDC to be 349 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[13]

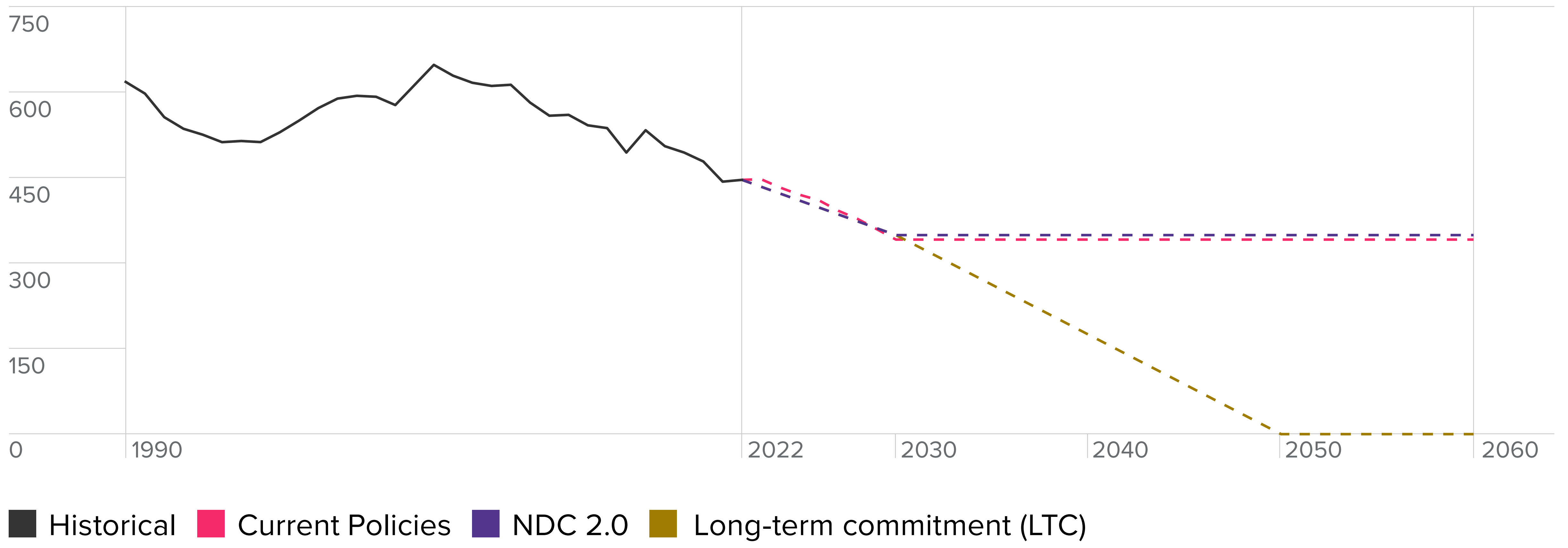
Covers all sectors[14]	✔
Covers Kyoto gases	✔

The Climate Change Act 2022 legislated Australia's emissions reduction target for net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Australia

Policies overview

✓ National adaptation plan[15]

Regular published risk assessments[16]	✓
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[17]	0.5% of GDP

✓ Carbon pricing system[18]

% of GHG emissions covered by carbon price	26%
Carbon price (\$/tCO_2e)	21.90
Aligned with the global carbon price corridor[19]	✗

Climate finance

3-year average climate finance contribution as a % of GDP[20]	0.02%
Proportional share of \$100 billion global climate finance commitment[21]	✗
Targeted level of international climate finance contribution as a % of GDP	0.02%
Target to increase global climate finance contributions[22]	✓

Energy opportunity (Prospective energy capacity)	MW/\$bn GDP	G20 rank
Wind[23]	120.89	1st
Solar[24]	57.56	2nd
Hydroelectric[25]	8.43	6th
Geothermal[26]	0	N/A

Australia

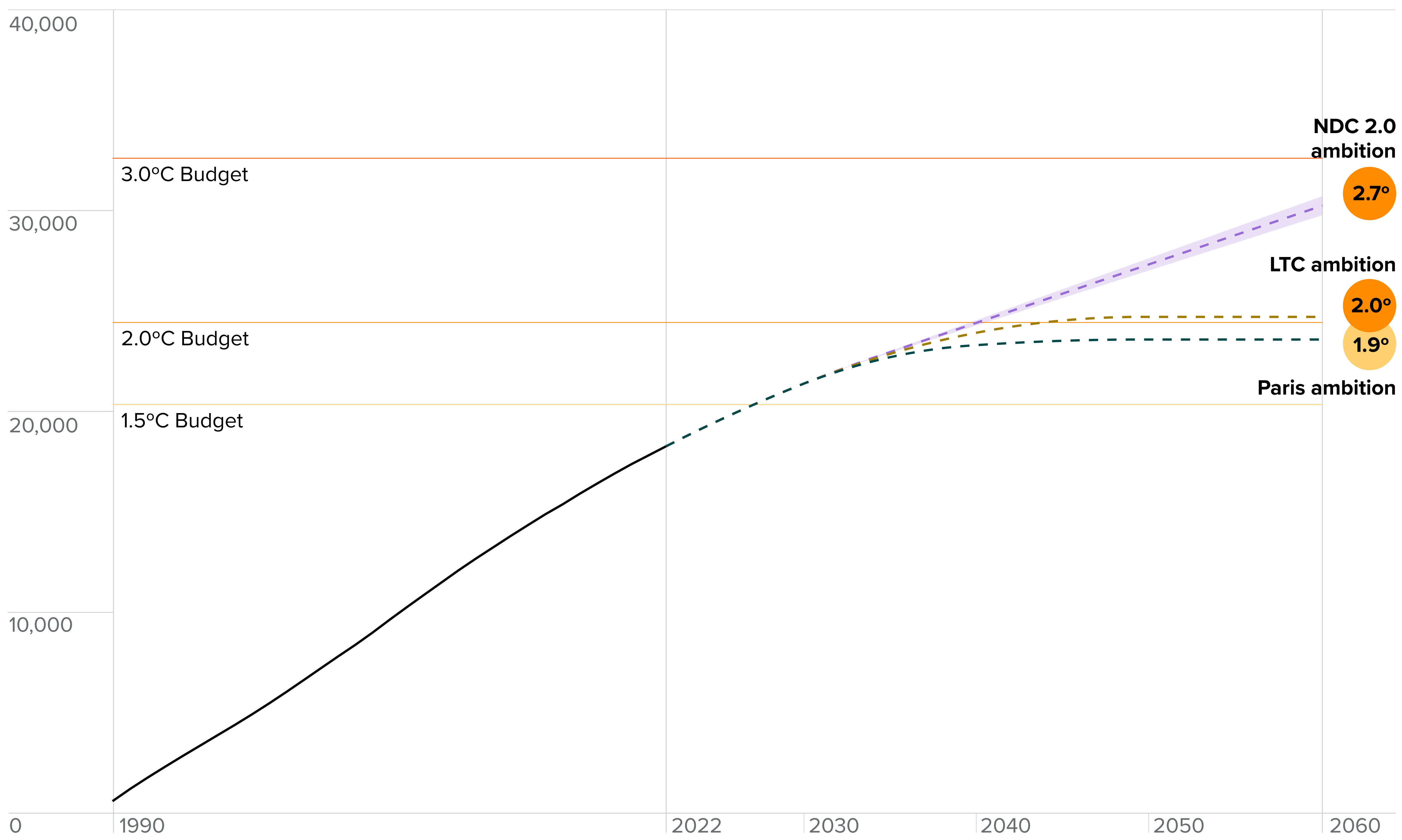
2035 targets

NDC 2.0 ambition: we estimate that, if Australia were to set targets based on the same ambition as its current NDC 2.0, it would set a 270-310 $MtCO_2e$ target for 2035. The median of this range would keep Australia on a greater than 2°C decarbonisation pathway.

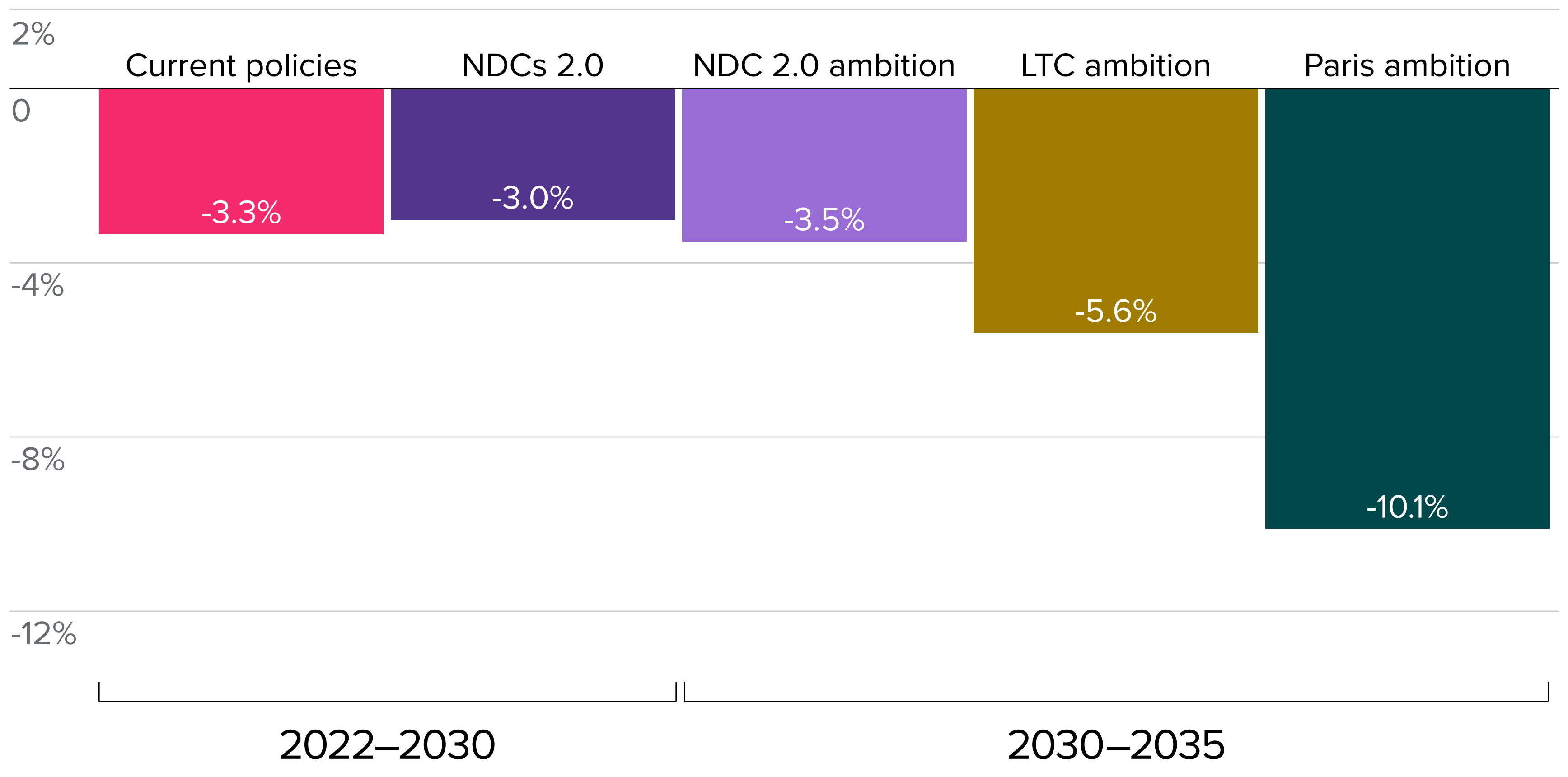
However, if Australia sets a 2035 target that is 205 $MtCO_2e$ or less in 2035, then we project that it will be on a below 2°C pathway and have a good chance of achieving its 2050 net zero target.

Australia will have to ramp up its annual rate of decarbonisation from 3.3% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 10% under **Paris ambition**.

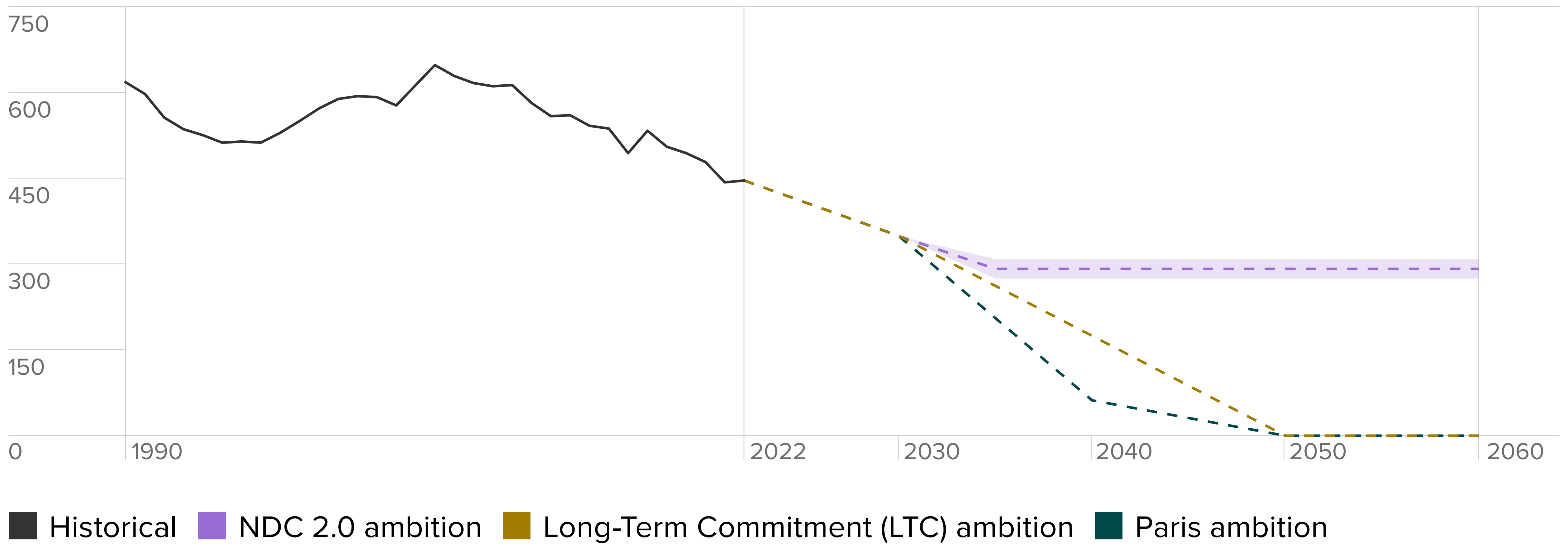
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Brazil

Physical risk city insights

Rio de Janeiro

Urban population
13 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Medium	Medium	Medium	0%
Heatwaves	Low	Low	Medium	+193%
Water stress	Medium	Medium	Medium	+60%

Located between mountains on Brazil's Atlantic coast, Rio de Janeiro has a tropical climate with hot summers and warm winters. Changing rainfall patterns and increasingly frequent droughts mean **water stress** is at a medium risk level and is anticipated to increase by 193% by 2050. **Heatwave** days are estimated to increase from 14 days to over 40 days, becoming a medium risk by 2050.

São Paulo

Urban population
22 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	-3%
Heatwaves	Low	Low	Medium	+139%
Water stress	Low	Low	Low	+55%

São Paulo sits at the edge of an extensive plateau, 70km away from the Atlantic coastline. It has a subtropical climate with hot, rainy summers, and mild winters. **Heatwave** risk is expected to grow from low to medium risk by 2050, with a projected increase from 15 to 35 annual days of extreme heat.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C +4.0°C

Brazil

We project that, by 2030, Brazil's current policies will result in the country overshooting its NDC by 33%, or 391 $MtCO_2e$.

We also estimate that Brazil will surpass its 1.5°C emissions budget by 2032.

NDC 2.0[27]

Conditionality	Unconditional
Covers all sectors[28]	✓

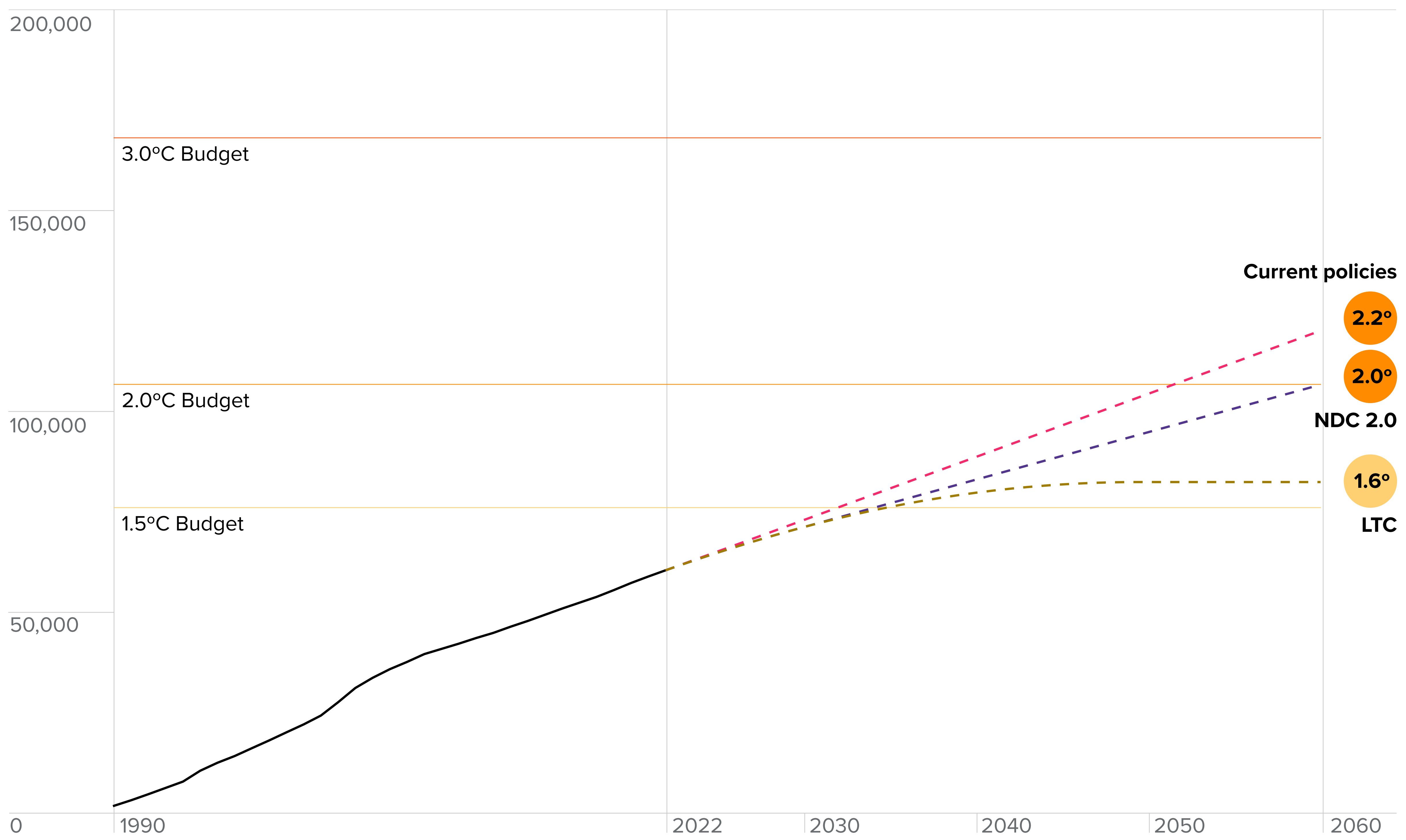
In its most recent (2023) NDC, Brazil has pledged to limit emissions to 1.2 $GtCO_2e$ in 2030. This was reported using AR5 GWP values and includes all sectors. We therefore estimate Brazil's NDC to be 1.19 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)

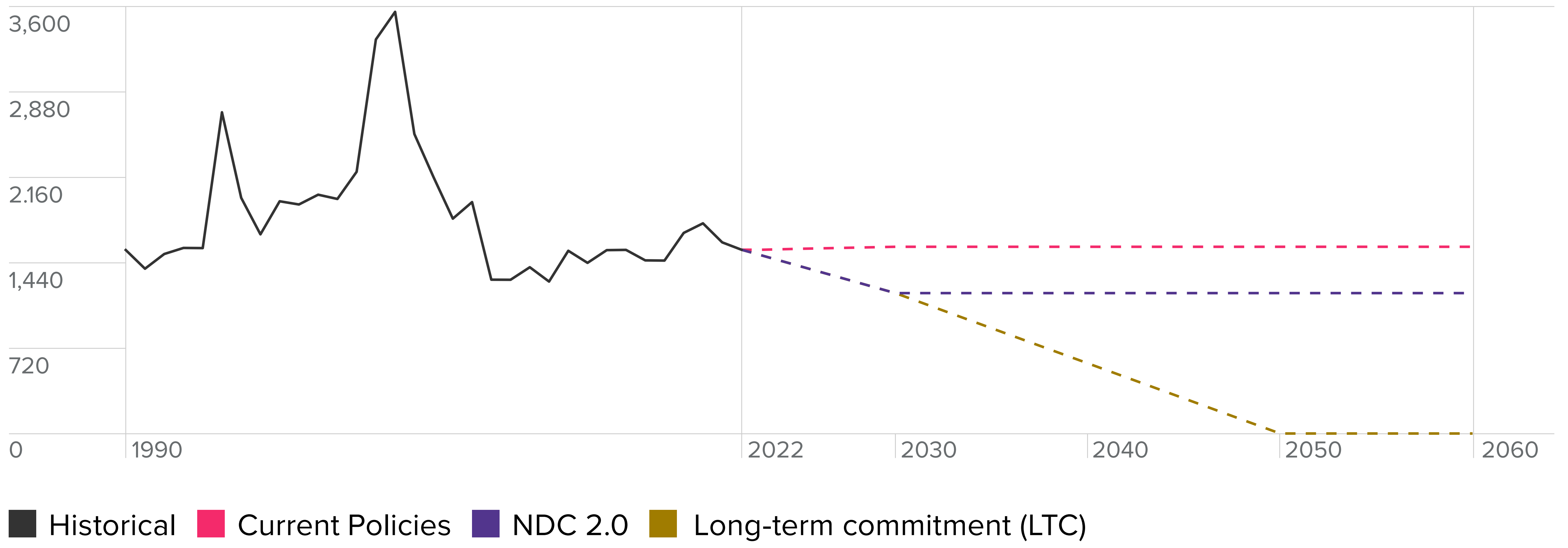
Covers all sectors	Unclear
Covers Kyoto gases	Unclear

In its 2023 NDC, Brazil reiterated its objective to achieve 'climate neutrality' by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Brazil

Policies overview

✓ National adaptation plan[29]

Regular published risk assessments	✗
Monitoring and evaluating report[30]	✓
Part of a sovereign catastrophe risk pool	✗

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[31]	0.1% of GDP

✗ Carbon pricing system

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[32]	83.02	2nd
Solar[33]	64.00	1st
Hydroelectric[34]	9.25	5th
Geothermal[35]	0	N/A

Brazil

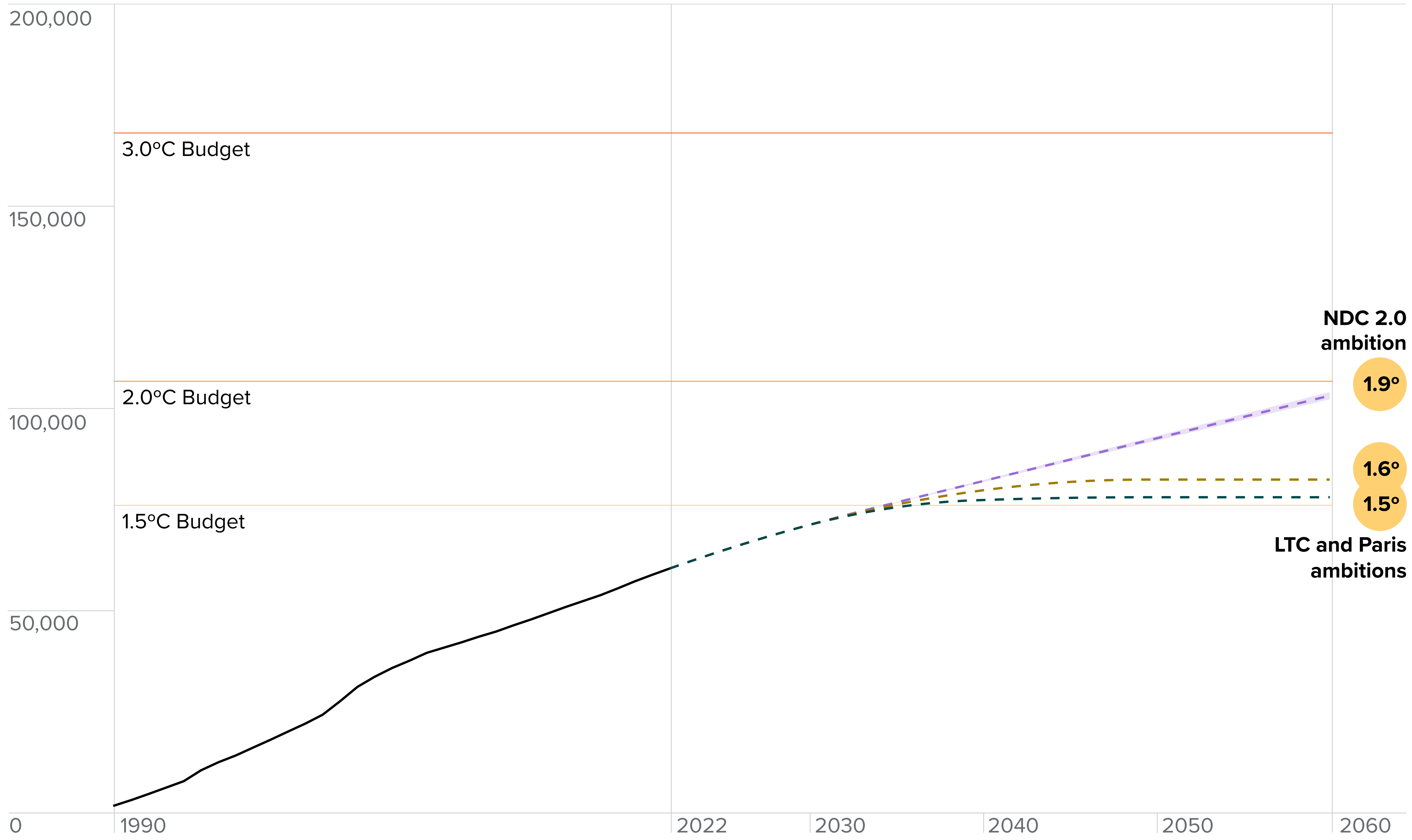
2035 targets

NDC 2.0 ambition: we estimate that, if Brazil were to set targets based on the same ambition as its current NDC 2.0, it would set a 1.03–1.09 $GtCO_2e$ target for 2035. The middle of this range would keep Brazil on a below 2°C decarbonisation pathway.

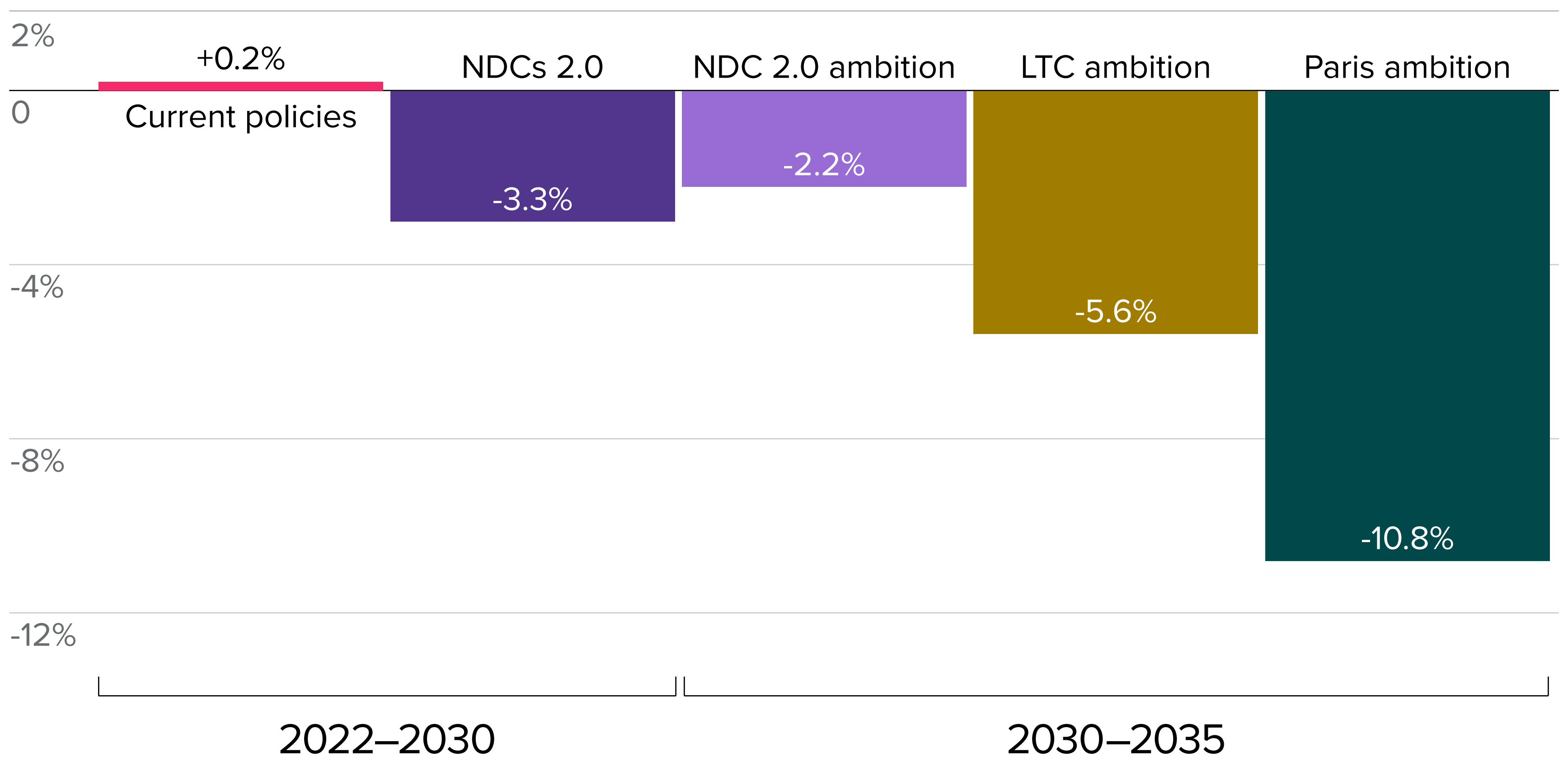
However, if Brazil sets a 2035 target that is 670 $MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a good chance of achieving its 2050 net zero target.

Brazil will have to substantially ramp up its efforts to decarbonise, going from +0.2% growth in emissions under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 11% under **Paris ambition**.

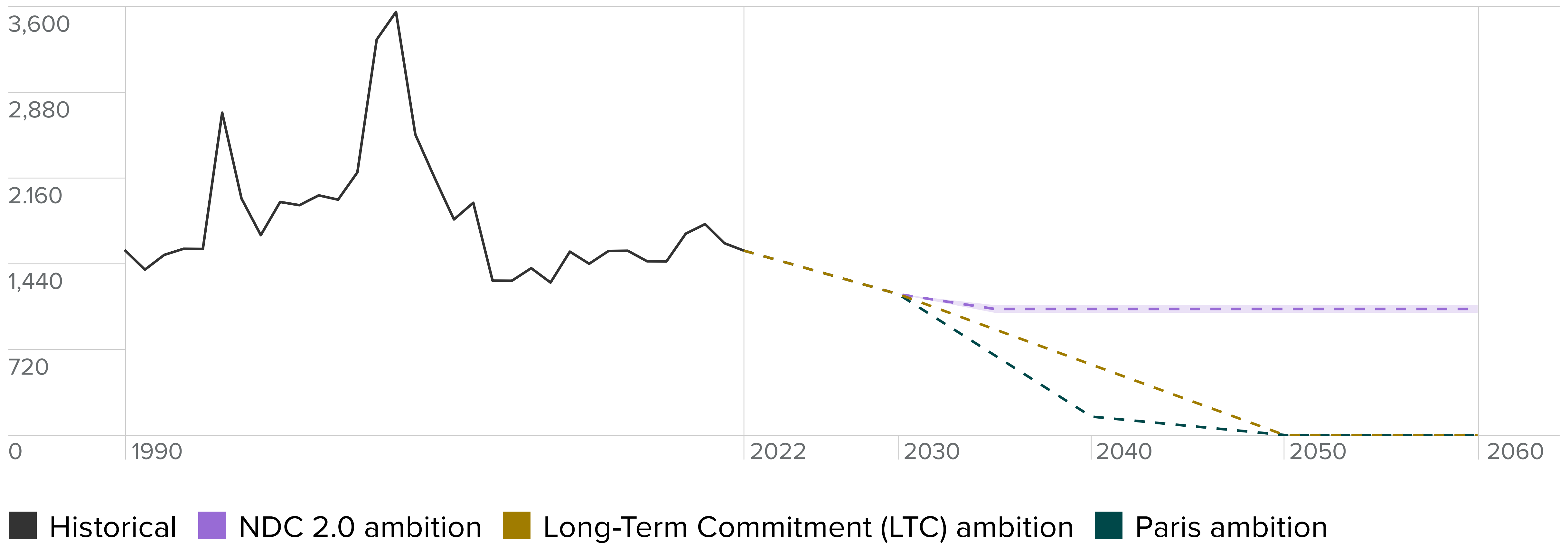
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Canada

Physical risk city insights

Montréal

Urban population
4.2 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	Medium	Medium	Medium	+102%
Flooding	Medium	Medium	Medium	-9%
Heatwaves	Low	Low	Low	+82%

Montreal is located on an island in the Saint Lawrence River and has a humid continental climate with cold winters and warm summers. **Flooding** risk is expected to slightly reduce under high emission scenarios due to the increasing frequency of dry spells. The risk of a category 1 **cyclone** in Montréal is projected to rise substantially from 1 every century to 1 in every 45 years.

Toronto

Urban population
6.2 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	Low	Low	Low	+82%
Heatwaves	Low	Low	Low	+108%
Water stress	Low	Low	Low	+72%

Located on the northern shore of Lake Ontario, Toronto experiences a humid continental climate including cold winters with significant snowfall and warm, humid summers. The city's proximity to the Great Lakes influences its weather patterns, with warmer temperatures in winter and cooler temperatures in summer than would be otherwise. Toronto has relatively low exposure to climate hazards compared to other cities in our survey, with all hazards remaining at a low risk level in 2050.

Projected temperature increase by 2050 (High-emissions scenario)

Canada

We project that, by 2030, Canada's current policies will result in the country overshooting its NDC by 37%, or 175 $MtCO_2e$.

We also estimate that Canada will surpass its 1.5°C emissions budget by 2027.

NDC 2.0[36]

Conditionality	Unconditional
Covers all sectors	✔

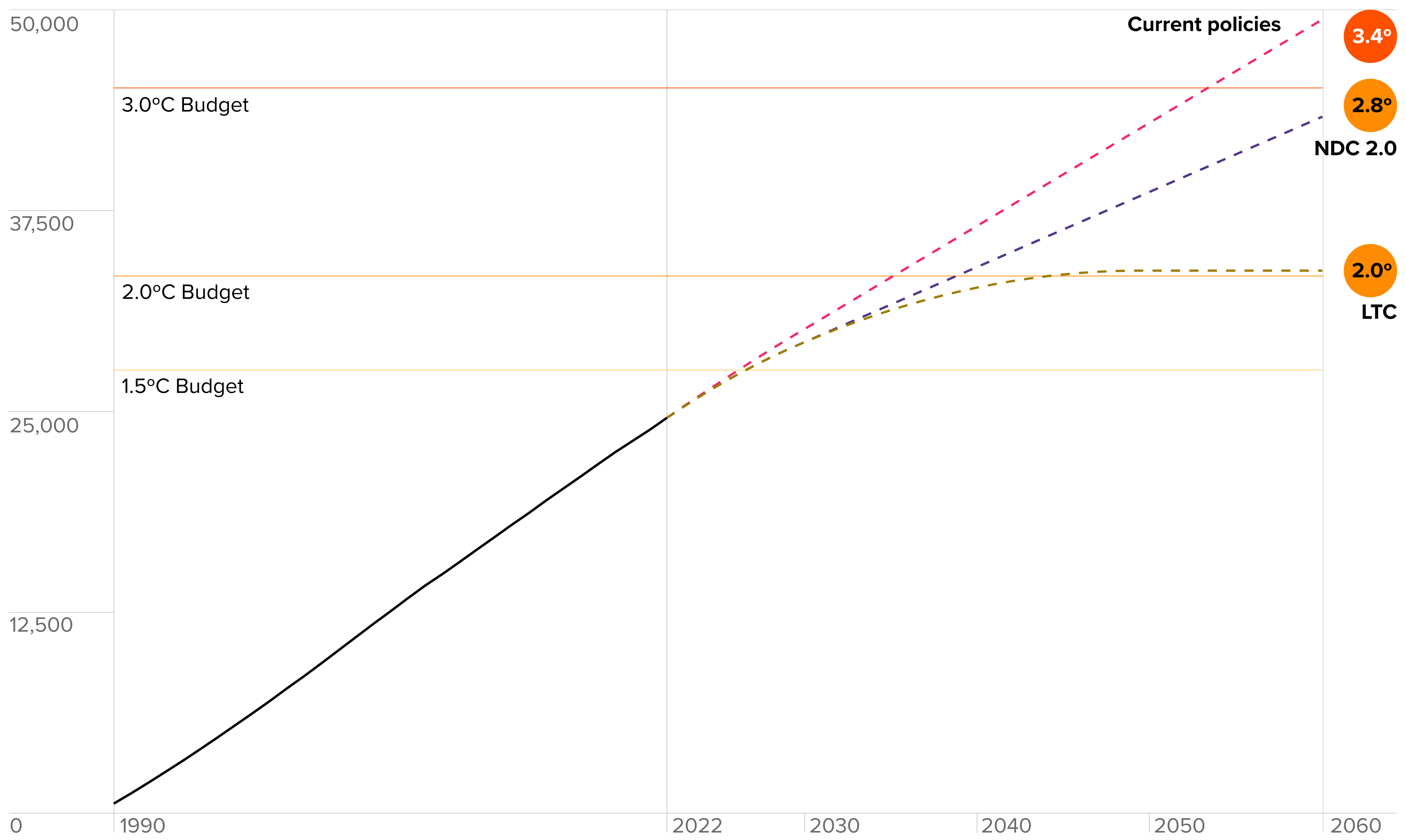
In its most recent (2021) NDC, Canada pledged to reduce GHG emissions by at least 40–45% below 2005 levels by 2030. We estimate Canada's NDC to be 467 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[37]

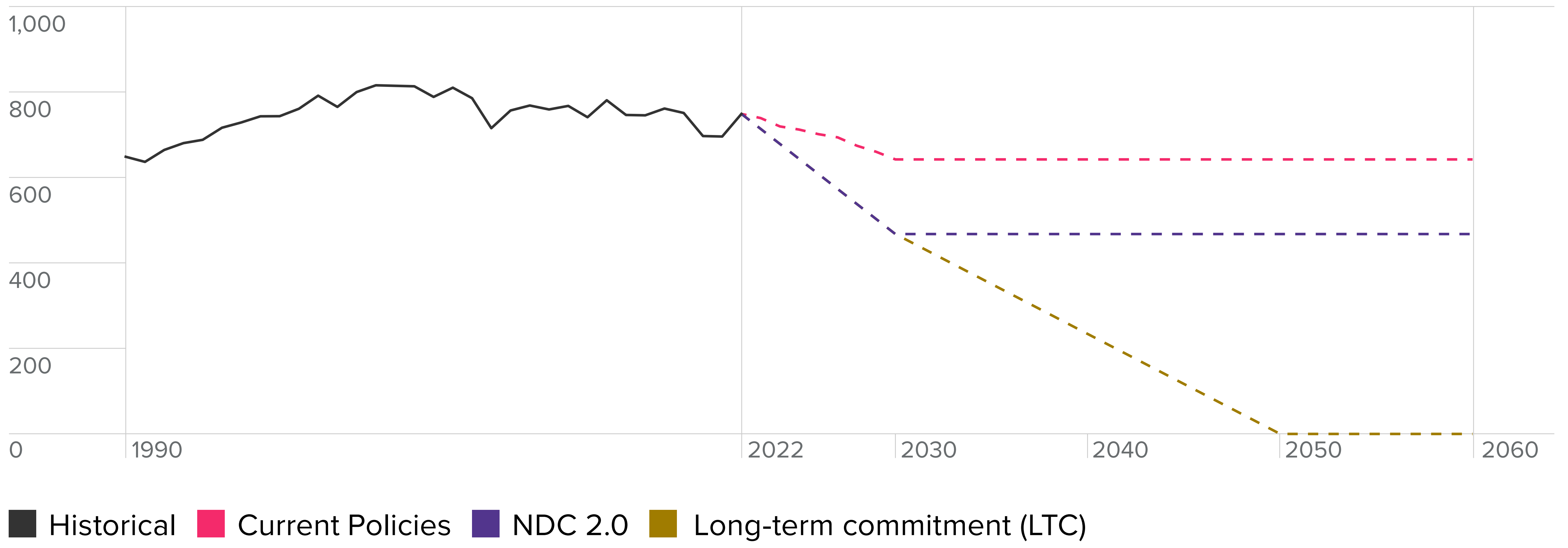
Covers all sectors[38]	✔
Covers Kyoto gases	✔

In its 2021 NDC, Canada signed the Canadian Net-Zero Emissions Accountability Act into law. Its ambition is to achieve net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Canada

Policies overview

✓ National adaptation plan[39]

Regular published risk assessments[40]	✓
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

✓ Commited to fossil fuel subsidies phase out[42] — 2023

Annual amount spent on explicit fossil fuel subsidies[43]	0.1% of GDP[41]

✓ Carbon pricing system

% of GHG emissions covered by carbon price	Tax	31%
	ETS	1%
Carbon price ($/t$CO_2$e)	Tax[44]	58.95
	ETS[45]	58.95
Aligned with the global carbon price corridor[46]		✓

Climate finance

3-year average climate finance contribution as a % of GDP[47]	0.04%
Proportional share of $100 billion global climate finance commitment[48]	✗
Targeted level of international climate finance contribution as a % of GDP	0.04%
Target to increase global climate finance contributions[49]	✗

Energy opportunity

(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Wind[50]	5.18	11th
Solar[51]	3.13	13th
Hydroelectric[52]	2.67	9th
Geothermal[53]	0.14	3rd

Canada

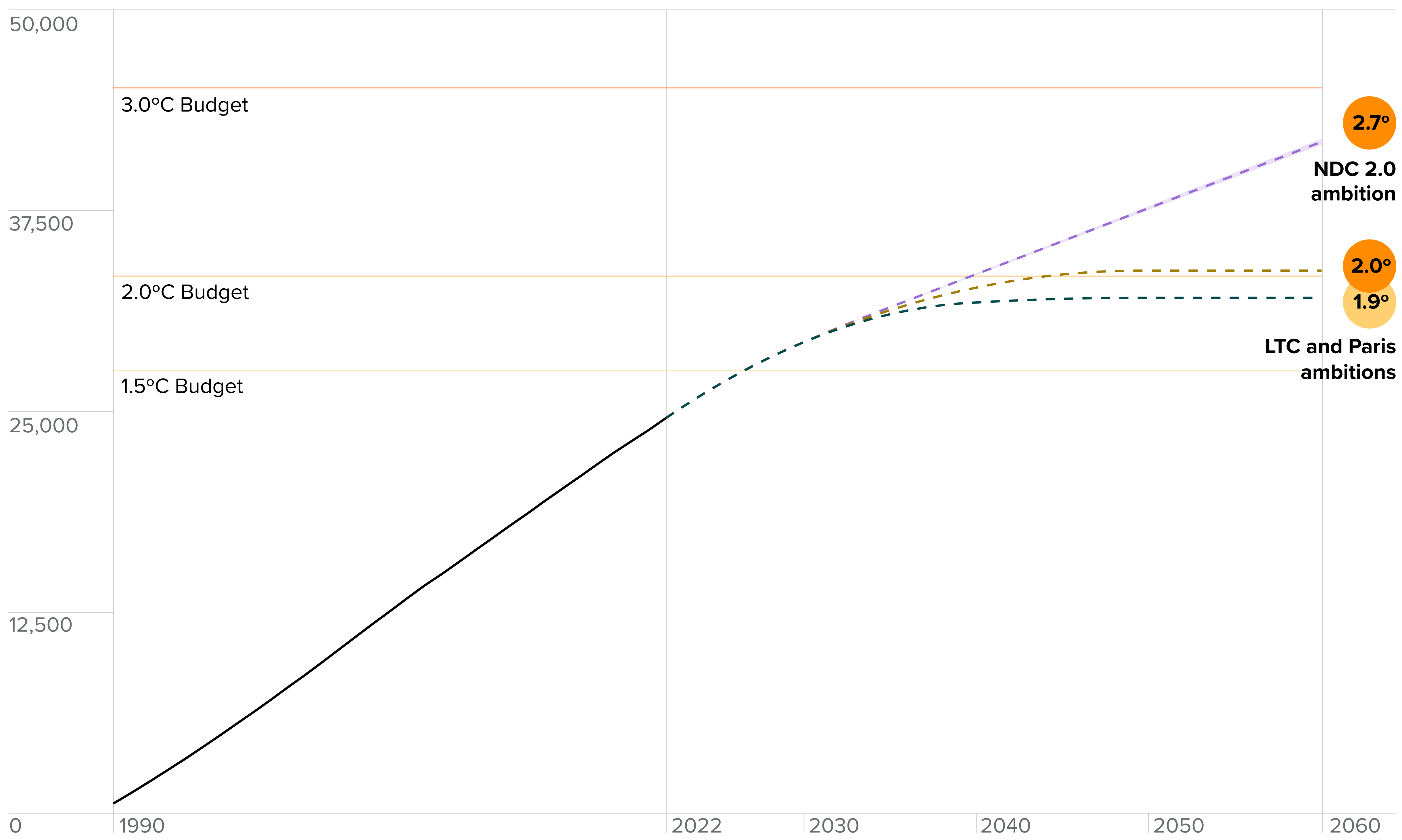
2035 targets

NDC 2.0 ambition: we estimate that, if Canada were to set targets based on the same ambition as its current NDC 2.0, it would set a 400-420 $MtCO_2e$ target for 2035. The median of this range would keep Canada on a greater than 2°C decarbonisation pathway.

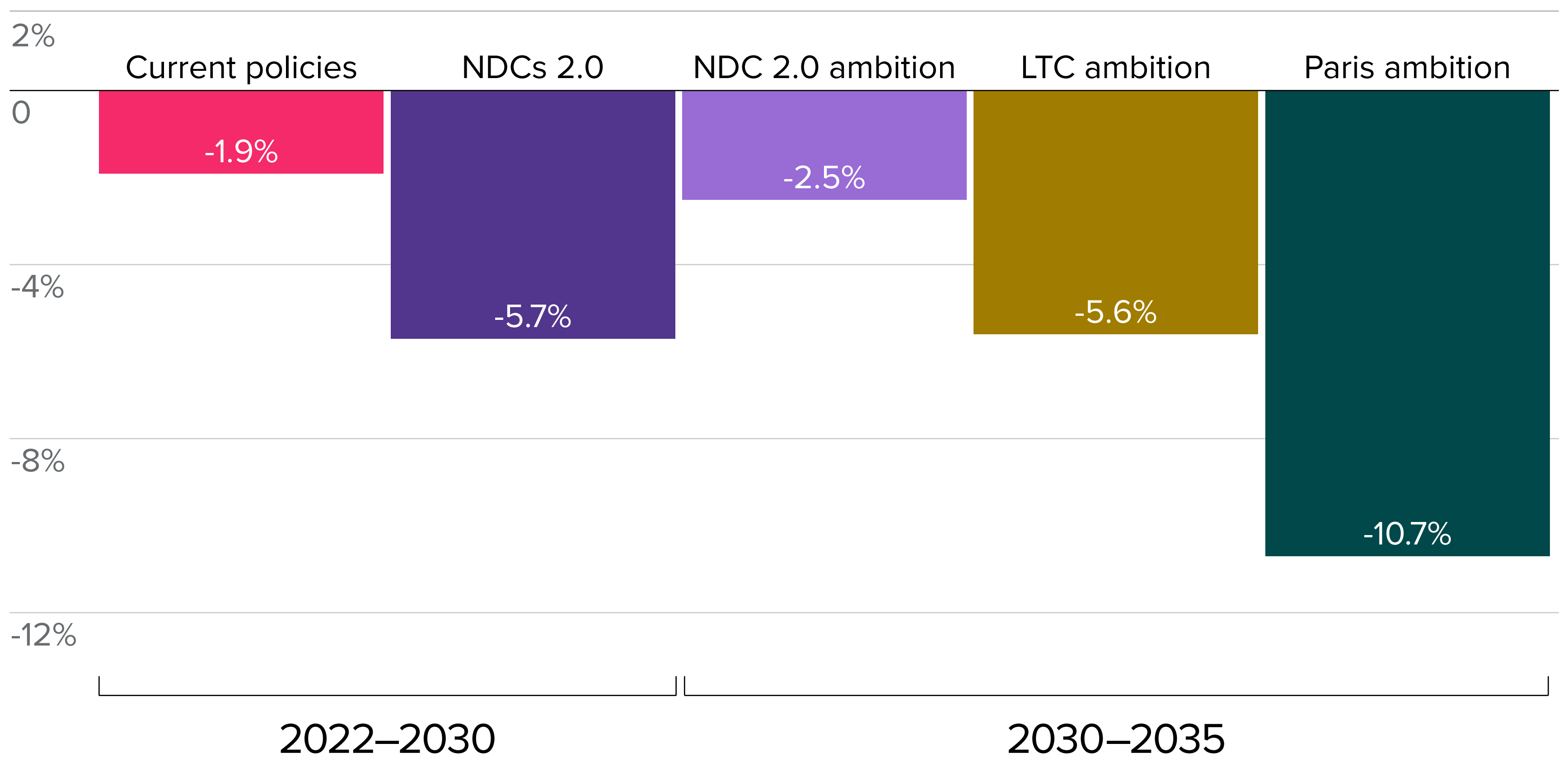
However, if Canada sets a 2035 target that is less than 266 $MtCO_2e$ in 2035, then we project that it will be on a below 2°C pathway and have a good chance of achieving its 2050 net zero target.

Canada will have to substantially ramp up its annual rate of decarbonisation from 1.9% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 11% under **Paris ambition**.

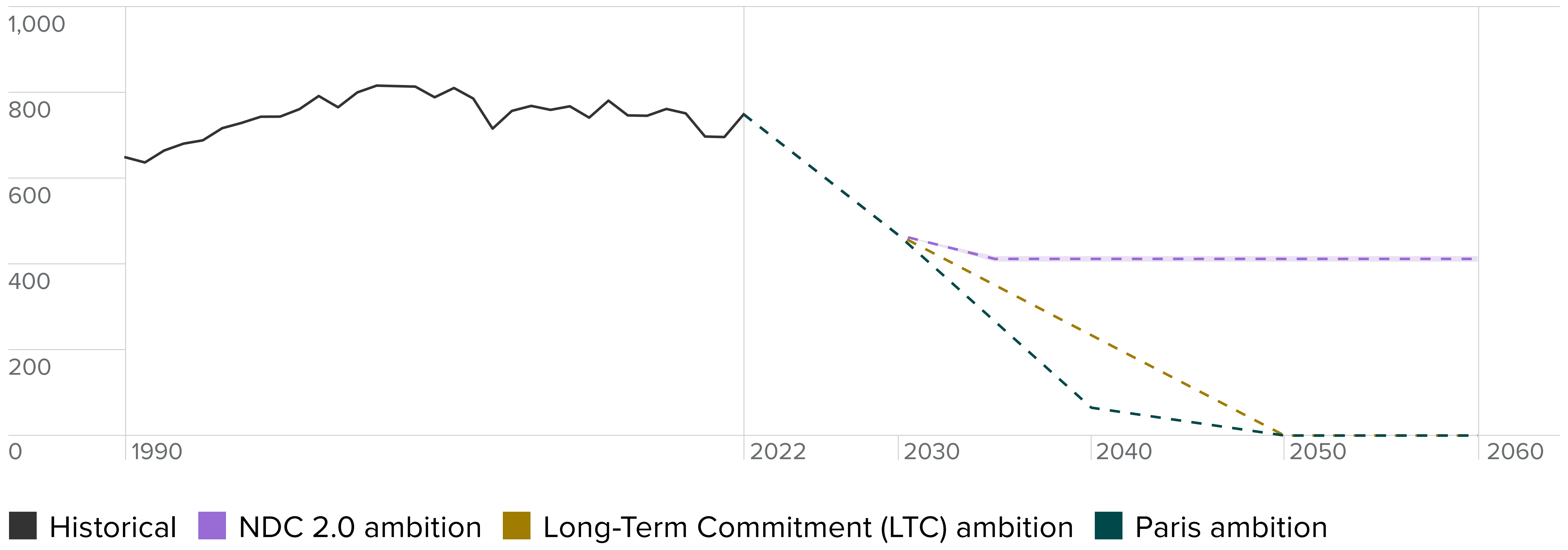
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



China

Physical risk city insights

Beijing

Urban population
20 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	Low	Low	Low	+187%
Heatwaves	Low	Low	Low	+109%
Water stress	Medium	Medium	Medium	+16%

Beijing, located in northern China, has a continental climate with hot summers and cold winters. **Water stress** levels are expected to increase by 16% by 2050, remaining as a medium risk. **Heatwaves** are expected to double between 2024 and 2050, from 10 to 20 days. The risk of **cyclones** in Beijing is projected to increase, however the low baseline means this will remain a low risk.

Shanghai

Urban population
27 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	High	High	High	+54%
Heatwaves	Low	Low	Medium	+114%
Water stress	Low	Medium	Medium	+25%

Located at the east end of the Yangtze River Delta, Shanghai has a humid, subtropical climate. Shanghai's proximity to the coast contributes to a high risk of severe **cyclones,** which is projected to increase by a further 50% by 2050. Days of **extreme heat** are expected to more than double, from the baseline of 17 days annually up to 37. **Water stress** is anticipated to see a 25% increase by 2050.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C
+4.0°C

China

We project that, by 2030, China's current policies mean that it will reach, and be 8% or 1.18 $GtCO_2e$ under, its NDC.

We also estimate that China will surpass its 1.5°C emissions budget by 2030.

NDC 2.0[54]

Conditionality	Unconditional
Covers all sectors	✗

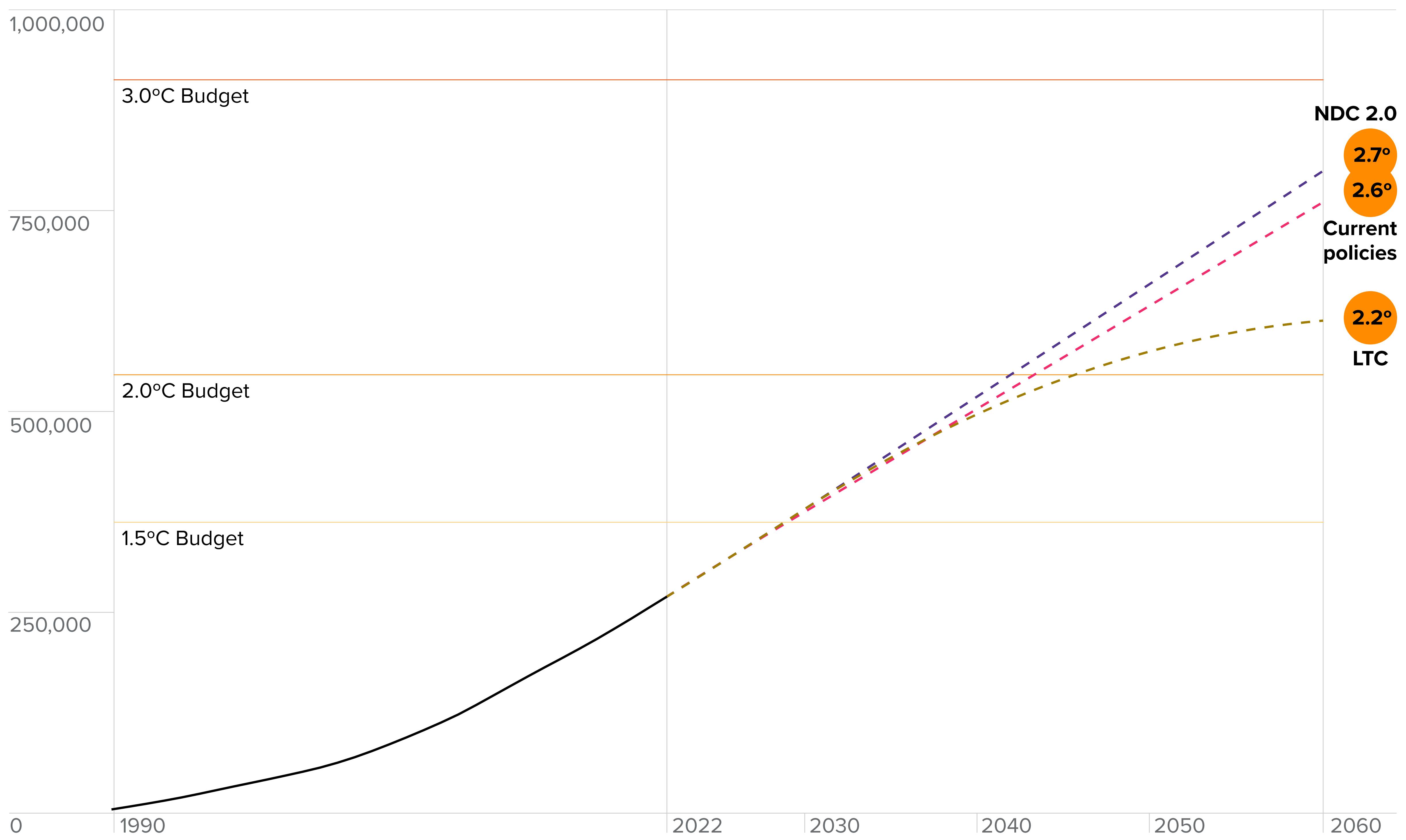
In its most recent (2021) NDC, China has pledged to lower carbon intensity by over 65% from 2005 levels in 2030. We estimate China's NDC to be 14.1 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[55]

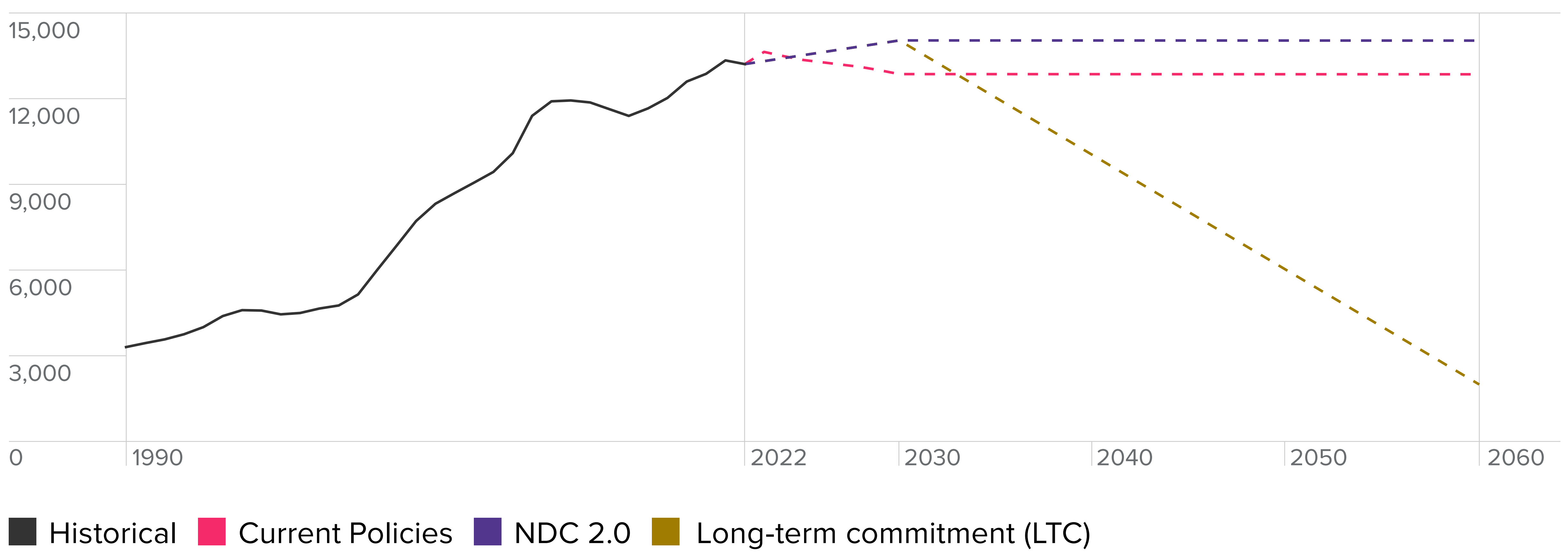
Covers all sectors	✗
Covers Kyoto gases	✗

In its long-term strategy, China stated that its ambition is to achieve carbon neutrality before 2060. In our analysis, we take this to be a CO_2 only target, hence we calculate China's long-term commitment to be 2.02 $GtCO_2e$ in 2060 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



China

Policies overview

✔ National adaptation plan[56]

Regular published risk assessments[57]	✔
Monitoring and evaluating report	✖
Part of a sovereign catastrophe risk pool	✖

✖ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[58]	1.5% of GDP

✔ Carbon pricing system[59]

% of GHG emissions covered by carbon price	32%
Carbon price ($/t$CO_2$e)	12.57
Aligned with the global carbon price corridor[60]	✖

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Solar[61]	31.82	3rd
Hydroelectric[62]	31.56	1st
Wind[63]	27.82	6th
Geothermal[64]	0	N/A

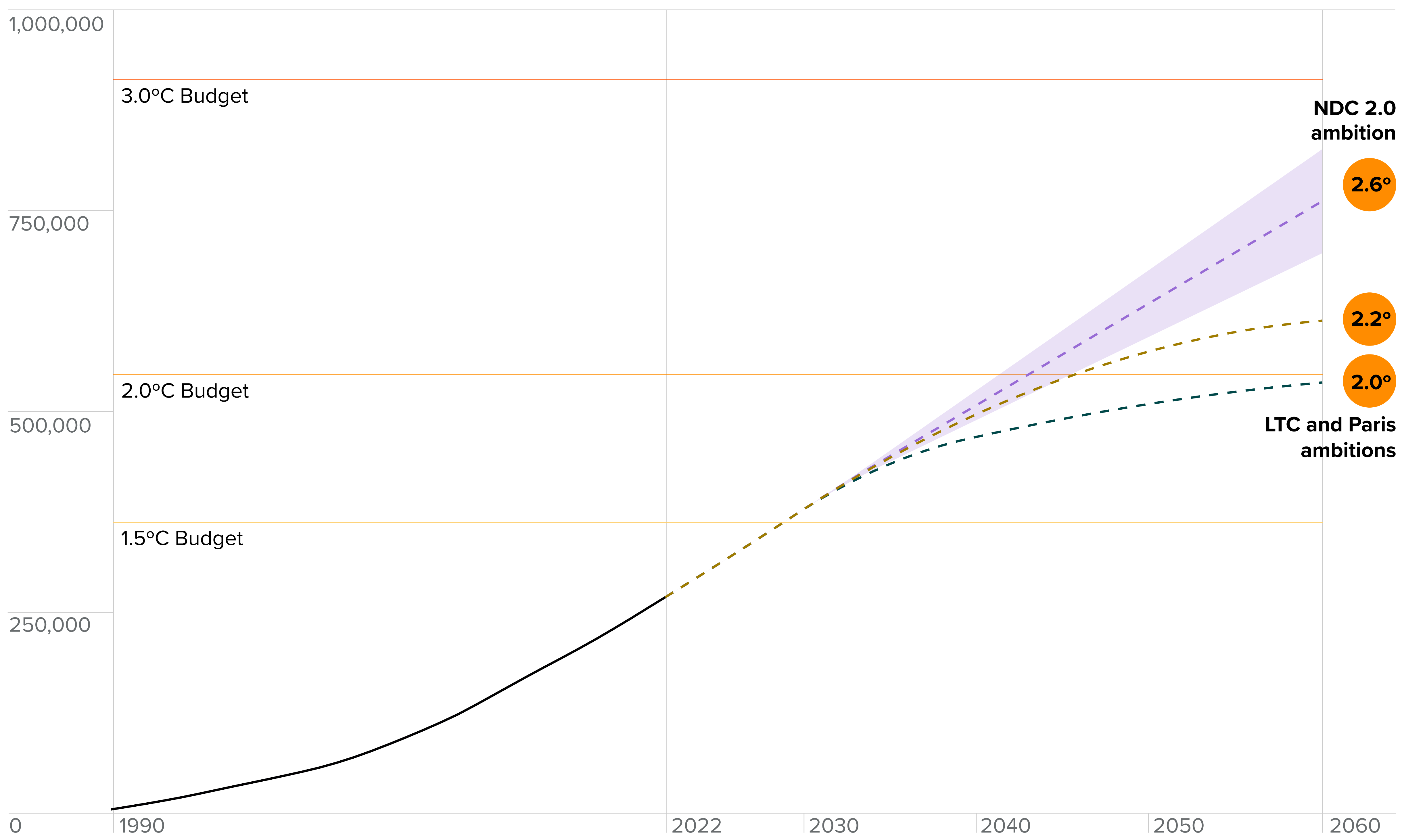
2035 targets

NDC 2.0 ambition: we estimate that, if China were to set targets based on the same ambition as its current NDC 2.0, it would set a 1–1.5 $GtCO_2e$ target for 2035. The median of this range would keep China on a greater than 2°C decarbonisation pathway.

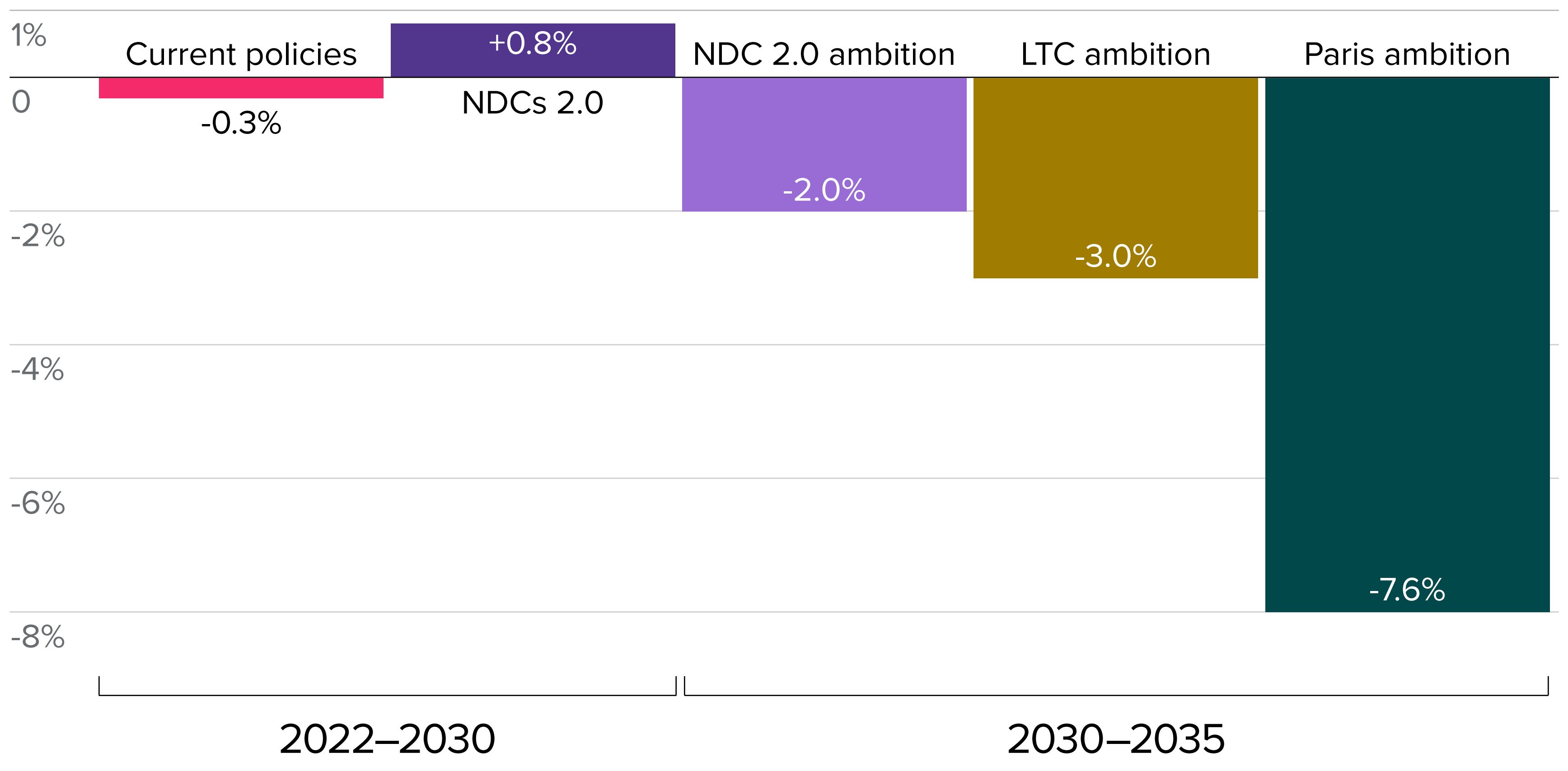
However, if China sets a 2035 target that is less than 0.95 $GtCO_2e$ in 2035, then we project that it will be on a 2°C pathway and have a good chance of achieving its 2060 long-term commitment.

China will have to substantially ramp up its annual rate of decarbonisation from 0.3% under current policies from 2024–2030 to 3% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 8% under **Paris ambition**.

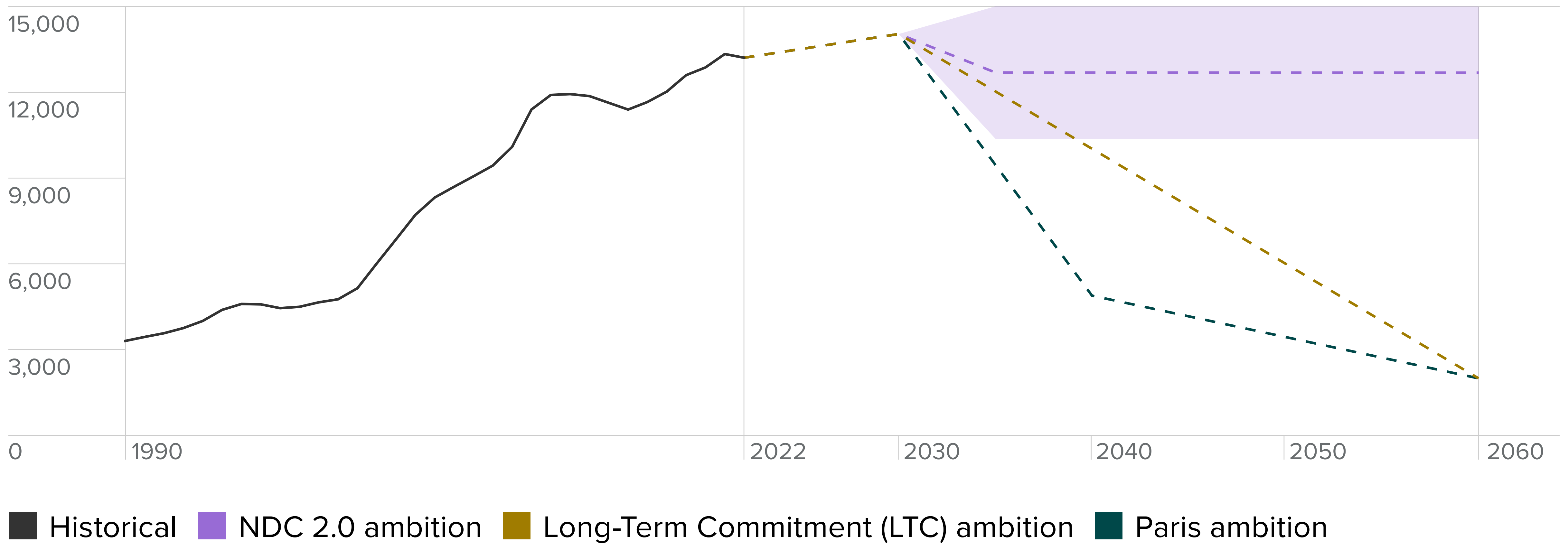
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



France

Physical risk city insights

Marseille

Urban population
1.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	-23%
Heatwaves	Low	Low	Medium	+110%
Water stress	Low	Medium	Medium	+83%

Marseille, located on the southern coast of France, enjoys a Mediterranean climate with hot, dry summers and mild winters. In 2050, days of **extreme heat** are projected to double, from an average of 21 in 2024 up to 44, increasing risk levels from low to medium. **Water stress** is projected to increase by 80% by 2050, increasing to a medium risk. **Flooding** is projected to remain a low risk.

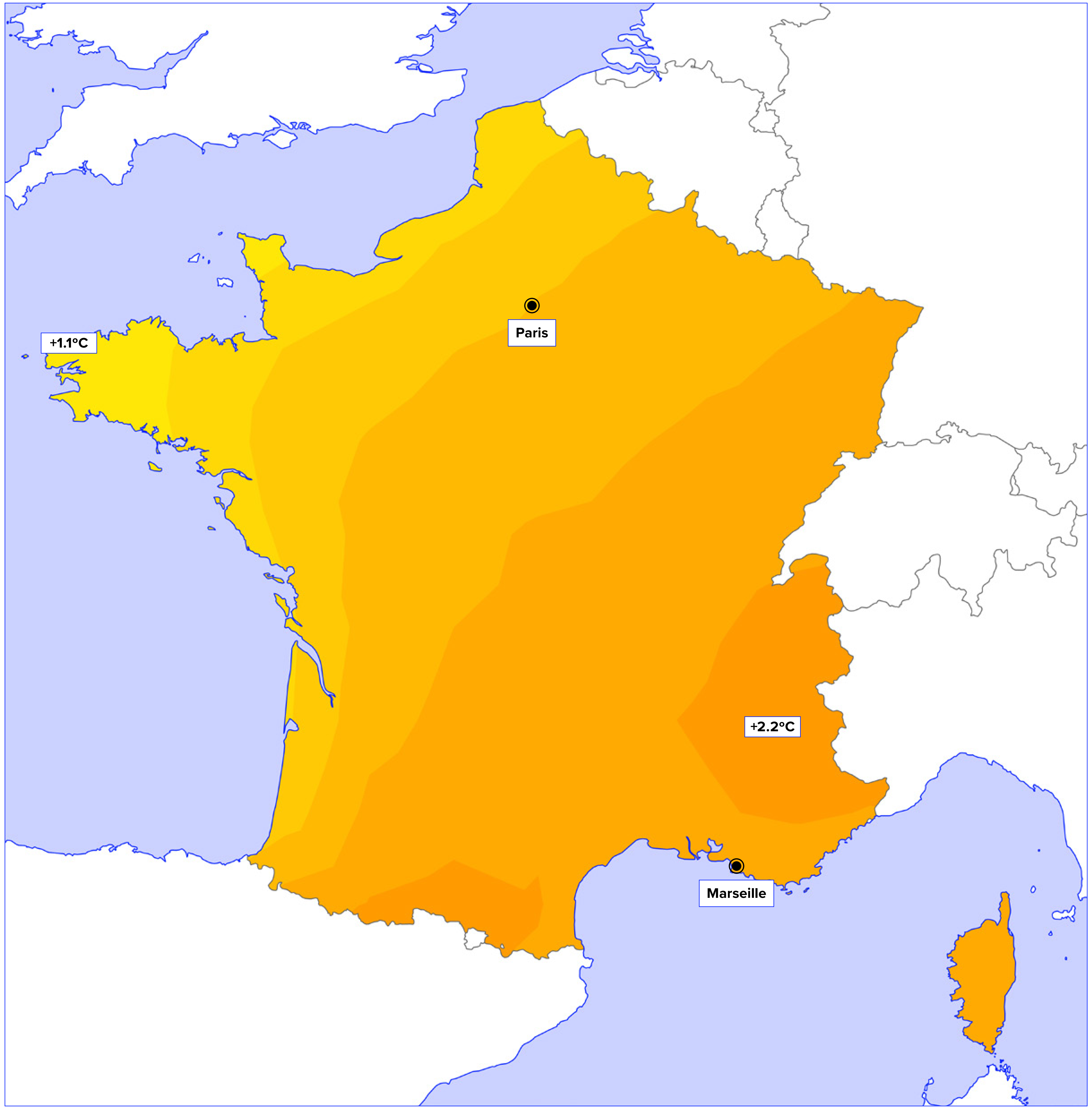
Paris

Urban population
11 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	-52%
Heatwaves	Low	Low	Low	+87%
Water stress	Low	Medium	Medium	+58%

Located along the Seine River in northern France, Paris enjoys a temperate climate with mild winters and warm summers. The city is currently considered lower risk for major physical hazards. Higher temperatures and changing precipitation patterns on the Seine and Marne Rivers are likely to increase **water stress** from a low to a medium risk.

Projected temperature increase by 2050 (High-emissions scenario)



France

We project that, by 2030, France's current policies will result in the country overshooting its NDC by 20%, or 48 $MtCO_2e$.

We also estimate that France will surpass its 1.5°C emissions budget by 2038.

NDC 2.0[65]

Conditionality	Unconditional
Covers all sectors	✓

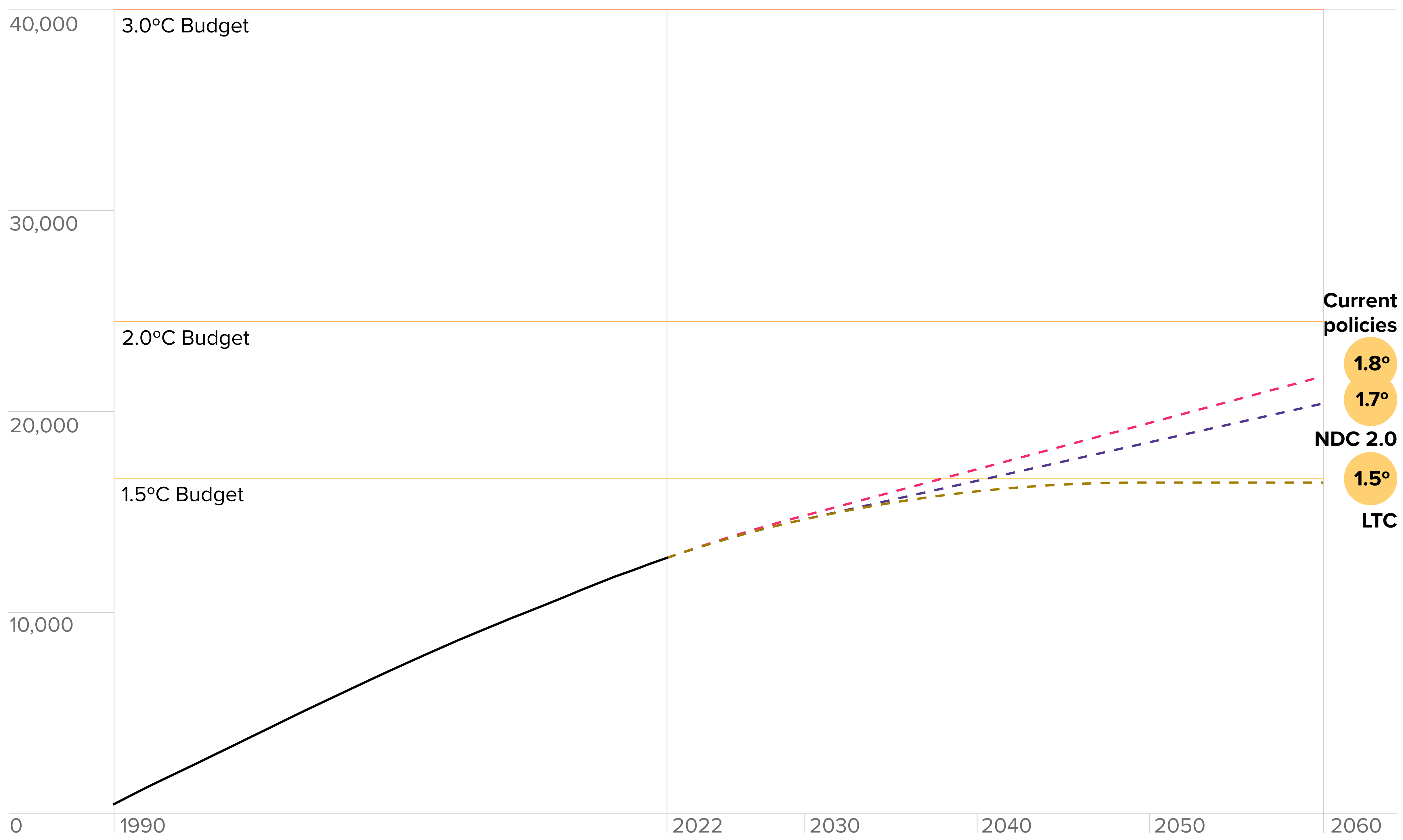
France is party to the European Union's NDC, which has pledged to reduce emissions by at least 55% below 1990 levels by 2030. We calculate France's 2030 target to be 240 $MtCO_2e$, using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[66]

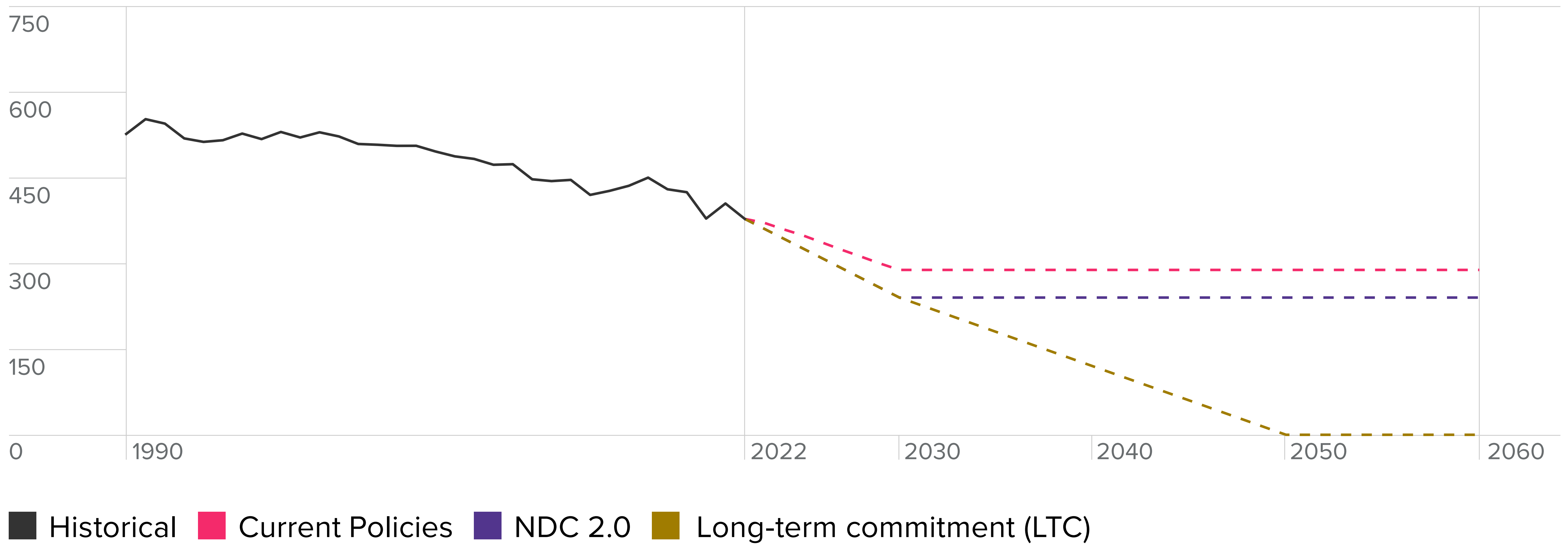
Covers all sectors[67]	✓
Covers Kyoto gases	✓

In 2019, France signed the Energy and Climate Act into law. Its ambition is to achieve net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



France

Policies overview

✓ National adaptation plan[68]

Regular published risk assessments[69]	✓
Monitoring and evaluating report[70]	✓
Part of a sovereign catastrophe risk pool	Exempt

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[71]	0.6% of GDP

✓ Carbon pricing system[72]

% of GHG emissions covered by carbon price	40%
Carbon price ($/t$CO_2$e)	47.94
Aligned with the global carbon price corridor[73]	✓

Climate finance

3-year average climate finance contribution as a % of GDP[74]	0.23%
Proportional share of $100 billion global climate finance commitment[75]	✓
Targeted level of international climate finance contribution as a % of GDP[76]	0.21%
Target to increase global climate finance contributions	✗

Energy opportunity
(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Wind[77]	6.32	9th
Solar[78]	1.14	18th
Hydroelectric[79]	0	N/A
Geothermal[80]	0	N/A

France

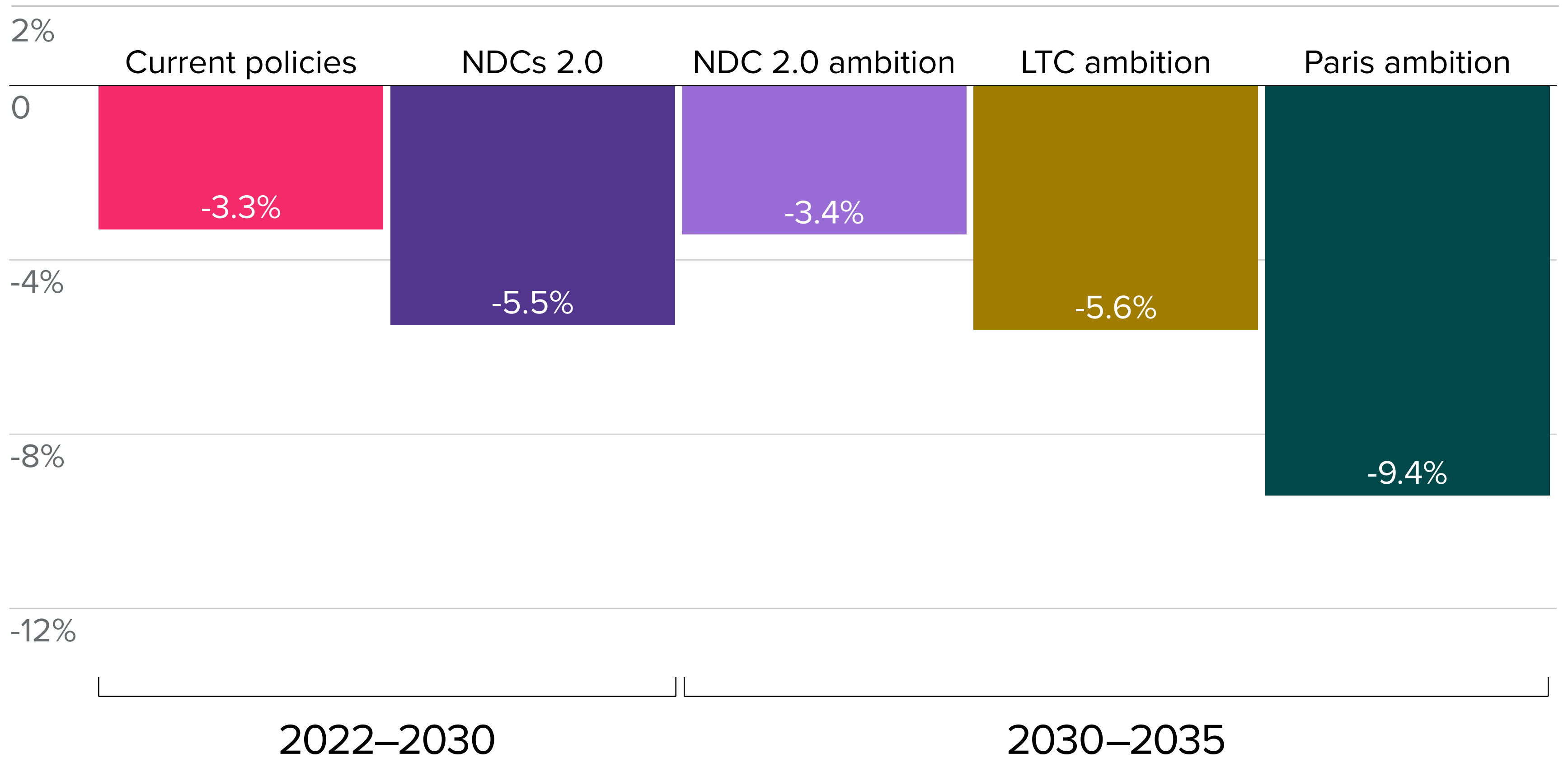
2035 targets

NDC 2.0 ambition: we estimate that, if France were to set targets based on the same ambition as its current NDC 2.0, it would set a 200-206 $MtCO_2e$ target for 2035. The middle of this range would keep France on a well below 2°C decarbonisation pathway.

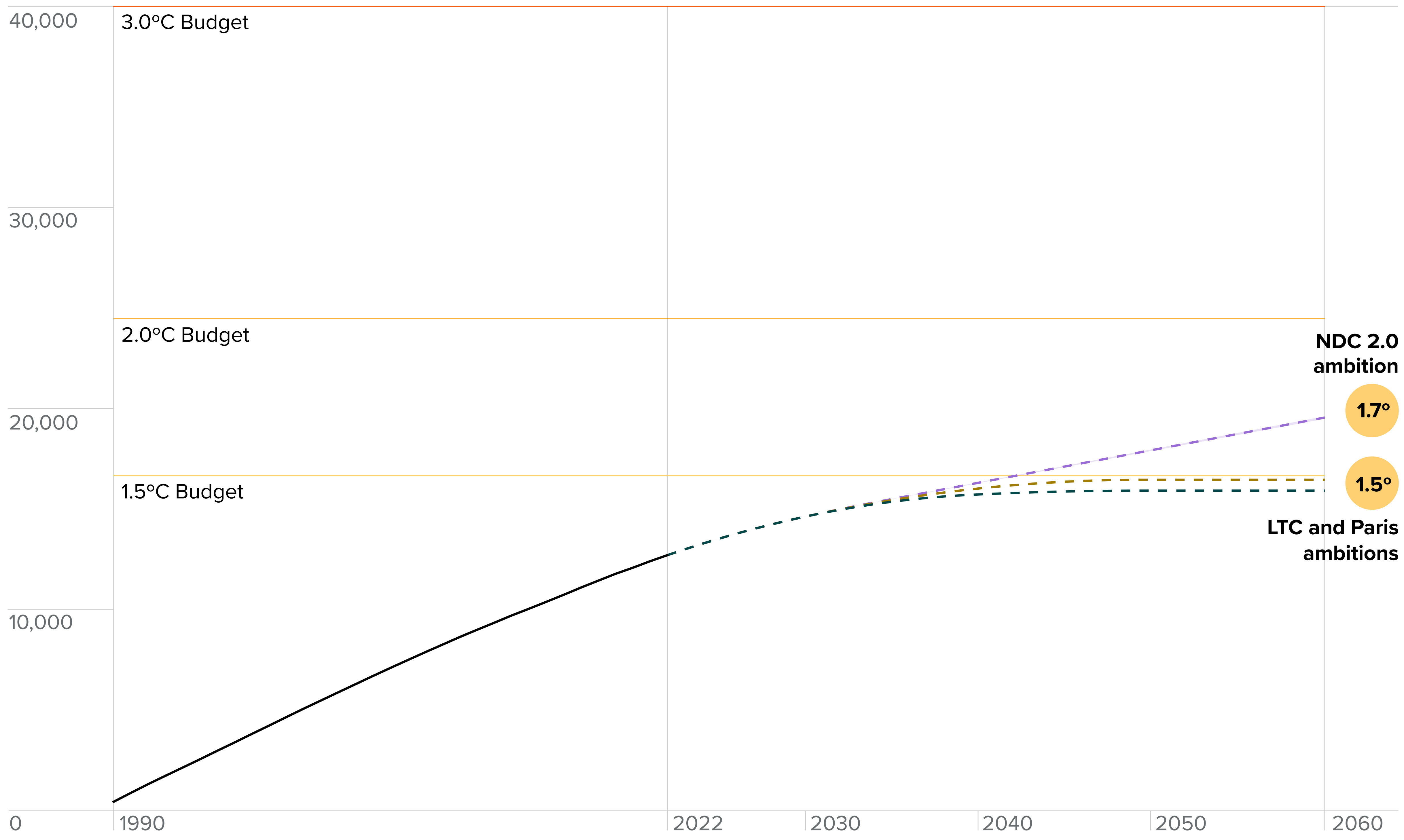
However, if France sets a 2035 target that is less than 180 $MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a reasonable chance of achieving its 2050 net zero target.

France will have to substantially ramp up its annual rate of decarbonisation from 3.3% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 9% under **Paris ambition**.

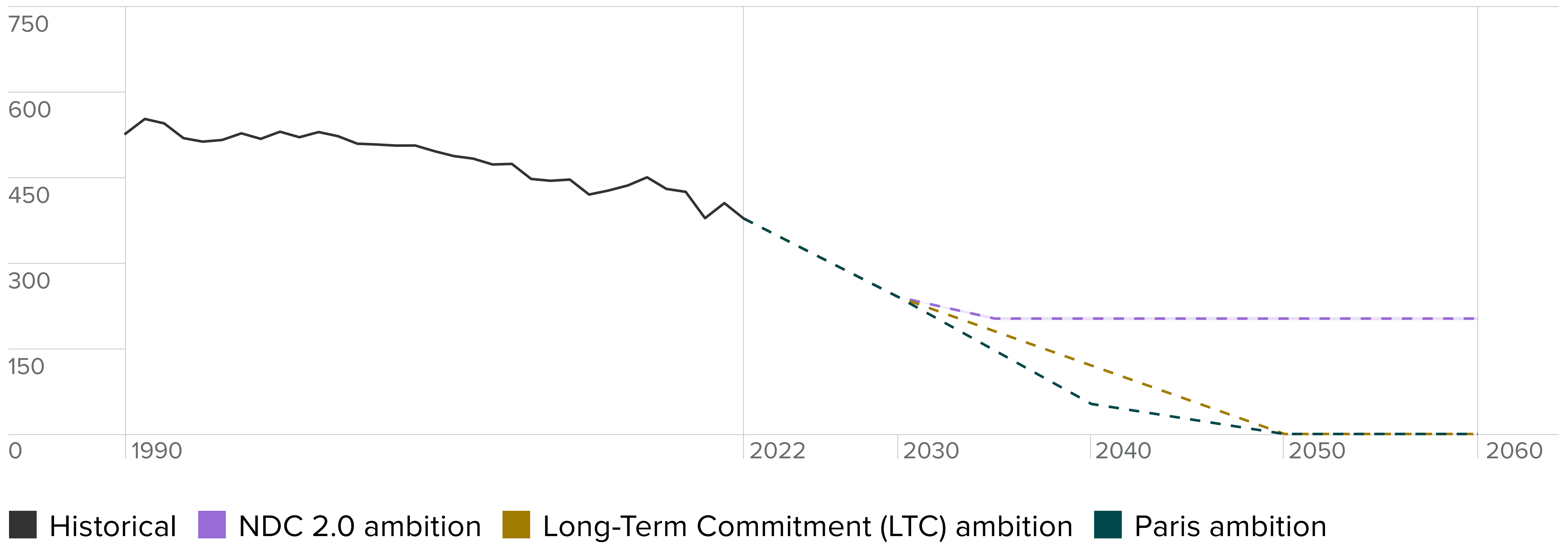
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Germany

Physical risk city insights

Berlin

Urban population
3.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+79%
Water stress	Low	Low	Medium	+67%

Situated in northeastern Germany, Berlin experiences a temperate continental climate with cold winters and warm summers. Days of extreme heat are expected to increase by nearly 80% by 2050, from 11 days of **extreme heat** per year to 20. **Water stress** is also expected to see an increase, from a low risk in 2024 to a medium risk in 2050, with a 67% increase.

Frankfurt

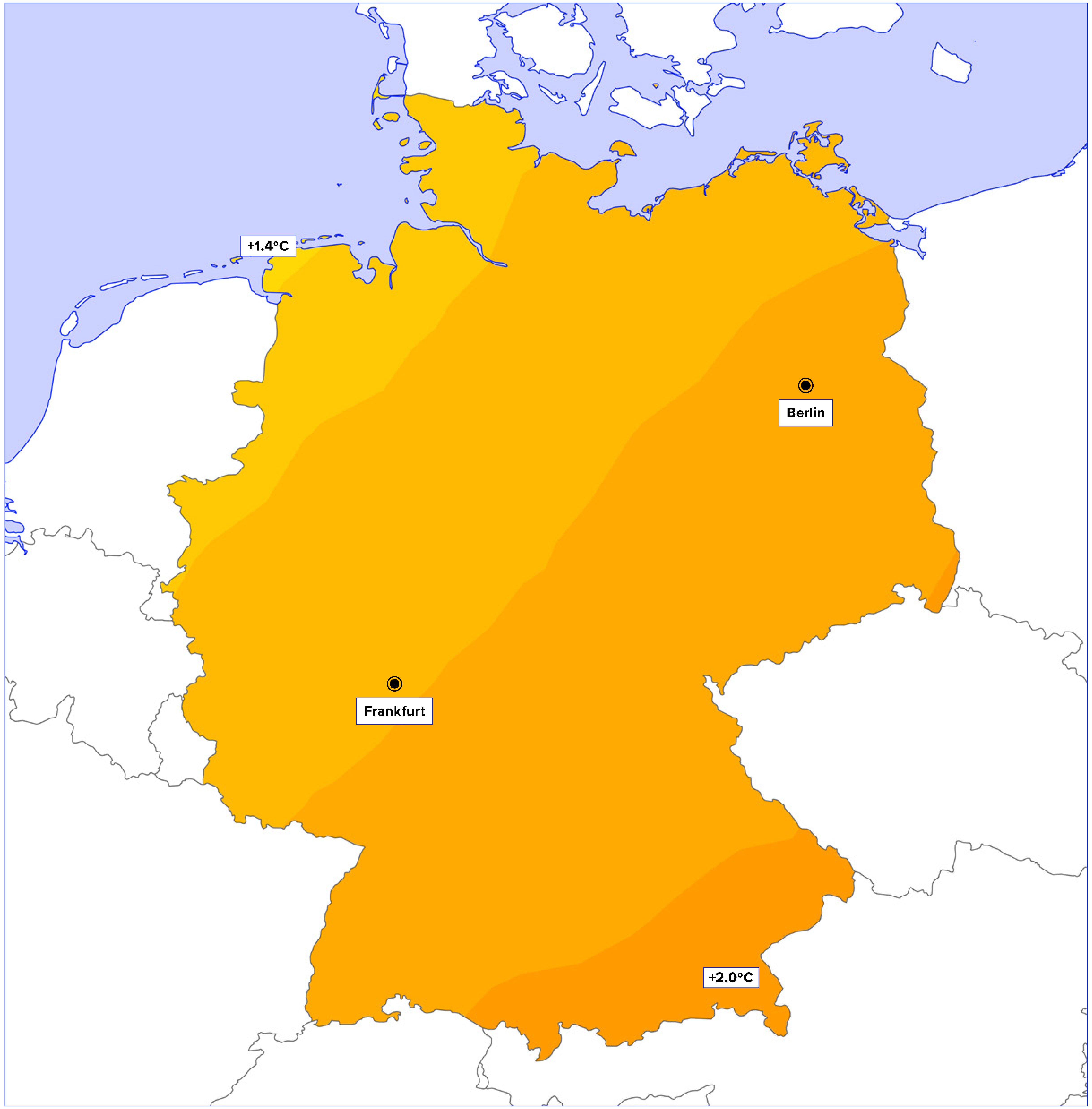
Urban population
0.8 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Medium	Medium	Medium	-1%
Heatwaves	Low	Low	Low	+83%
Water stress	Low	Medium	Medium	+55%

Frankfurt, located in central Germany along the Main River, experiences a temperate climate with moderate rainfall. **Water stress** is expected to increase, rising from a low to a medium risk by 2035. Days of **extreme heat** in Frankfurt are projected to see an 80% increase, from an average of 11 per year to over 20 by 2050. Frankfurt's current medium risk of **flooding** is not expected to change significantly.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C +4.0°C



Germany

We project that, by 2030, Germany's current policies will result in the country overshooting its NDC by 36%, or 154 $MtCO_2e$.

We also estimate that Germany will surpass its 1.5°C emissions budget by 2032.

NDC 2.0[81]

Conditionality	Unconditional
Covers all sectors	✓

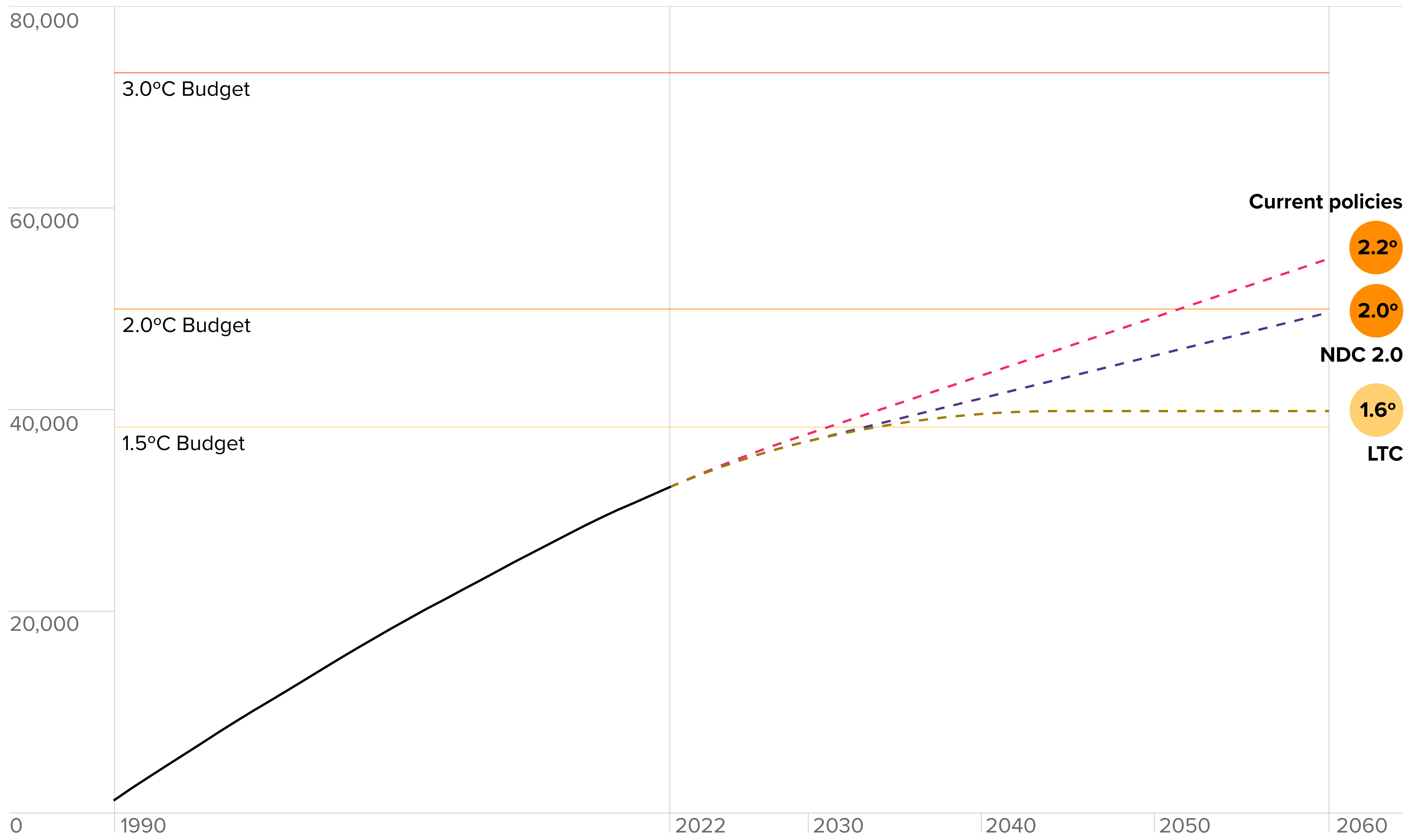
Germany is party to the European Union's NDC, which has pledged to reduce emissions by at least 55% below 1990 levels by 2030. We calculate Germany's 2030 target to be 426 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[82]

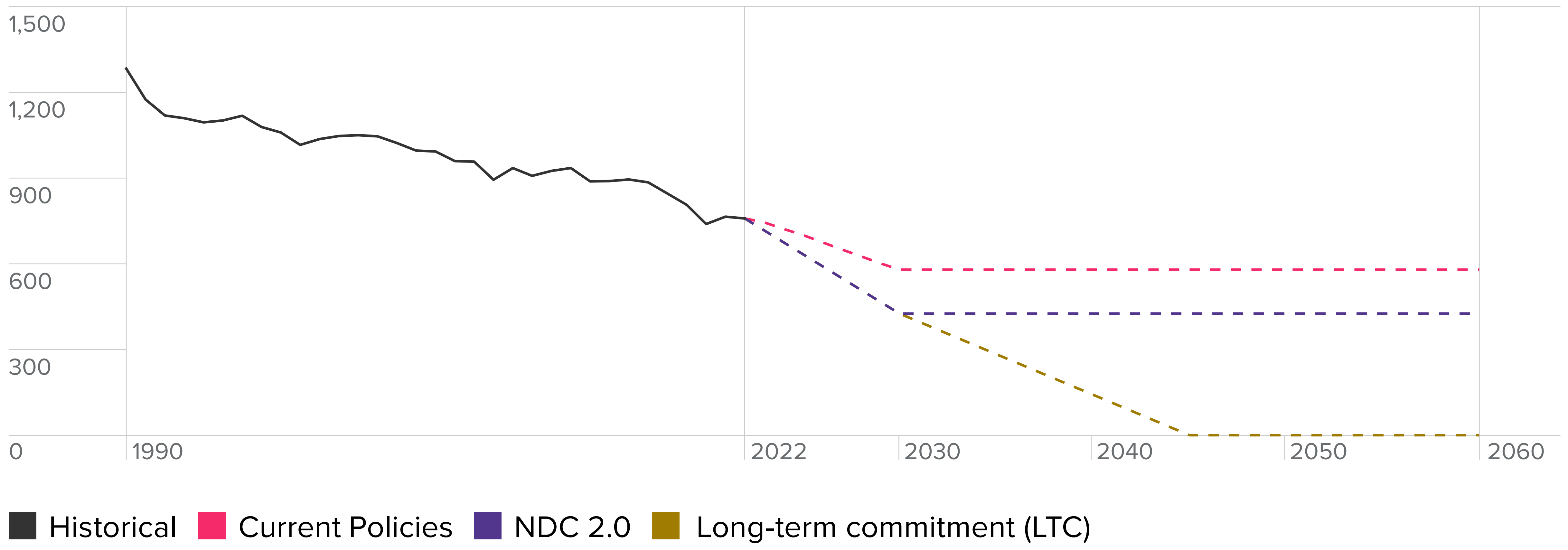
Covers all sectors[83]	✓
Covers Kyoto gases	✓

In its latest NDC, Germany reaffirmed its ambition to achieve net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2045 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Germany

Policies overview

✓ National adaptation plan[84]	
Regular published risk assessments[85]	✓
Monitoring and evaluating report[86]	✓
Part of a sovereign catastrophe risk pool	Exempt

✓ Commited to fossil fuel subsidies phase out[87]	2025
Annual amount spent on explicit fossil fuel subsidies[88]	1.0% of GDP

✓ Carbon pricing system[89]	
% of GHG emissions covered by carbon price	39%
Carbon price ($/t$CO_2$e)	48.37
Aligned with the global carbon price corridor[90]	✓

Climate Finance

3-year average climate finance contribution as a % of GDP[91]	0.20%
Proportional share of $100 billion global climate finance commitment[92]	✓
Targeted level of international climate finance contribution as a % of GDP	0.14%
Target to increase global climate finance contributions[93]	✗

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[94]	3.55	16th
Solar[95]	2.07	17th
Hydroelectric[96]	0.16	15th
Geothermal[97]	0	N/A

Germany

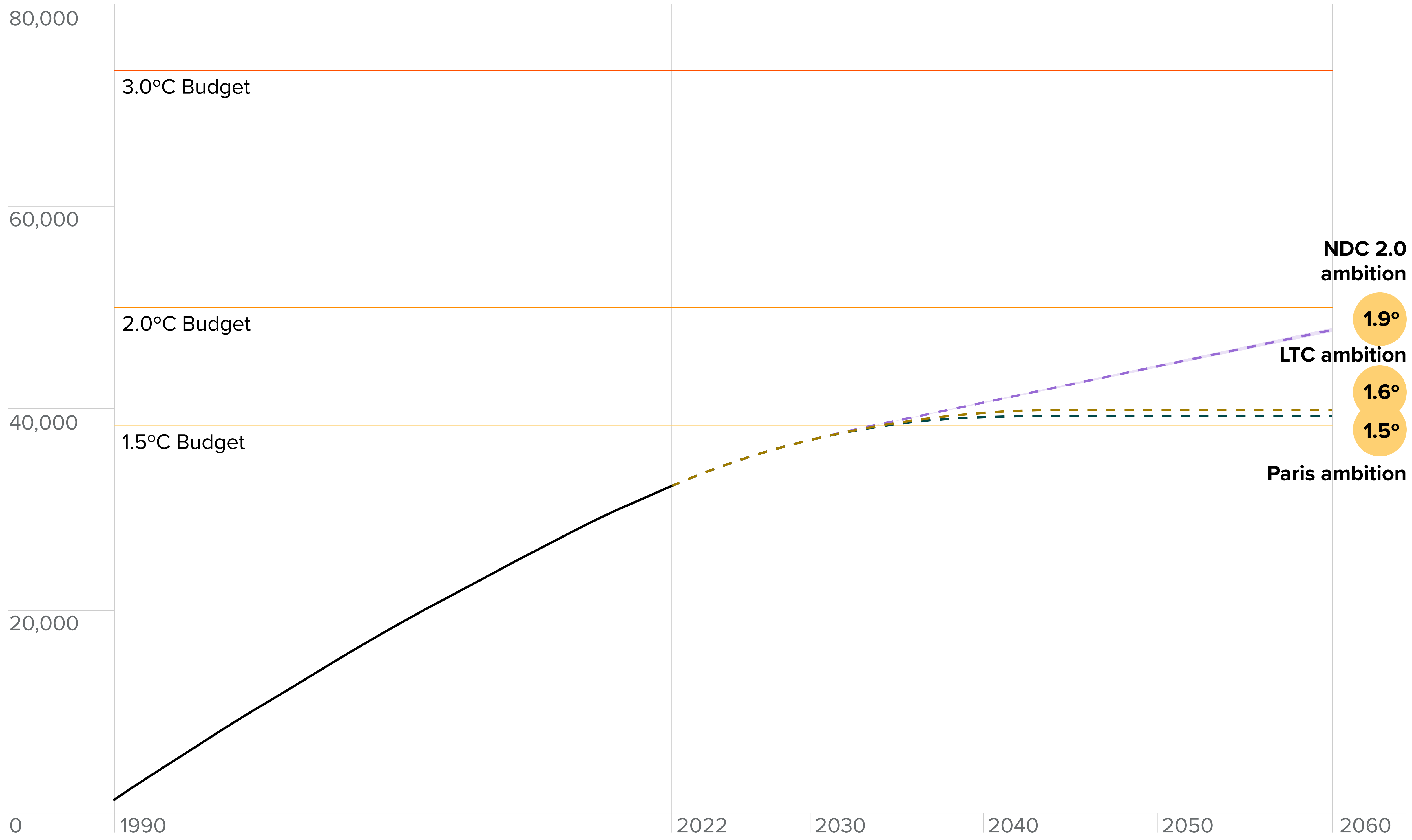
2035 targets

NDC 2.0 ambition: we estimate that, if Germany were to set targets based on the same ambition as its current NDC 2.0, it would set a 350-370 $MtCO_2e$ target for 2035. The median of this range would keep Germany on a below 2°C decarbonisation pathway.

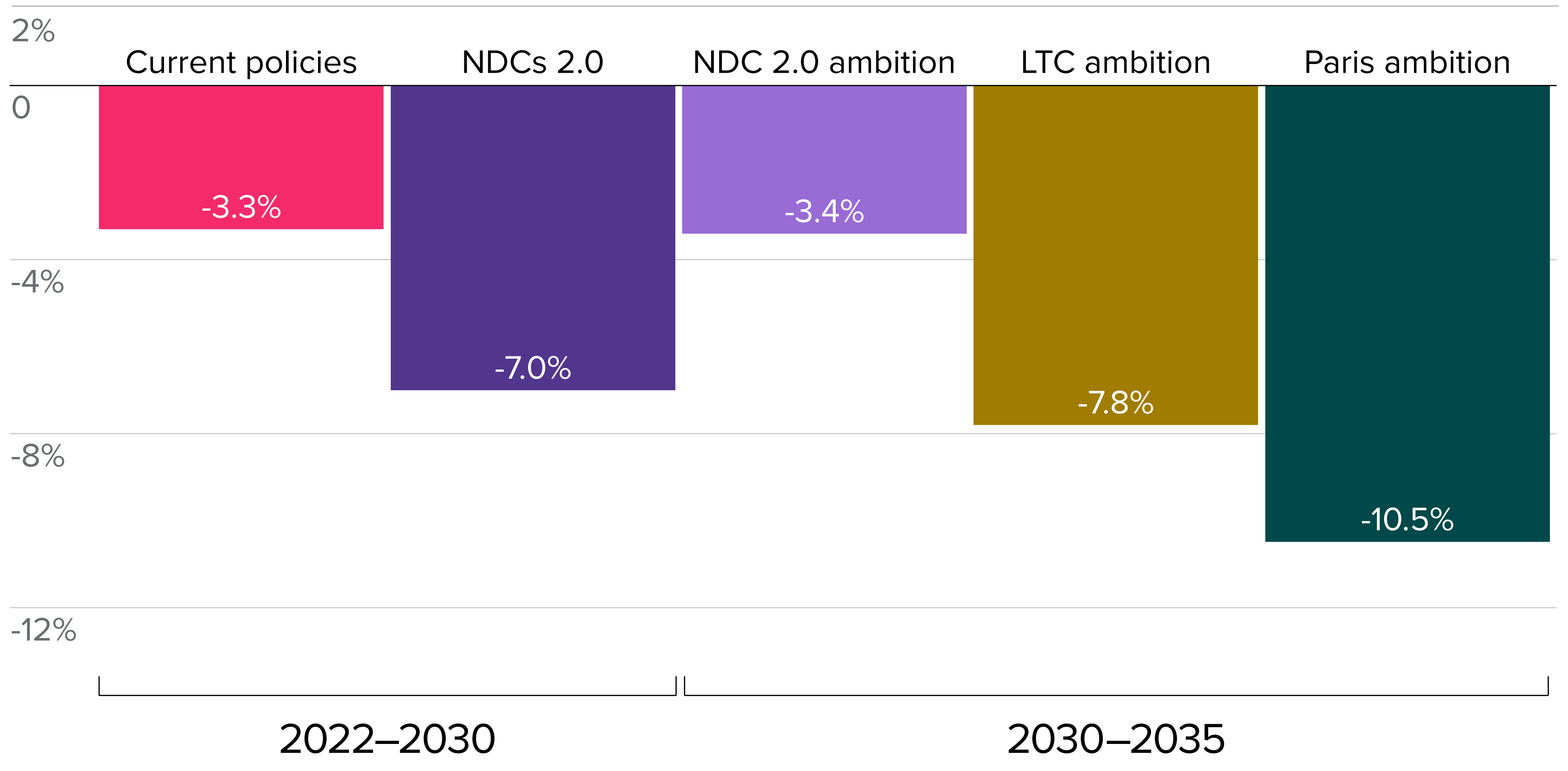
However, if Germany sets a 2035 target that is less than 245$MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a good chance of achieving its 2045 net zero target.

Germany will have to substantially ramp up its annual rate of decarbonisation from 3.3% under current policies from 2024-2030 to 8% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 11% under **Paris ambition**.

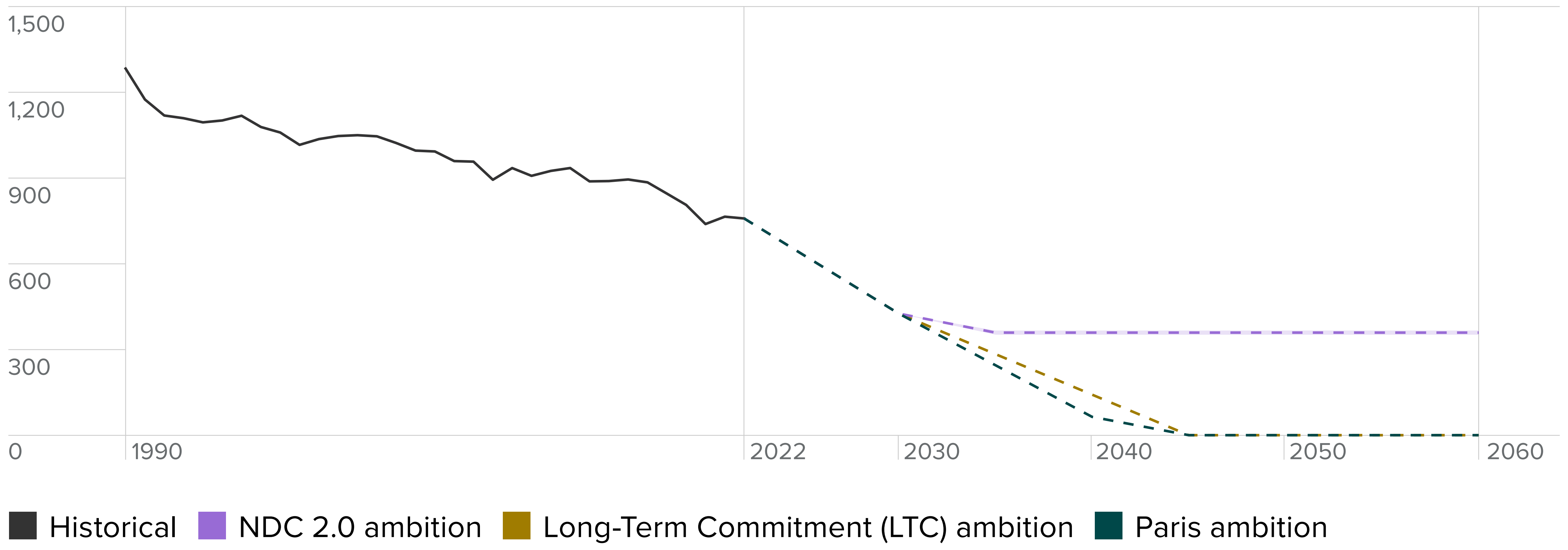
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



India

Physical risk city insights

Mumbai

Urban population
20 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Medium	Medium	Medium	0%
Heatwaves	Low	Low	Medium	+208%
Water stress	Medium	Medium	Medium	+35%

Mumbai, located on the western coast of India along the Arabian Sea, experiences a tropical climate with heavy monsoon rains. **Heatwaves** are a growing risk for Mumbai, with a 200%+ increase in days of extreme heat expected by 2050 - from 10 per year to over 30. Although **flooding** is already medium risk for Mumbai, this is not expected to increase significantly by 2050.

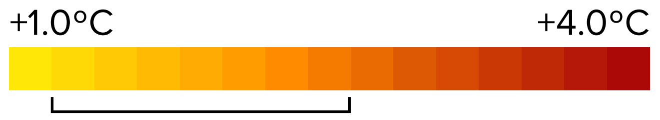
New Delhi

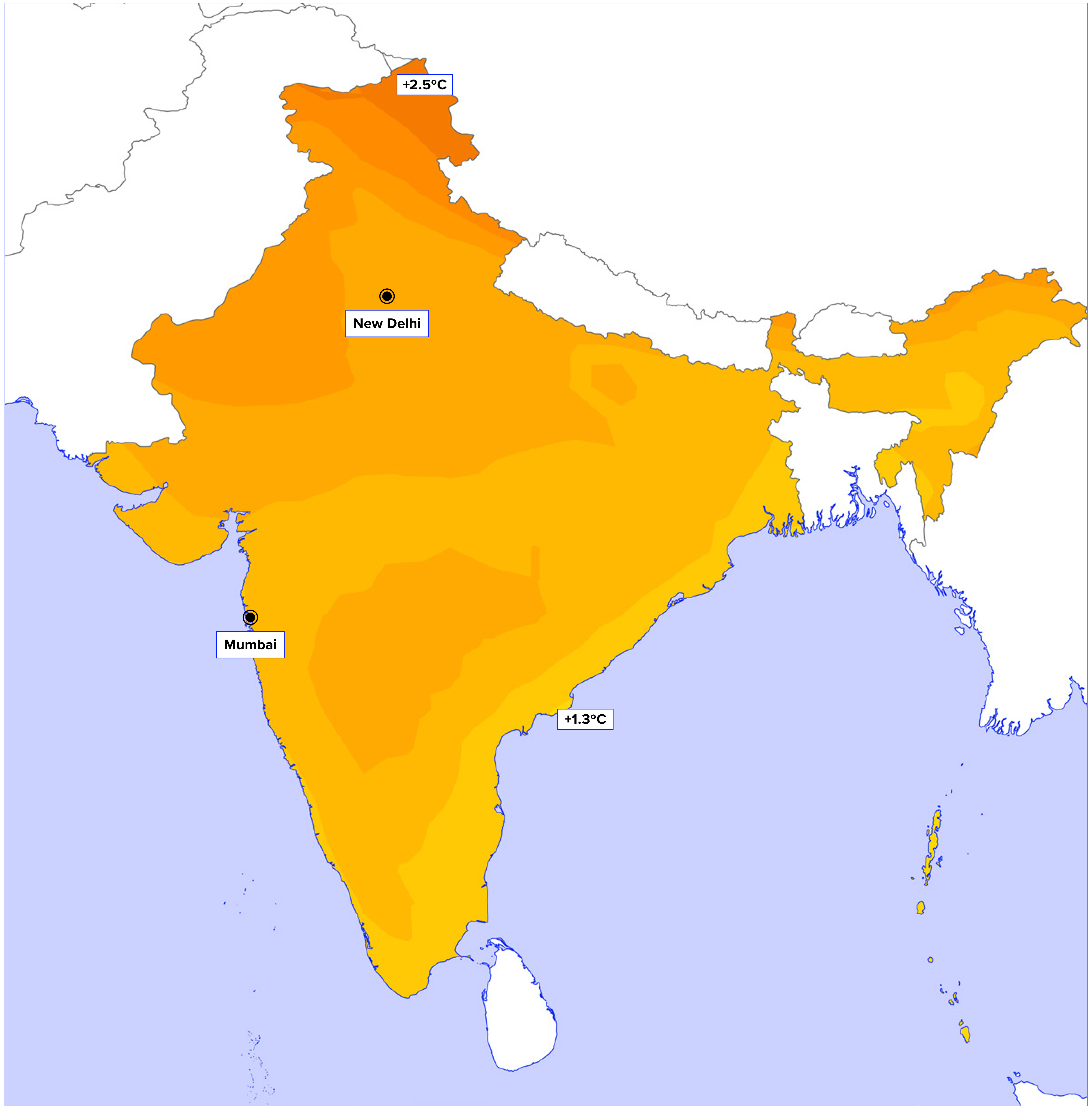
Urban population
30 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+46%
Heatwaves	Low	Low	Low	+168%
Water stress	Medium	Medium	Medium	+33%

New Delhi, situated in northern India, experiences a semi-arid climate with hot summers and mild winters. The city faces medium levels of **water stress** due to its limited freshwater resources and the increasing threat of drought. New Delhi is expected to see an increase in days of **extreme heat** - from 11 days per year to nearly 30.

Projected temperature increase by 2050 (High-emissions scenario)





India

We project that, by 2030, India's current policies will result in the country overshooting its NDC by 9%, or 311 $MtCO_2e$.

We also estimate that India will only surpass its 1.5°C emissions budget in 2054.

NDC 2.0[98]

Conditionality	Unconditional
Covers all sectors	✓

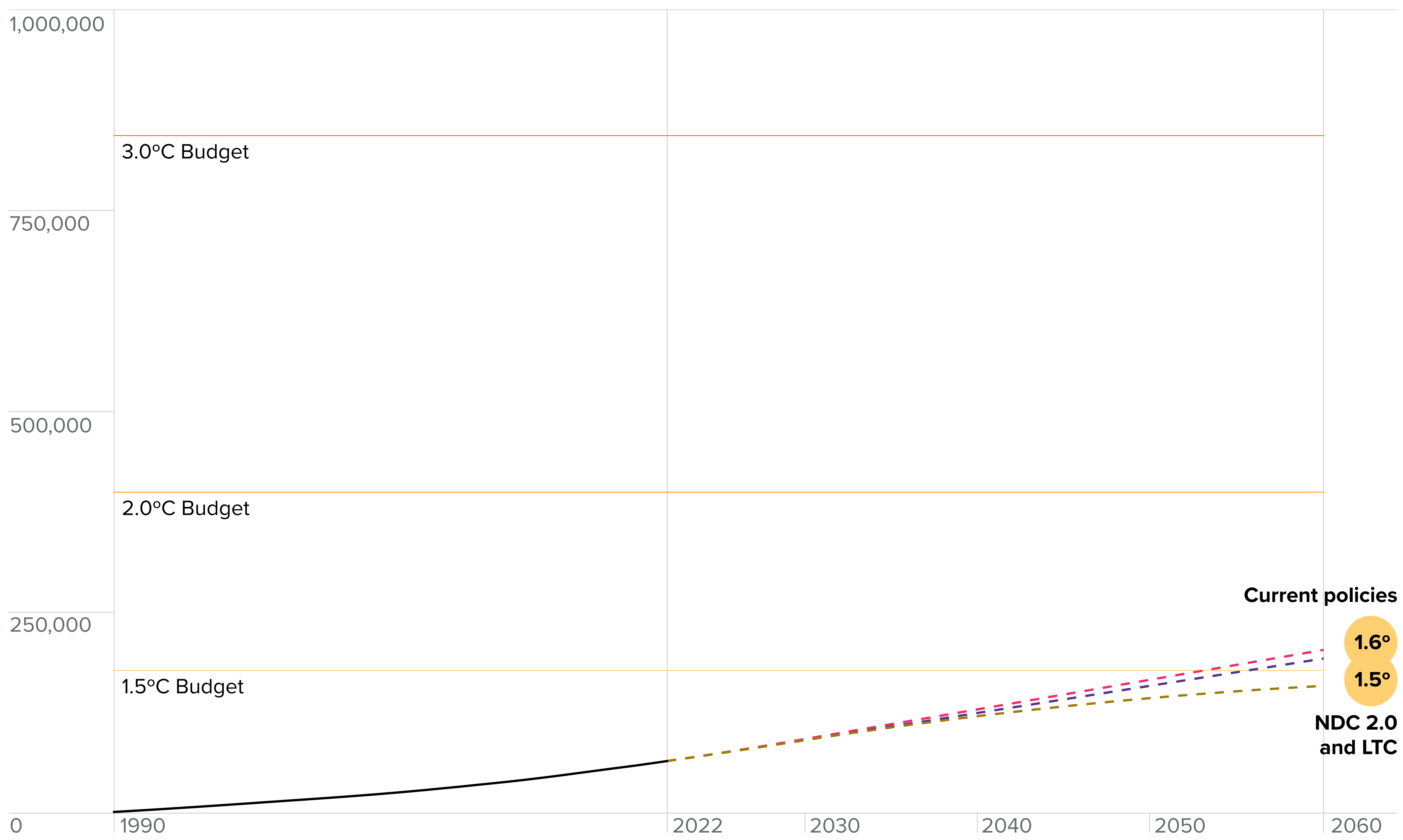
In its most recent (2021) NDC, India has pledged to reduce GHG emissions intensity by 45% compared to 2005 levels by 2030. We calculate India's 2030 target to be 3.38 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[99]

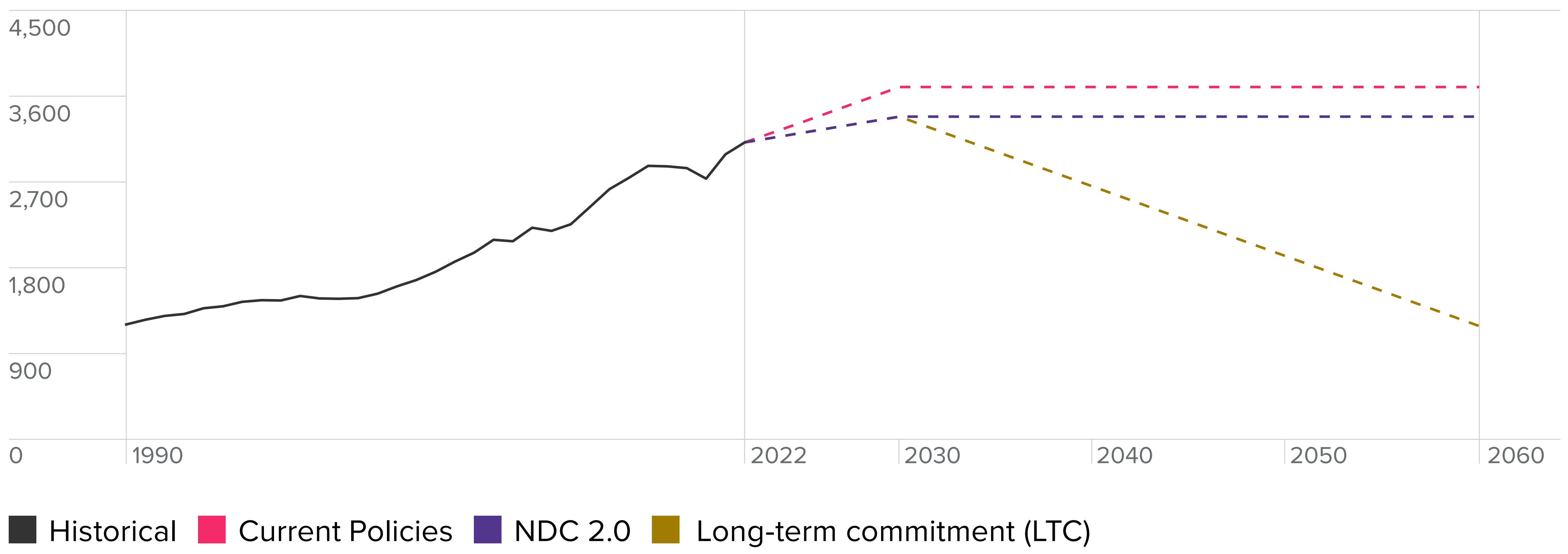
Covers all sectors[100]	Unclear
Covers Kyoto gases	Unclear

In 2022, India submitted its first Long-term Strategy for Low Carbon Development (LT-LEDS) which set a net zero target by 2070. We have assumed this to mean 0 $MtCO_2e$ in 2070 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



India

Policies overview

✖ National adaptation plan

Regular published risk assessments	✖
Monitoring and evaluating report	✖
Part of a sovereign catastrophe risk pool	✖

✖ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[101]	1.0% of GDP

✖ Carbon pricing system

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Hydroelectric[102]	29.23	2nd
Solar[103]	18.87	4th
Wind[104]	3.95	14th
Geothermal[105]	0	N/A

India

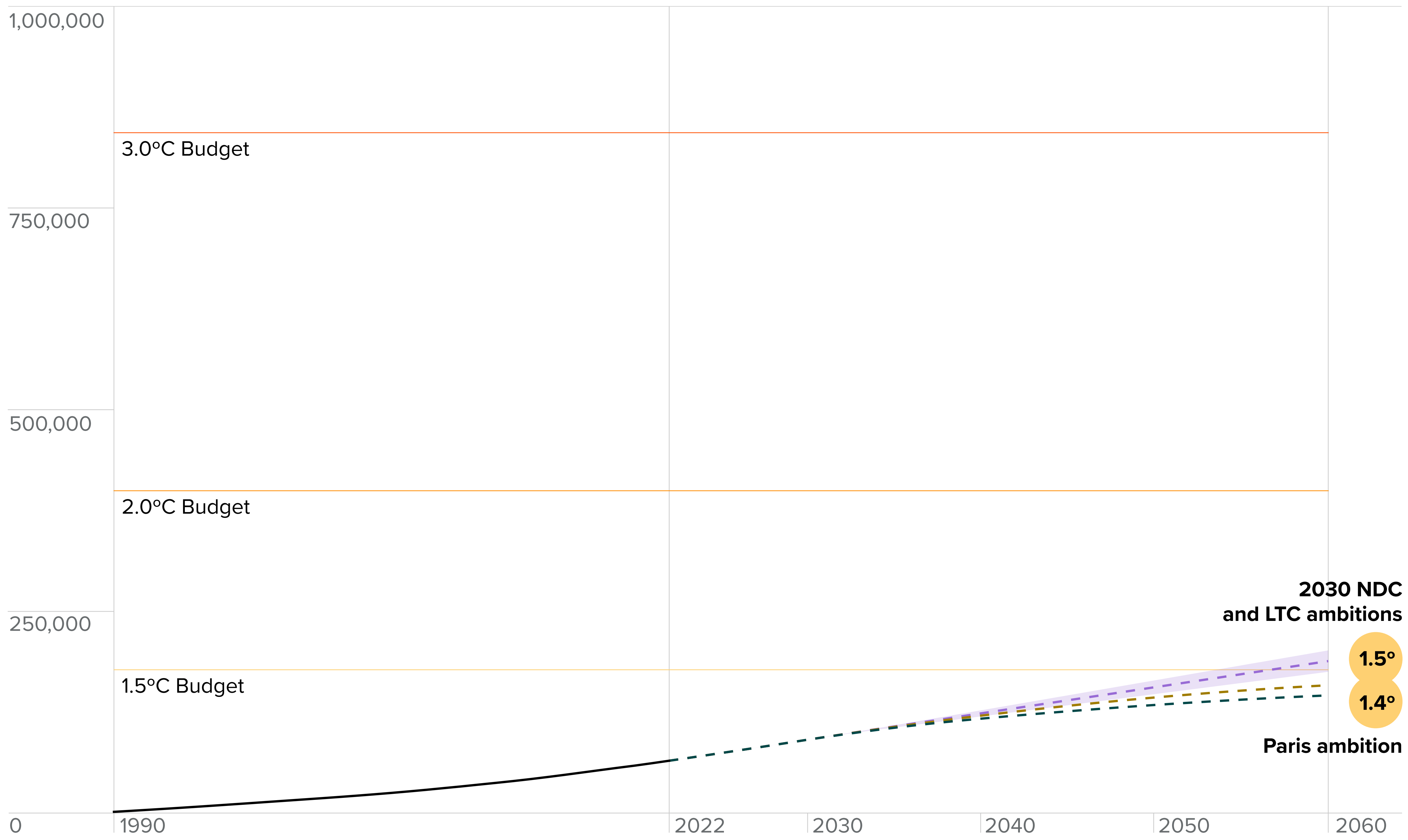
2035 targets

NDC 2.0 ambition: We estimate that, if India were to set targets based on the same ambition as its current NDC 2.0, it would set a 2760-3720 $MtCO_2e$ target for 2035. The median of this range would keep India on a 1.5°C decarbonisation pathway.

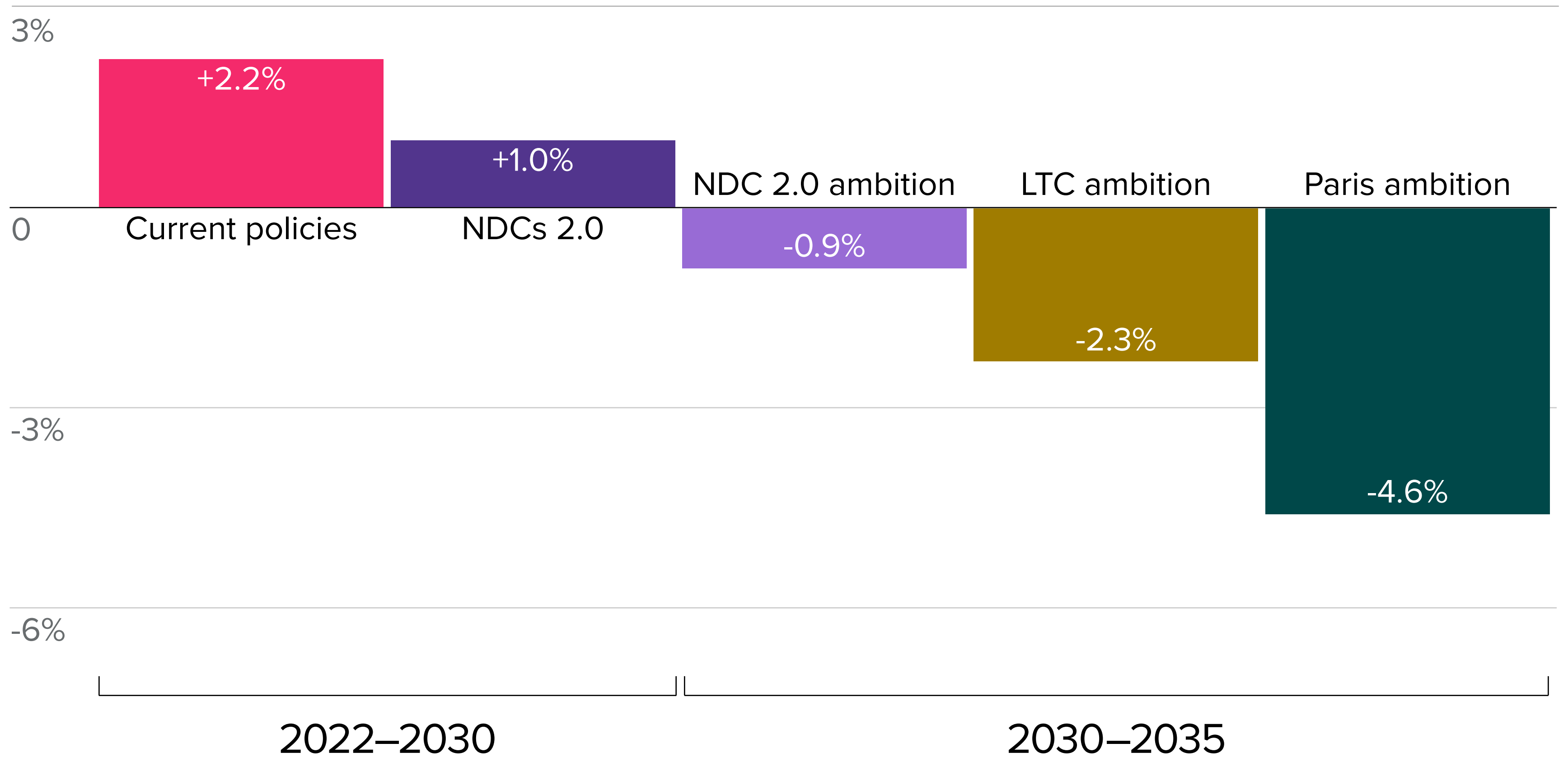
If India sets a 2035 target that is less than 2679 $MtCO_2e$ in 2035, then we project that it will be on a below 1.5°C pathway and have a good chance of achieving its 2070 net zero target.

India will have to ramp up its efforts to decarbonise, going from +2.2% growth in emissions under current policies from 2024-2030 to 2% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 5% under **Paris ambition**.

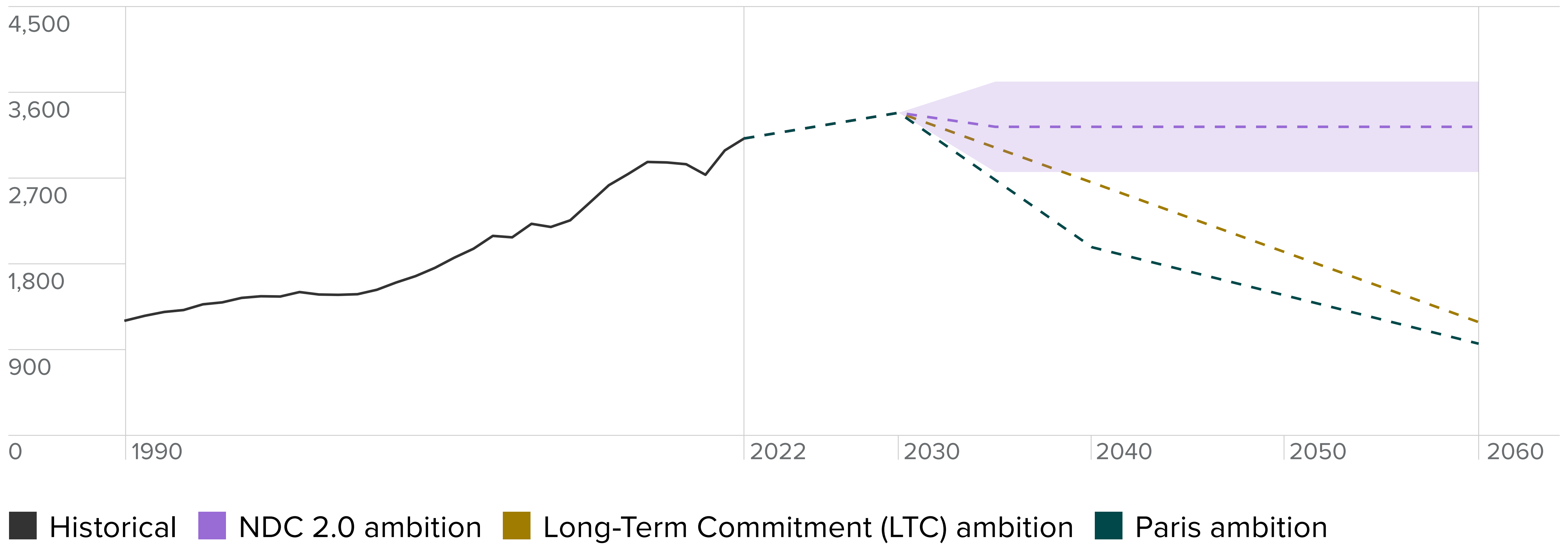
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Indonesia

Physical risk city insights

Jakarta

Urban population
11 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Medium	+453%
Heatwaves	Low	Low	Medium	+362%
Water stress	Medium	High	High	+45%

Jakarta, located on the northwest coast of the island of Java experiences a tropical climate with heavy rainfall. **Water stress** is a significant and growing risk for Jakarta, due to its rapidly growing population and limited freshwater resources. Days of **extreme heat** are projected to increase in frequency in Jakarta, reaching 50 annually in 2050.

Surabaya

Urban population
2.9 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+5%
Heatwaves	Medium	High	High	+375%
Water stress	Medium	High	High	+33%

Located on the northeastern corner of Java island, on the Madura Strait, Surabaya has a tropical climate. Surabaya currently faces a high level of **heatwaves risk** which is forecast to increase considerably from 30 to 145 days of extreme heat by 2050. The current medium risk level from **water stress**, due to its dense population and limited water supply, is also expected to increase to a high risk by 2035.

Projected temperature increase by 2050 (High-emissions scenario)

Indonesia

We project that, by 2030, Indonesia's current policies will result in the country overshooting its NDC by 11%, or 242 $MtCO_2e$.

We also estimate that Indonesia will surpass its 1.5°C emissions budget by 2032.

NDC 2.0[106]

Conditionality	Unconditional
Covers all sectors	✔

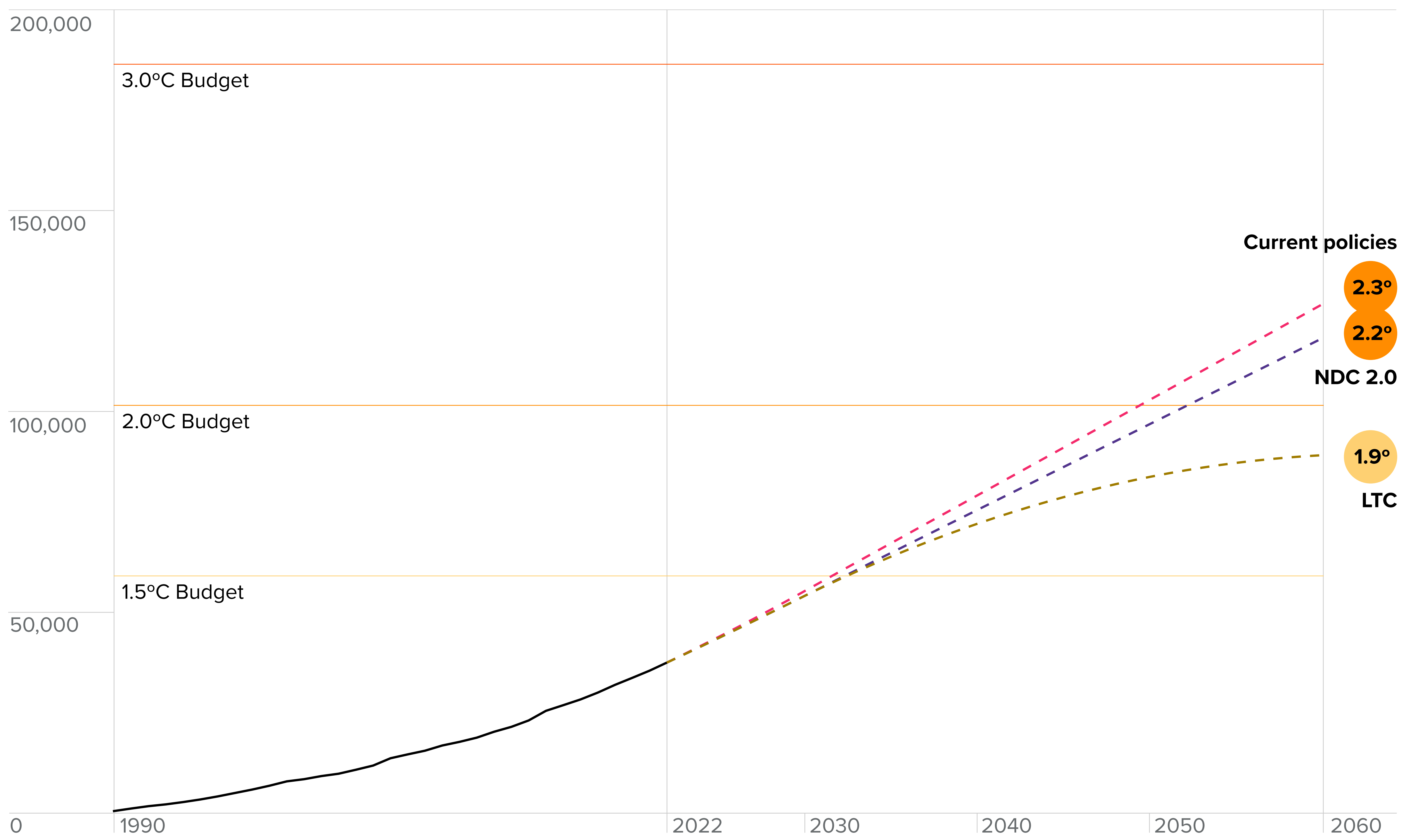
In its most recent (2022) NDC, Indonesia has pledged to reduce GHG emissions by 32% compared to a 2030 business-as-usual. We calculate Indonesia's 2030 target to be 2.14 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[107]

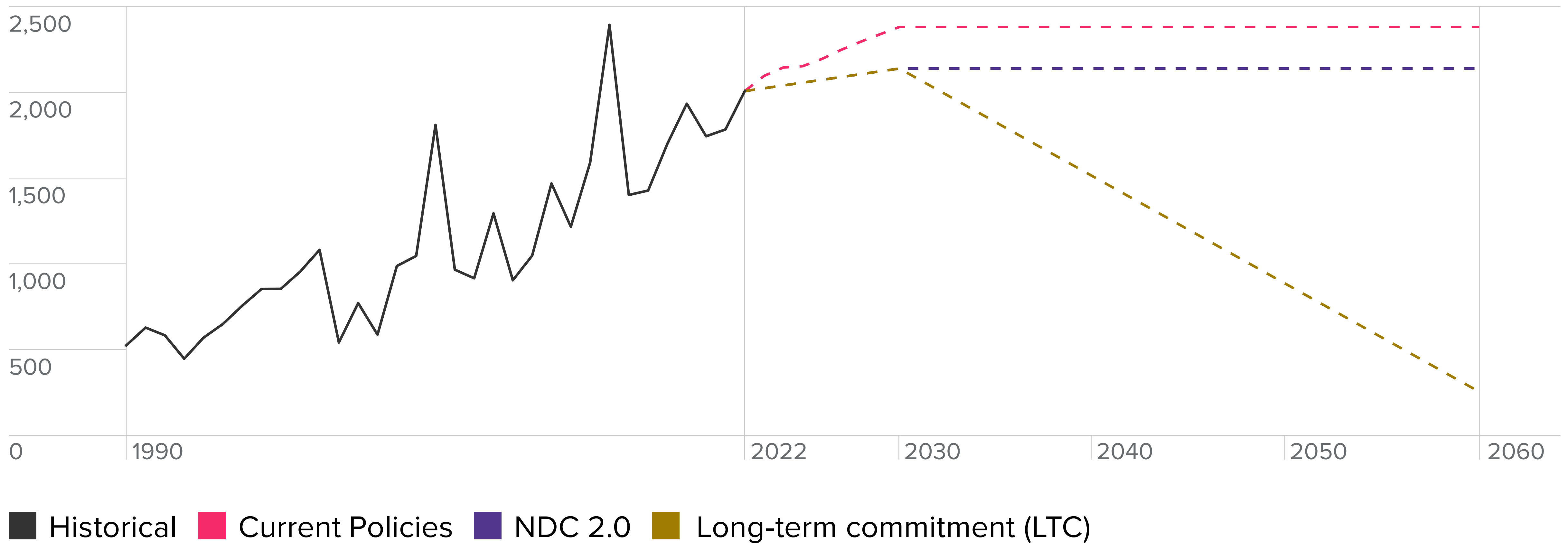
Covers all sectors[108]	Unclear
Covers Kyoto gases	Unclear

In its Long-Term Strategy (LTS) for low Carbon and Climate Resilience 2050, Indonesia has stated its ambition to achieve net zero GHG emissions by 2060. It is not specified whether the net zero target covers all GHG, but the LTS mentions certain gases for certain sectors. We estimate Indonesia's long-term commitment to be 255 $MtCO_2e$ in 2060 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Indonesia

Policies overview

✓ National adaptation plan[109]

Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool[110]	✓

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[111]	6.2% of GDP

✓ Carbon pricing system[112]

% of GHG emissions covered by carbon price	26%
Carbon price ($/t$CO_2$e)	0.61
Aligned with the global carbon price corridor[113]	✗

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity

(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Hydroelectric[114]	13.63	3rd
Solar[115]	12.06	8th
Geothermal[116]	2.29	1st
Wind[117]	1.81	18th

Indonesia

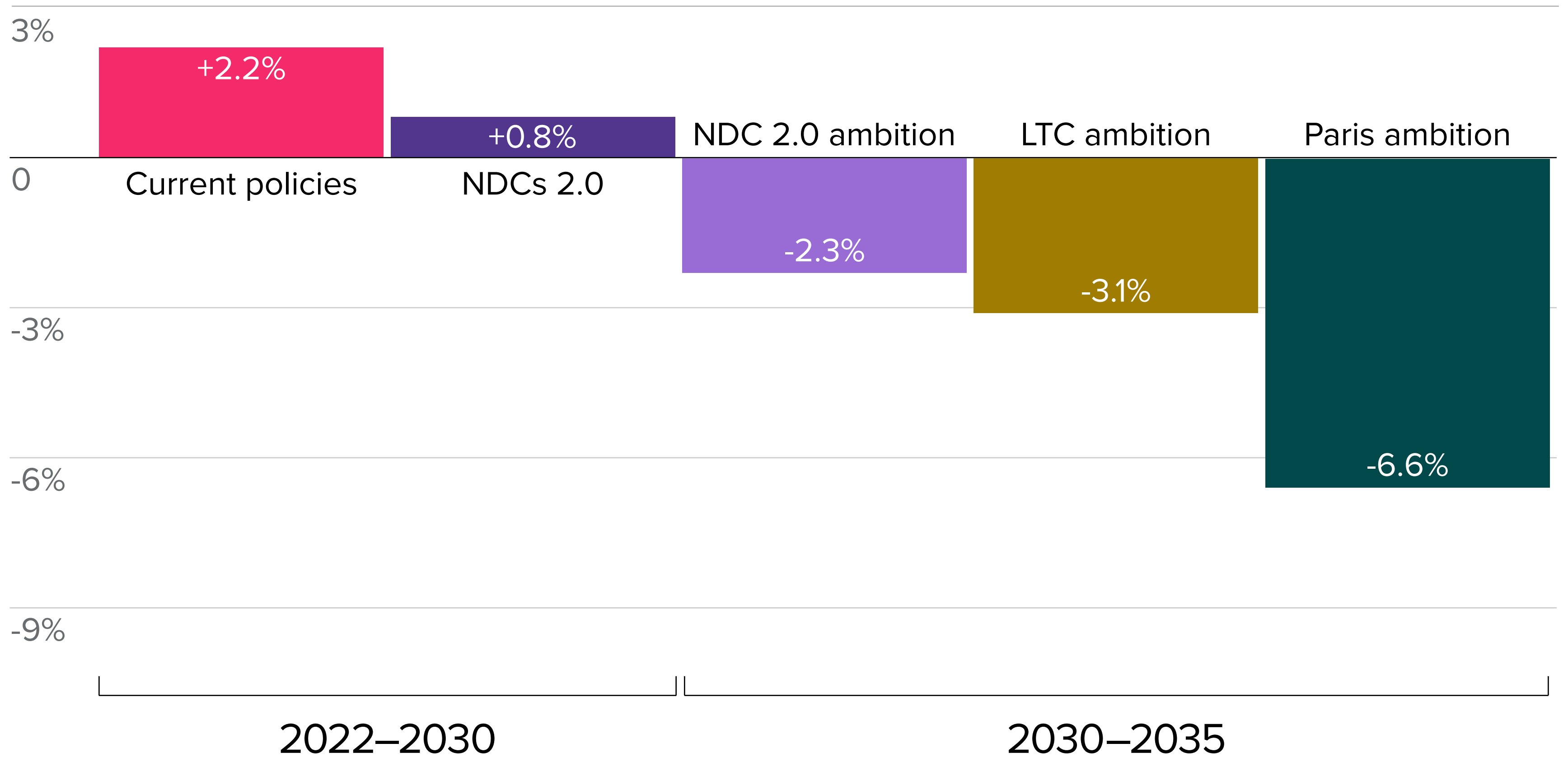
2035 targets

NDC 2.0 ambition: We estimate that, if Indonesia were to set targets based on the same ambition as its current NDC 2.0, it would set a 1.75–2.06 $GtCO_2e$ target for 2035. The middle of this range would keep Indonesia on a greater than 2°C decarbonisation pathway.

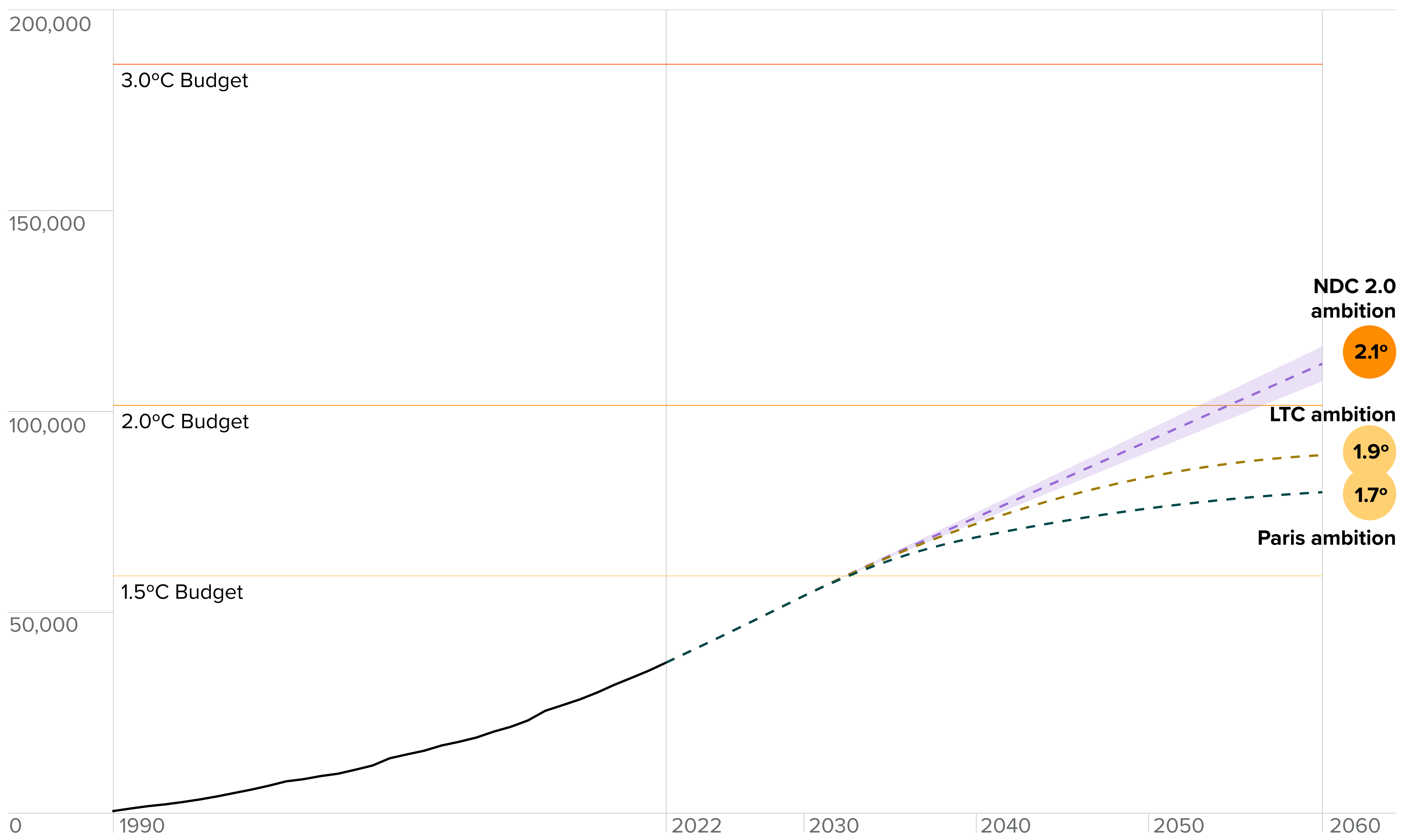
However, if Indonesia sets a 2035 target that is less than 1518 $MtCO_2e$ in 2035, then we project that it will be on a well below 2°C pathway and have a good chance of achieving its 2060 long-term commitment.

Indonesia will have to ramp up its efforts to decarbonise, going from +2.2% growth in emissions under current policies from 2024–2030 to 3% year-on-year decarbonisation from 2030–2035 to reach its 2035 target under **LTC ambition** and 7% under **Paris ambition**.

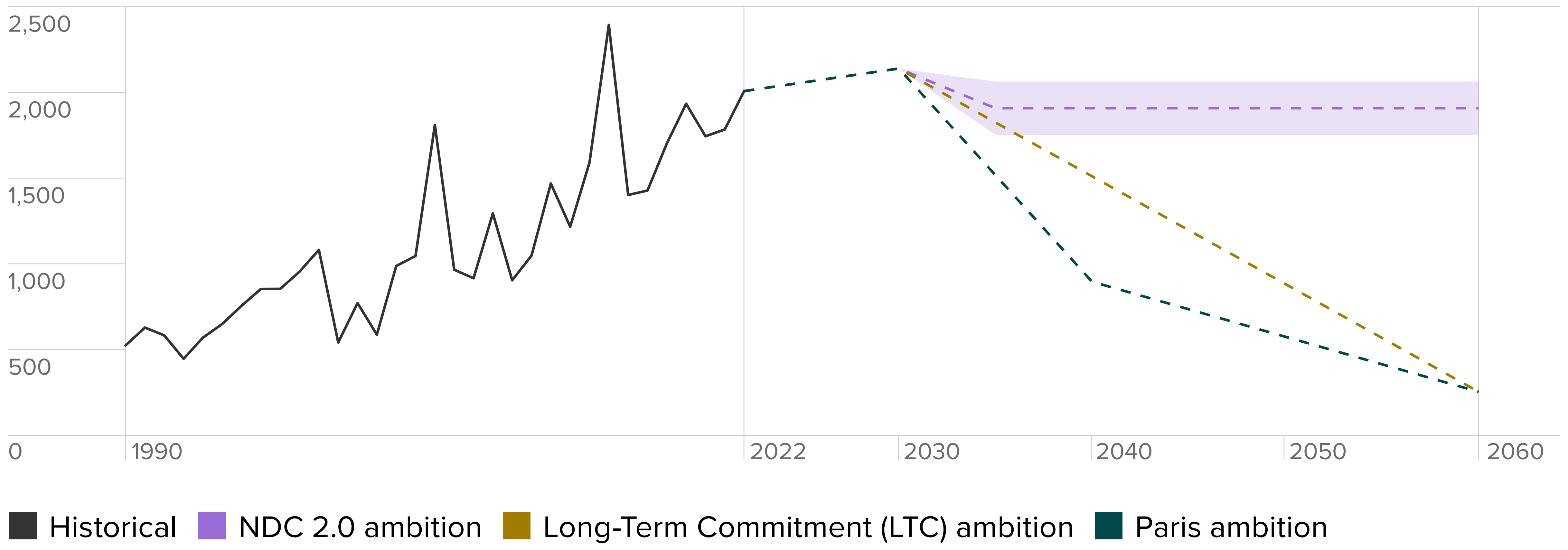
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Italy

Physical risk city insights

Milan

Urban population
3.1 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Medium	+128%
Water stress	Low	Low	Low	+51%

Milan, positioned in northern Italy, experiences a humid subtropical climate with distinct seasons. It combines high summer temperatures and extended dry spells. **Heatwaves** are projected to increase to a medium risk for Milan by 2050, from an expected 14 to 33 days of extreme heat per year. **Water stress** is also an increasing risk, with an expected 50% increase between 2024 and 2050.

Rome

Urban population
4.3 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+10%
Heatwaves	Low	Low	Medium	+114%
Water stress	Medium	High	High	+43%

Rome, located in central Italy along the Tiber River, experiences hot, dry summers and mild, wet winters. Currently, Rome faces medium risk from **water stress**, projected to increase to a high risk for the city by 2035. **Heatwaves** are another risk for the city, with an anticipated increase from low to medium risk by 2050 and an increase from 18 to 39 days of extreme heat expected per year.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C
+4.0°C

Italy

We project that, by 2030, Italy's current policies will result in the country overshooting its NDC by 16%, or 40 $MtCO_2e$.

We also estimate that Italy will surpass its 1.5°C emissions budget by 2036.

NDC 2.0[118]

Conditionality	Unconditional
Covers all sectors	✓

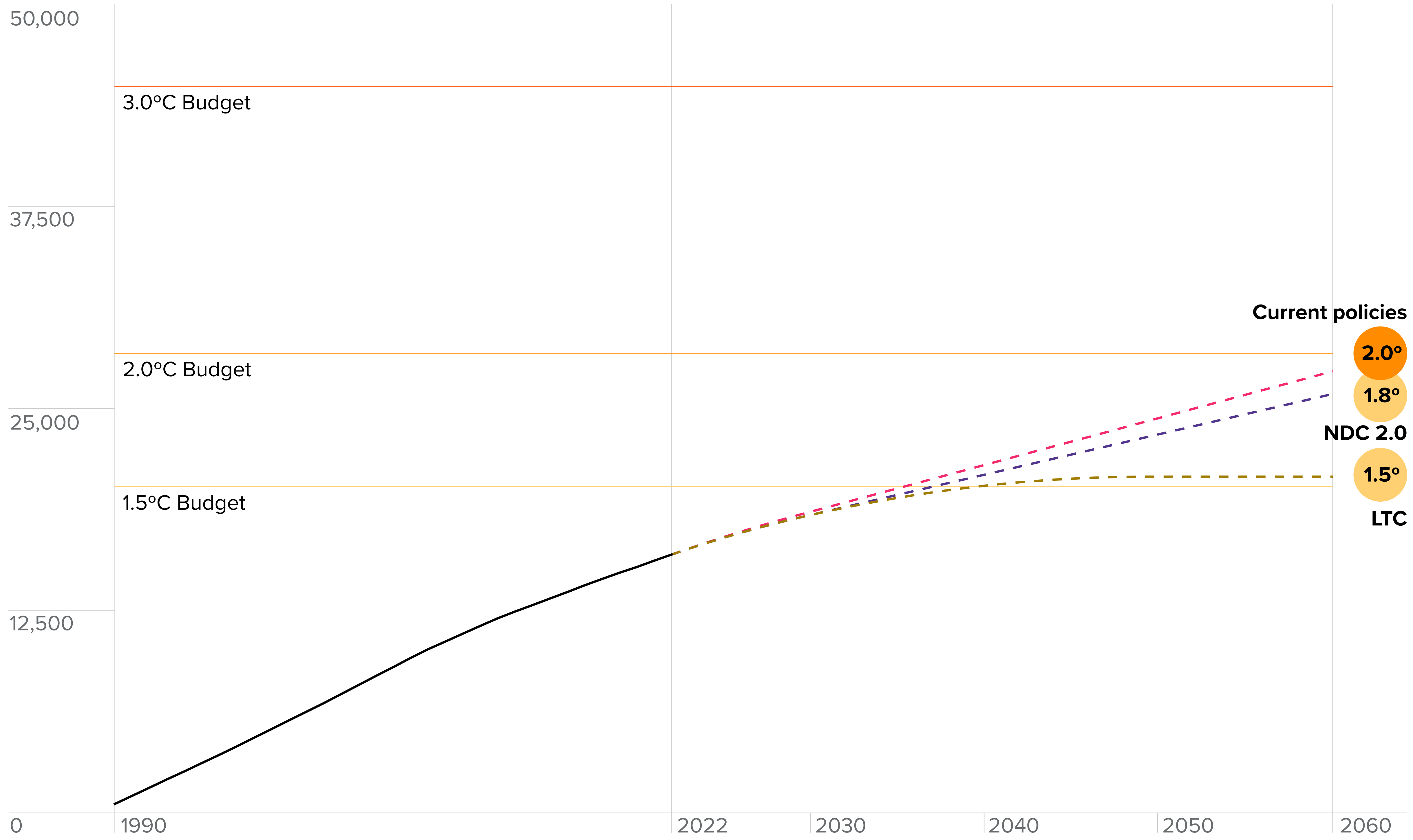
Italy is party to the European Union's NDC, which has pledged to reduce emissions by at least 55% below 1990 levels by 2030. We calculate Italy's 2030 target to be 249 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[119]

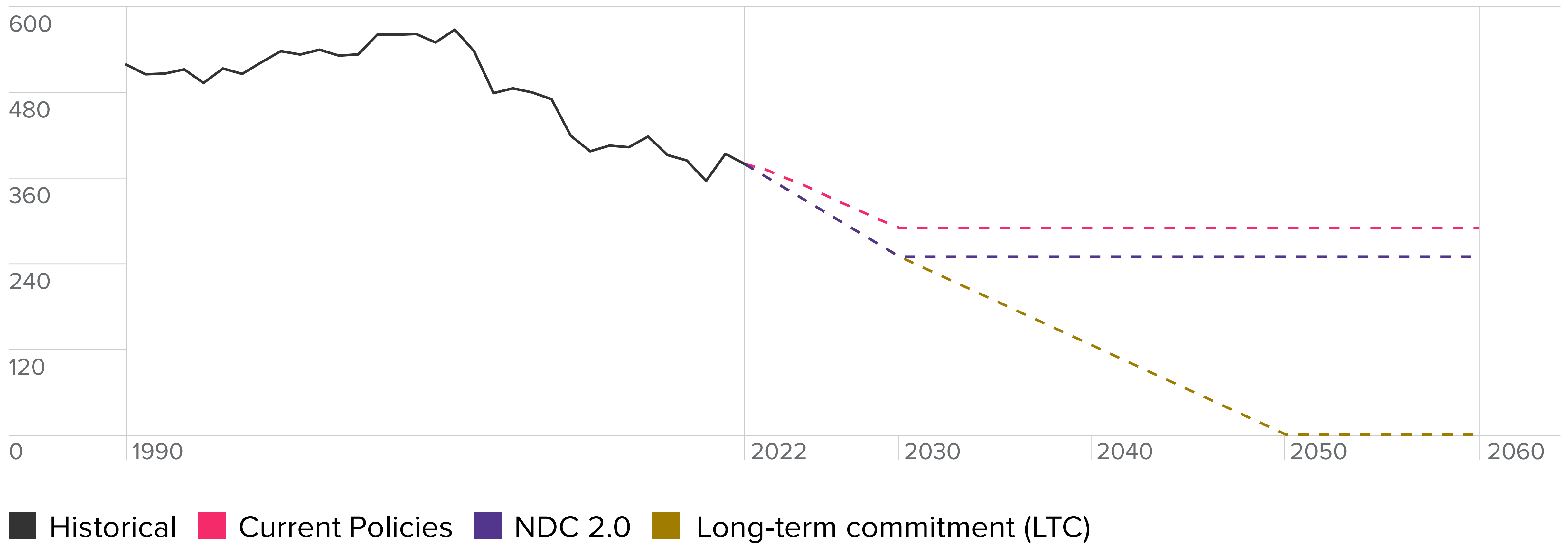
Covers all sectors[120]	✓
Covers Kyoto gases	✓

Italy is party to the European Union's NDC, which has pledged to reduce emissions by at least 55% below 1990 levels by 2030. We calculate Italy's 2030 target to be 249 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Italy

Policies overview

✓ National adaptation plan[121]	
Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

✓ Commited to fossil fuel subsidies phase out[122]	2025
Annual amount spent on explicit fossil fuel subsidies[123]	0.4% of GDP

✓ Carbon pricing system[124]	EU Emissions Trading System (see page 106)

Climate finance

3-year average climate finance contribution as a % of GDP[125]	0.03%
Proportional share of $100 billion global climate finance commitment[126]	✗
Targeted level of international climate finance contribution as a % of GDP	0.06%
Target to increase global climate finance contributions[127]	✓

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[128]	20.56	7th
Solar[129]	2.24	16th
Hydroelectric[130]	0.12	17th
Geothermal[131]	0	N/A

Italy

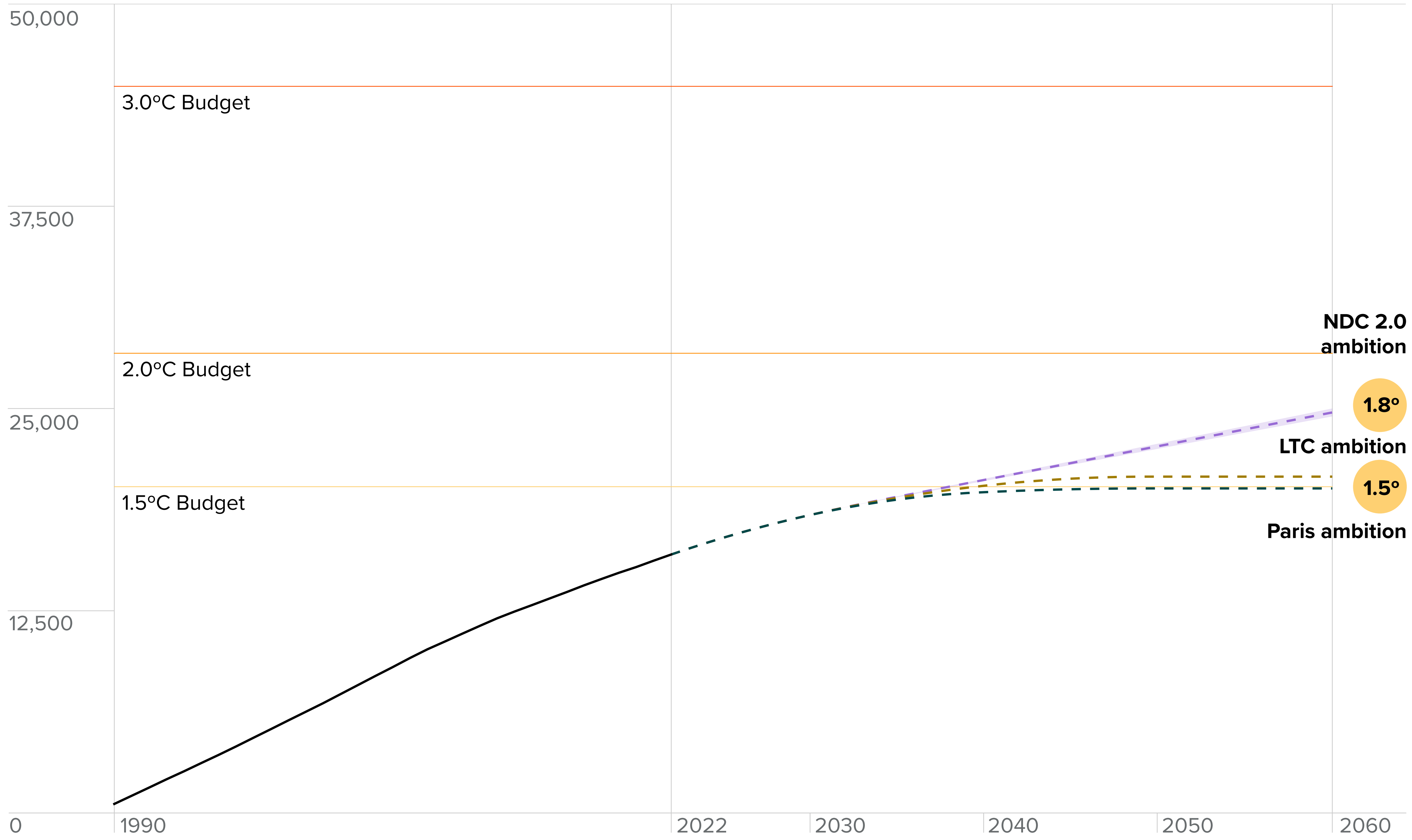
2035 targets

NDC 2.0 ambition: we estimate that, if Italy were to set targets based on the same ambition as its current NDC 2.0, it would set a 200-220 $MtCO_2e$ target for 2035. The median of this range would keep Italy on a well below 2°C decarbonisation pathway.

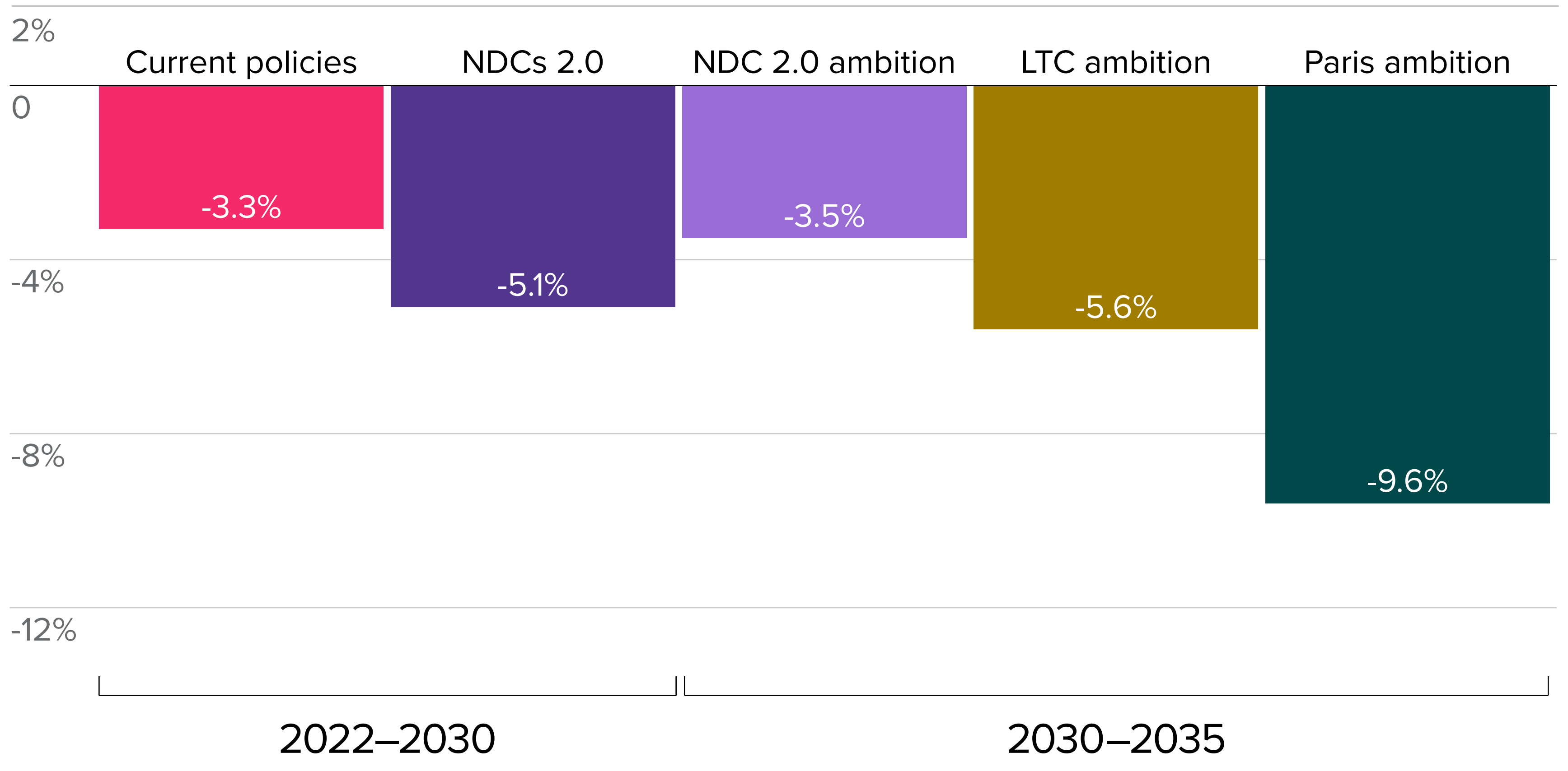
However, if Italy sets a 2035 target that is less than 187 $MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a reasonable chance of achieving its 2050 net zero target.

Italy will have to ramp up its annual rate of decarbonisation from 3.3% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 10% under **Paris ambition**.

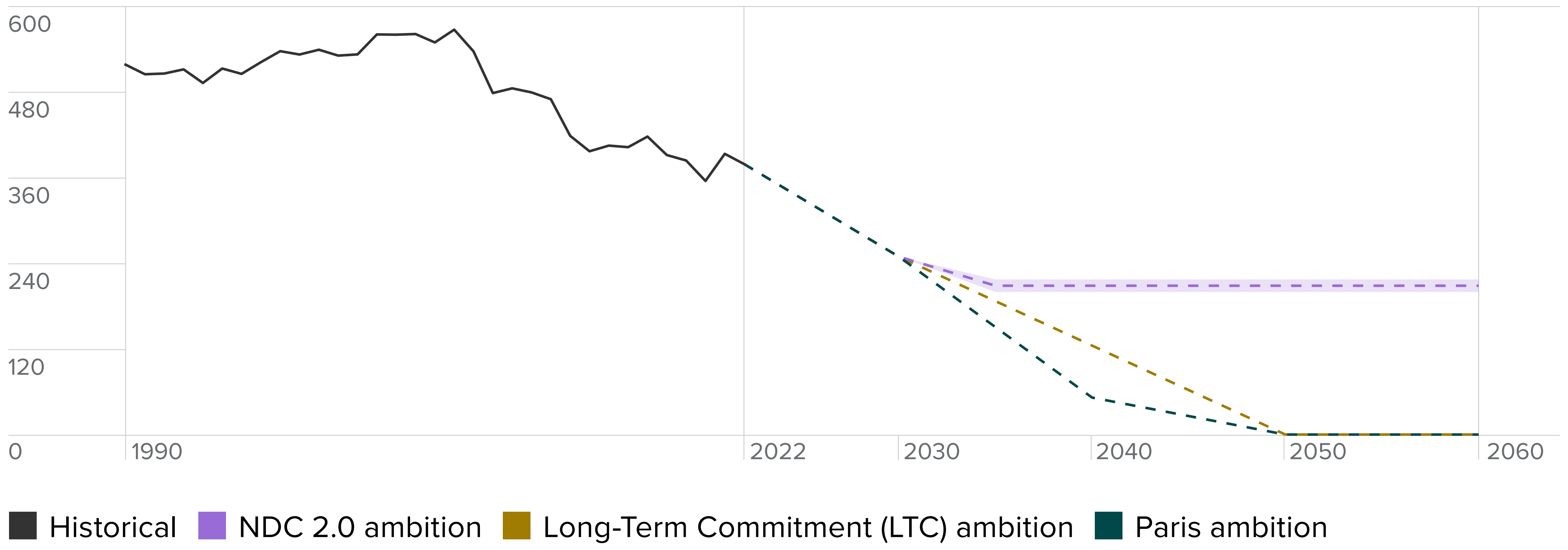
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Japan

Physical risk city insights

Tokyo

Urban population
34 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	High	High	High	+66%
Heatwaves	Low	Low	Low	+2%
Water stress	Low	Low	Medium	+136%

Situated on the eastern coast of Honshu Island on the Pacific Ocean, Tokyo has a humid subtropical climate. Tokyo faces a high risk of **cyclones**, with a 66% increase in the annual likelihood of a category 1 cyclone anticipated by 2050 – from 1 in every 11 years to 1 in every 7 years. Tokyo also faces growing risks from **water stress**, expecting a 136% increase in by 2050, rising to a medium risk level.

Yokohama

Urban population
3.8 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	High	High	High	+65%
Heatwaves	Low	Low	Medium	+132%
Water stress	Medium	Medium	Medium	+10%

Situated on the western coast of Tokyo Bay, Yokohama is Japan's second-largest city. **Cyclones** are a high risk for Yokohama; by 2050, a category 1 cyclone is forecast in the city on average once every 6 years. The number of days of **extreme heat** is anticipated to increase, from an average 14 days per year up to 32.

Projected temperature increase by 2050 (High-emissions scenario)

Japan

We project that, by 2030, Japan's current policies will result in the country overshooting its NDC by 27%, or 194 $MtCO_2e$.

We also estimate that Japan will surpass its 1.5°C emissions budget by 2031.

NDC 2.0[132]

Conditionality	Unconditional
Covers all sectors	✓

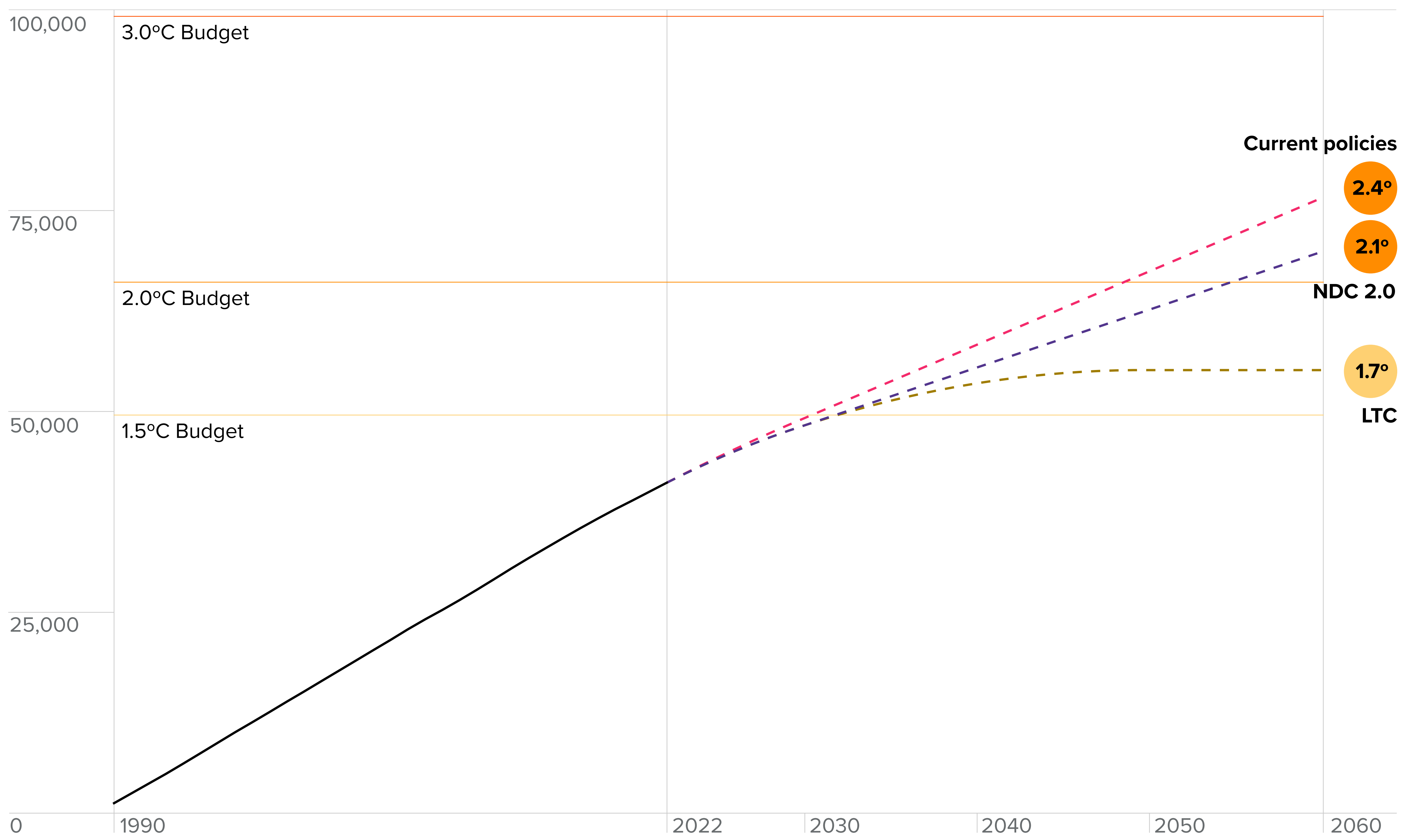
In its 2021 updated NDC, Japan has pledged to reduce emissions by 46% below 2013 levels by 2030, including LULUCF emissions. We calculate Japan's 2030 target to be 722 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[133]

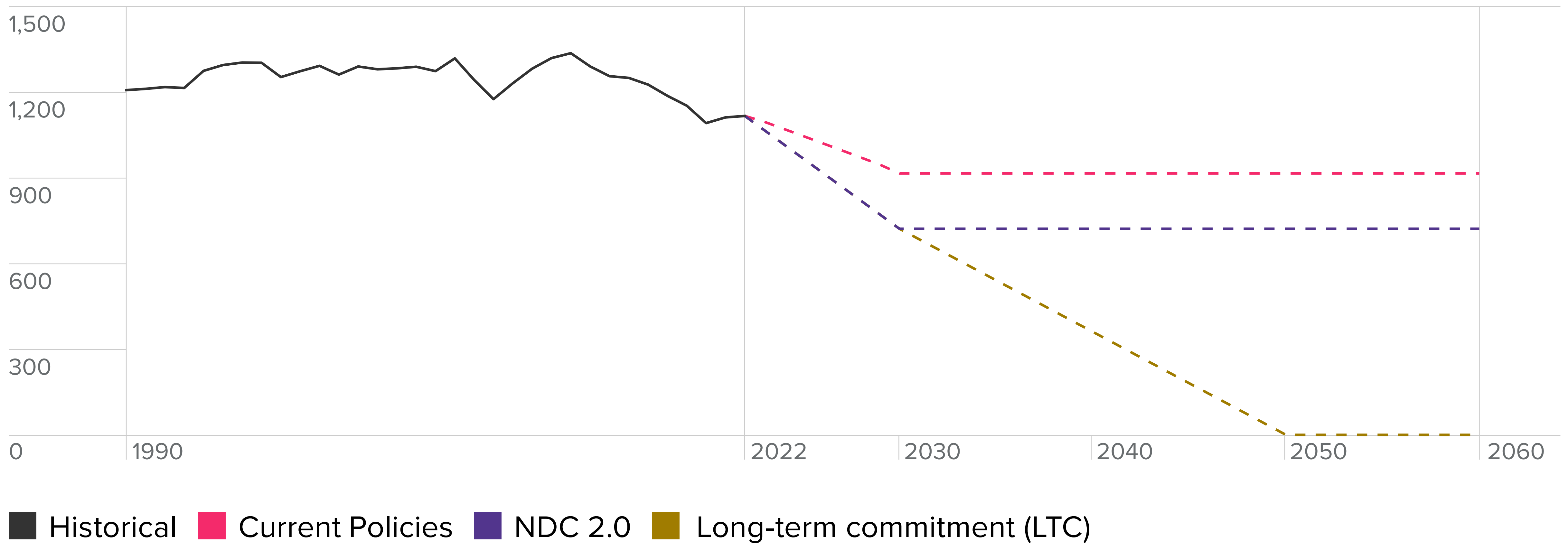
Covers all sectors[134]	✓
Covers Kyoto gases	✓

In 2020, Japan submitted its long-term strategy to the UNFCCC with the target of achieving net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Japan

Policies overview

✓ National adaptation plan[135]	
Regular published risk assessments[136]	✓
Monitoring and evaluating report[137]	✓
Part of a sovereign catastrophe risk pool[138]	✓

✗ Commited to fossil fuel subsidies phase out	
Annual amount spent on explicit fossil fuel subsidies[139]	0.6% of GDP

✓ Carbon pricing system[140]	
% of GHG emissions covered by carbon price	80%
Carbon price ($/t$CO_2$e)	1.91
Aligned with the global carbon price corridor[141]	✗

Climate finance

3-year average climate finance contribution as a % of GDP[142]	0.21%
Proportional share of $100 billion global climate finance commitment[143]	✓
Targeted level of international climate finance contribution as a % of GDP	N/A
Target to increase global climate finance contributions	✗

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[144]	6.03	10th
Solar[145]	0.53	20th
Hydroelectric[146]	0.14	16th
Geothermal[147]	0	N/A

Japan

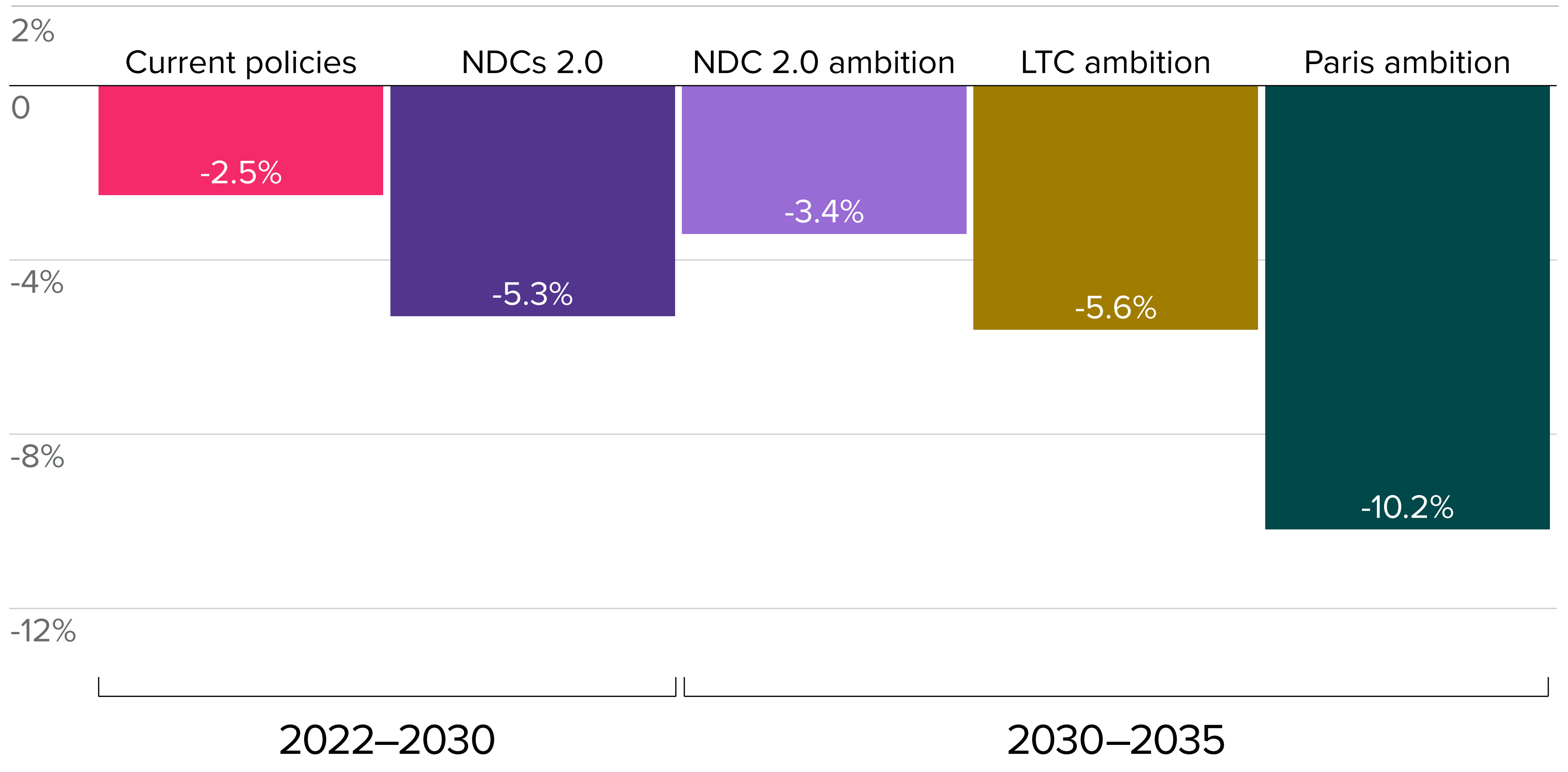
2035 targets

NDC 2.0 ambition: We estimate that, if Japan were to set targets based on the same ambition as its current NDC 2.0, it would set a 590-620 $MtCO_2e$ target for 2035. The median of this range would keep Japan on a 2°C decarbonisation pathway.

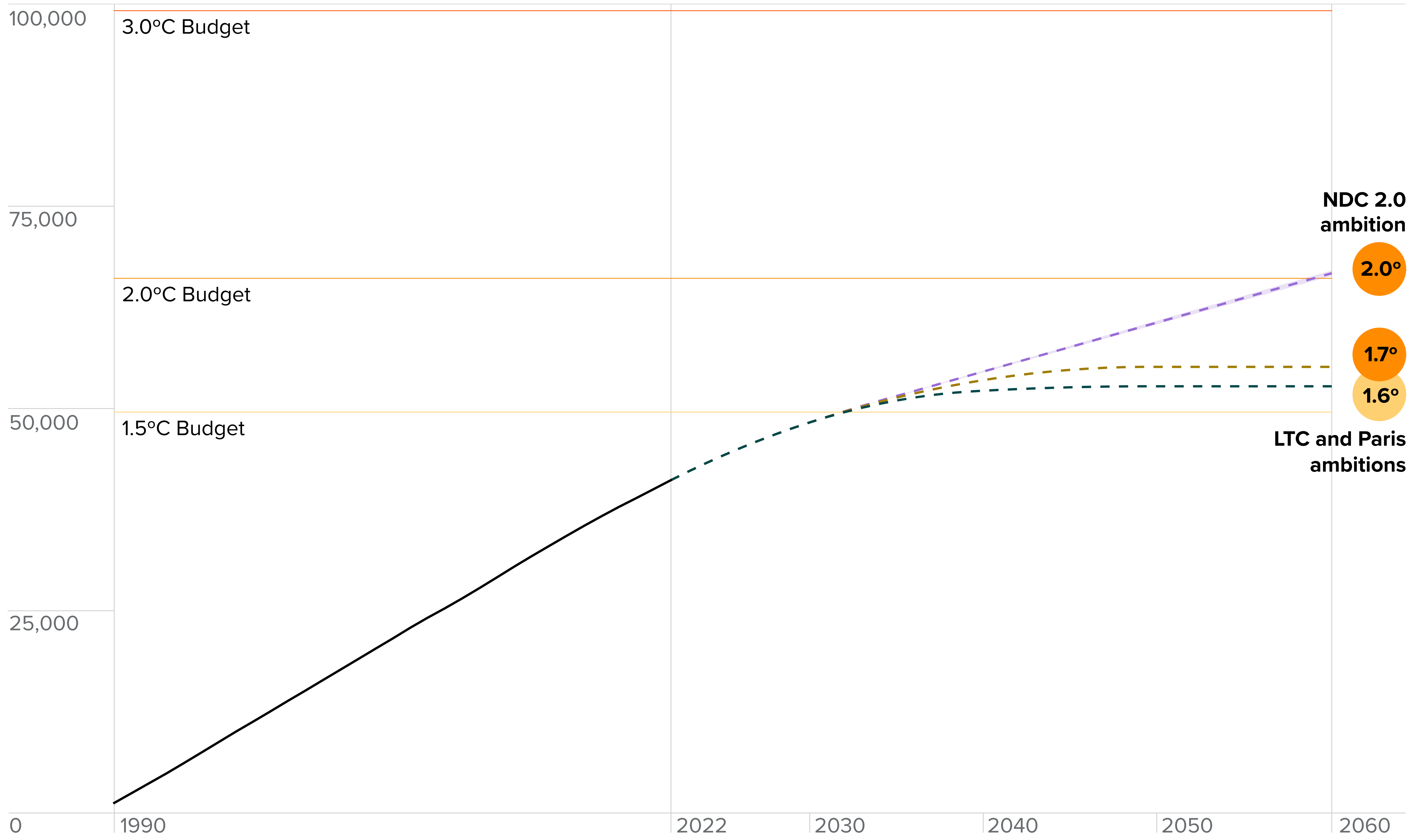
However, if Japan sets a 2035 target that is less than 541 $MtCO_2e$ in 2035, then we project that it will be on a well below 2°C pathway and have a reasonable chance of achieving its 2050 net zero target.

Japan will have to substantially ramp up its annual rate of decarbonisation from 2.5% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 10% under **Paris ambition**.

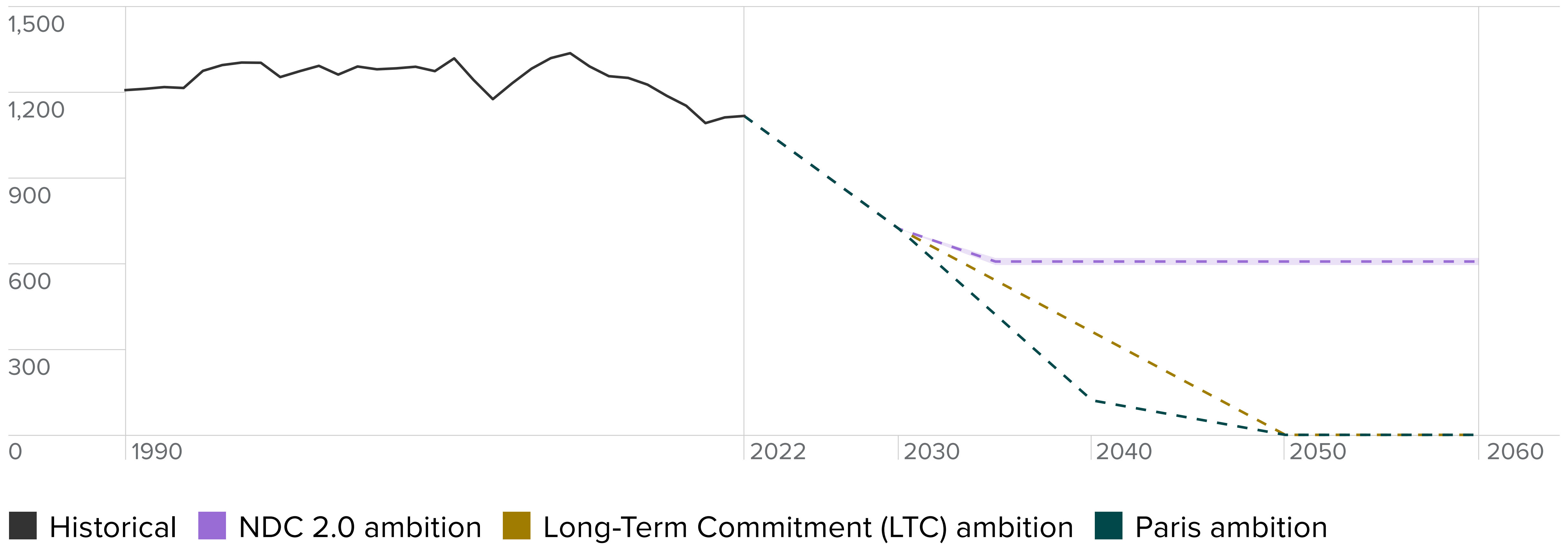
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Mexico

Physical risk city insights

Mexico City

Urban population
21.8 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	Low	Low	Low	+27%
Heatwaves	Low	Low	Low	+207%
Water stress	Medium	Medium	High	+73%

One of the few major cities not located along the banks of a river, Mexico City is situated in the Valley of Mexico, an inland basin in the centre of the country. The city's reliance on underground aquifers and variant rainfall patterns make it exposed to **water stress,** which is projected to become a high risk in 2050. **Heatwaves** are expected to increase from 8 days currently to 26 days per year in 2050.

Tijuana

Urban population
2.1 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	Low	Low	Low	+187%
Heatwaves	Low	Low	Medium	+109%
Water stress	Medium	Medium	High	+24%

Bordered by mountains ranges and the Sonoran Desert, Tijuana has an arid sub-tropical climate. Currently experiencing an average of 15 days of **extreme heat** per year, the city is expected to face over a 100% increase by 2050, to over 30 days per year. Tijuana's reliance on the diminishing Colorado River, makes **water stress** a medium risk currently, which is expected to become high risk by 2050.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C +4.0°C

Mexico

We project that, by 2030, Mexico's current policies will result in the country overshooting its NDC by 40%, or 205 $MtCO_2e$.

We also estimate that Mexico will surpass its 1.5°C emissions budget by 2038.

NDC 2.0[148]

Conditionality	Unconditional
Covers all sectors	✔

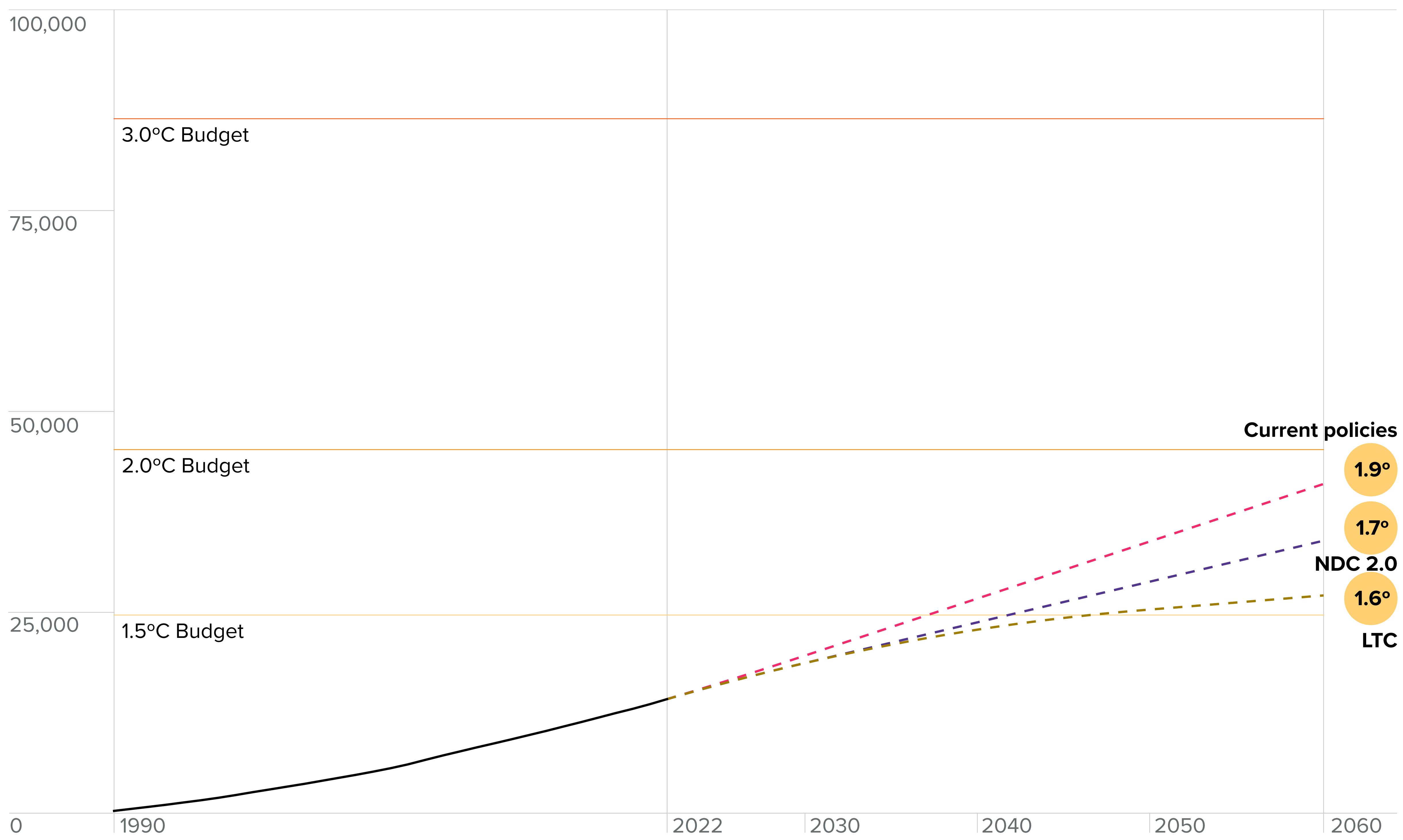
In its revised 2022 NDC, Mexico pledged to reduce its GHG emissions by up to 35% (30% with own resources and an additional 5% with agreed international support for clean energy) from a business-as-usual-scenario. We calculate Mexico's 2030 target to be 508 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[149]

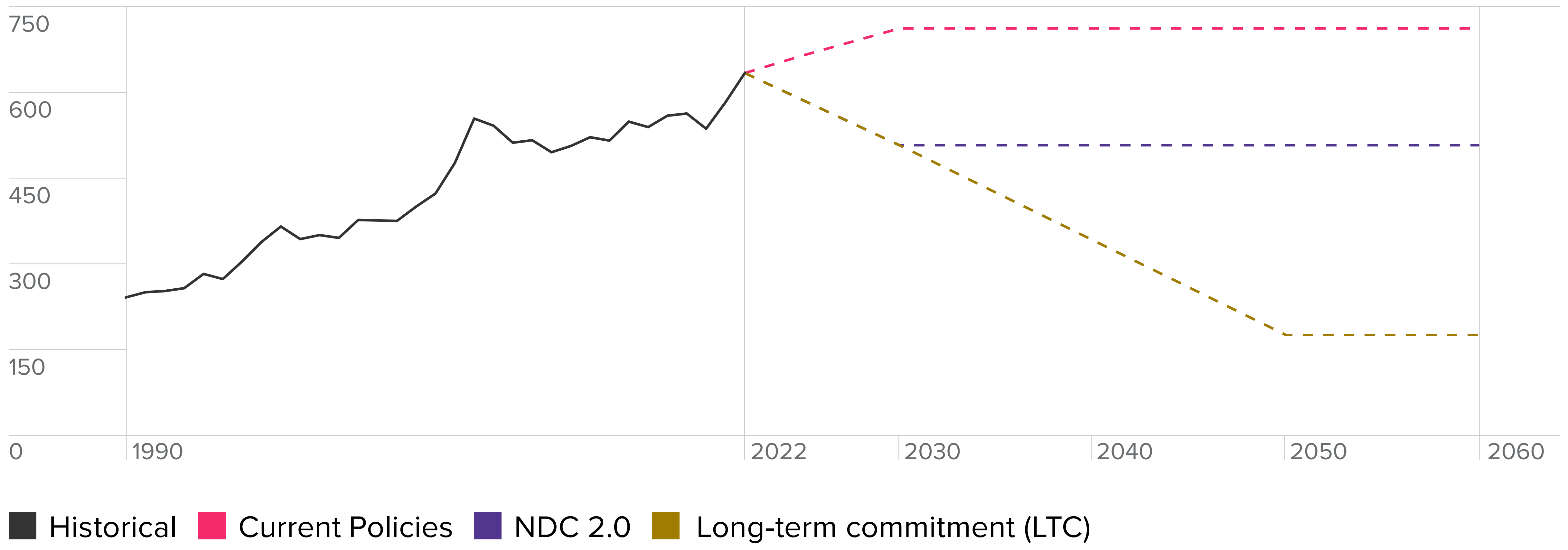
Covers all sectors[150]	Unclear
Covers Kyoto gases	Unclear

Mexico has not set a net zero target. However, in its 2016 Mid-Century Strategy, it stated that its goal was to reduce GHG emissions by 50% below 2000 levels. There has been no update since 2016 and its continued use as a target is unclear. For the purposes of our analysis, we assume the mid-century target is still valid and calculate Mexico's 2050 target to be 175 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Mexico

Policies overview

National adaptation plan ✗

Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	✗

Commited to fossil fuel subsidies phase out ✗

Annual amount spent on explicit fossil fuel subsidies[151]	1.1% of GDP

Carbon pricing system ✓

% of GHG emissions covered by carbon price	Tax	29%
	ETS	40%
Carbon price ($/tCO$_2$e)	Tax	4.31[152]
	ETS	0[153]
Aligned with the global carbon price corridor[154]		✗

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity

(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Solar[155]	10.96	9th
Wind[156]	1.46	19th
Hydroelectric[157]	0.42	14th
Geothermal[158]	0	N/A

Mexico

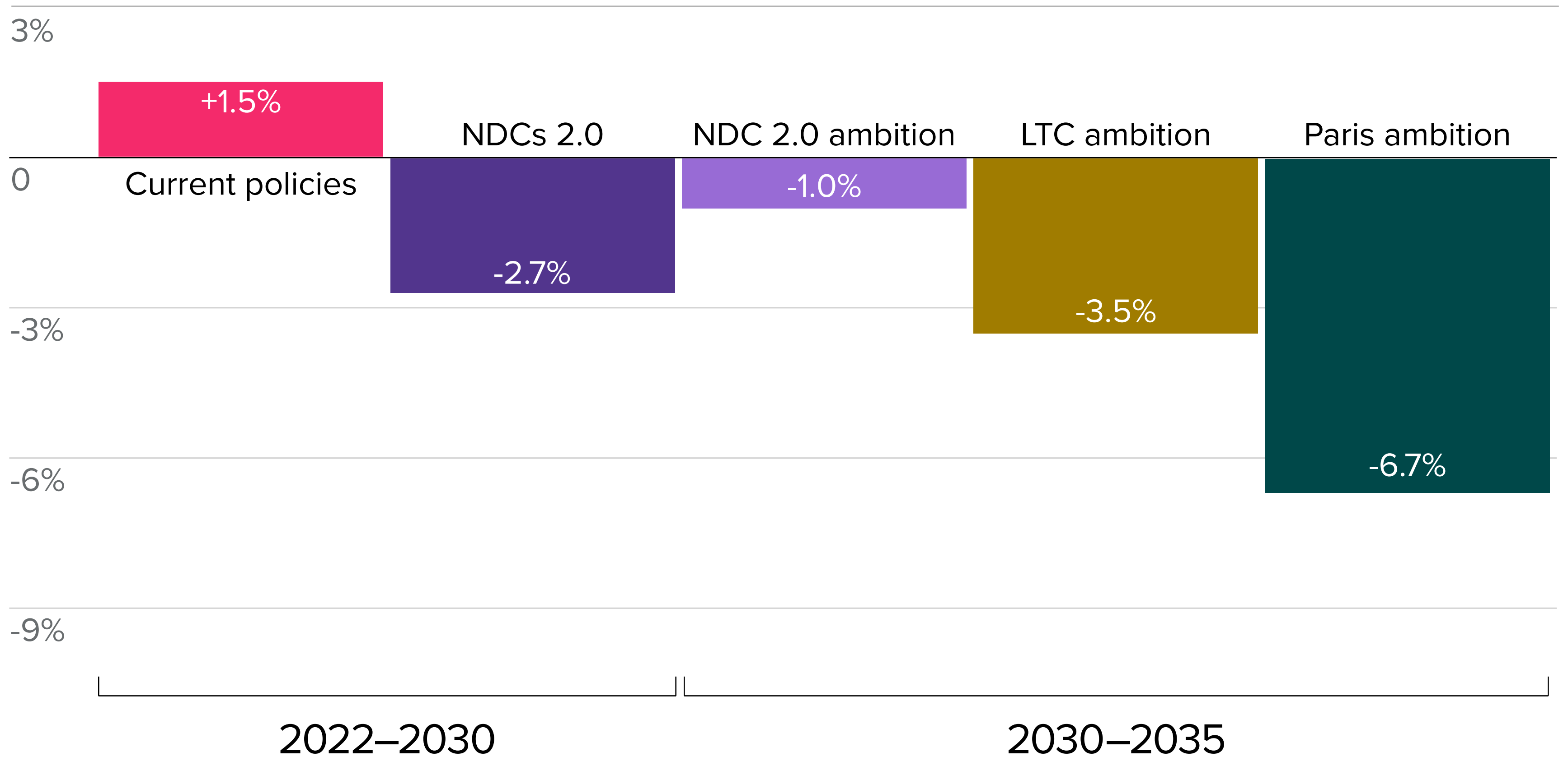
2035 targets

NDC 2.0 ambition: we estimate that, if Mexico were to set targets based on the same ambition as its current NDC 2.0, it would set a 460-510 $MtCO_2e$ target for 2035. The median of this range would keep Mexico on a below 2°C decarbonisation pathway.

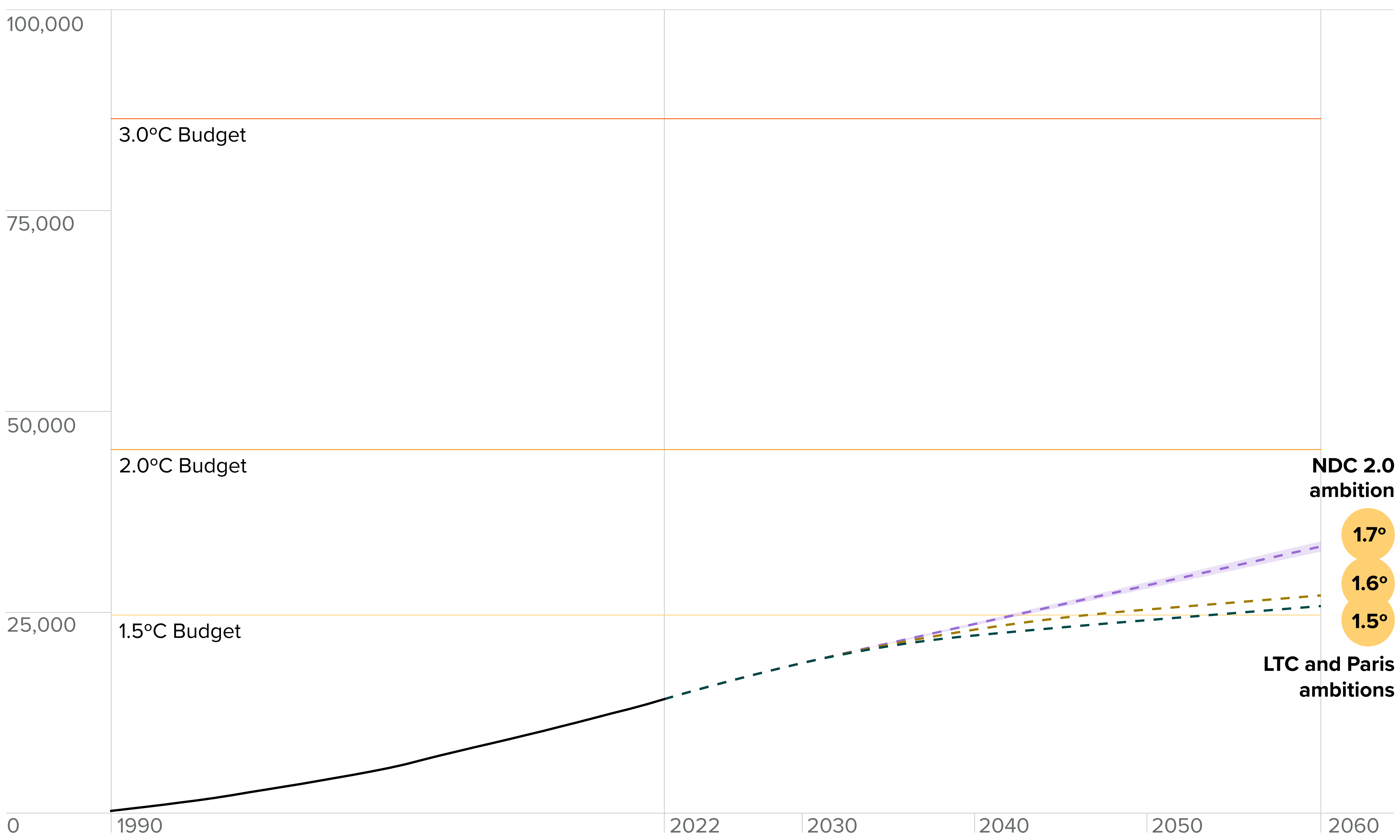
However, if Mexico sets a 2035 target that is less than 385 $MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a good chance of achieving its 2050 long-term commitment.

Mexico will have to ramp up its efforts to decarbonise, going from +1.5% growth in emissions under current policies from 2024-2030 to 4% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 7% under **Paris ambition**.

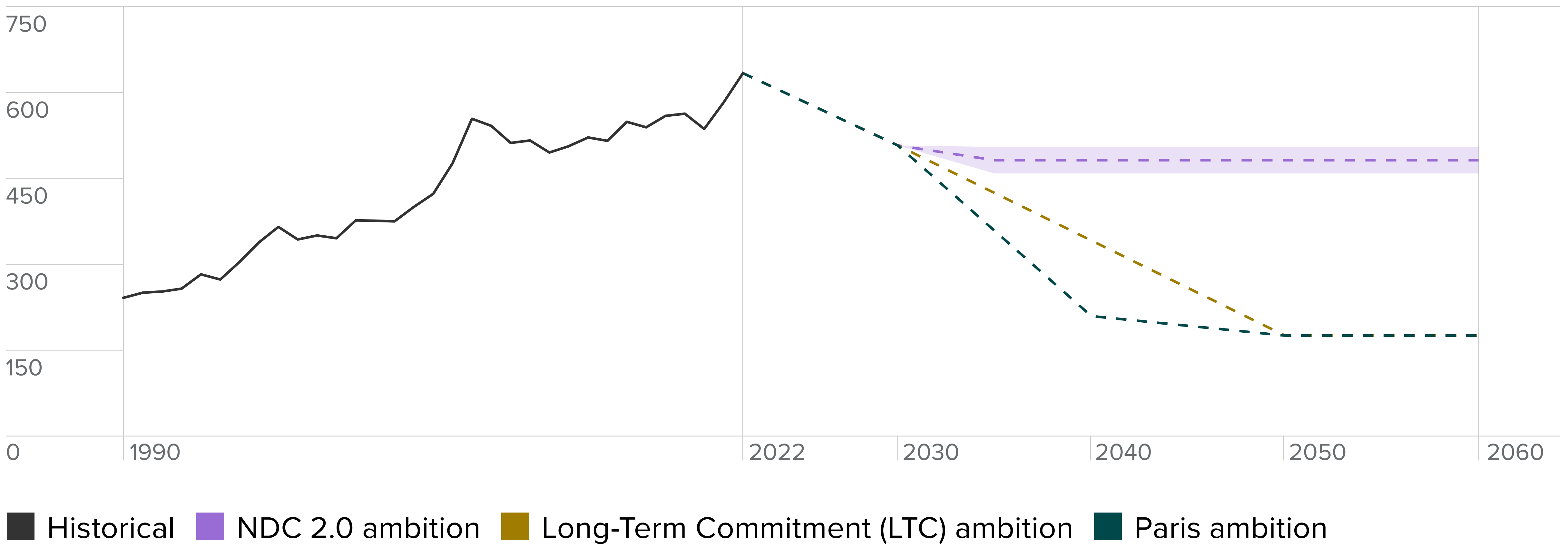
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Russia

Physical risk city insights

Moscow

Urban population
12.5 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+110%
Water stress	Medium	Medium	Medium	+48%

Situated on the banks of the Moskva River, Moscow has a continental climate with warm summers and cold winters. The city currently experiences medium **water stress** risk, due to its high dependence on surface water supply which is vulnerable to pollution and drops in volume levels. By 2050, this risk is expected to see a 48% increase. **Heatwaves** are projected stay at a low risk, but still see a 110% increase by 2050.

Saint Petersburg

Urban population
5.4 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+86%
Water stress	Low	Low	Low	+190%

Saint Petersburg is built on a series of islands and lowlands at the head of the Gulf of Finland. Physical risks for Saint Petersburg are expected to increase by 2050, but remain at low levels. An 86% increase in **heatwaves** would see the city experience 19 days of extreme heat per year in 2050 compared to 10 days currently. Similarly, **water stress** risk is expected to increase threefold, but remain at low levels.

Projected temperature increase by 2050 (High-emissions scenario)

+1.0°C +4.0°C

Russia

We project that, by 2030, Russia's current policies mean that it will reach, and be 33% or 681 $MtCO_2e$ under, its NDC.

We also estimate that Russia will surpass its 1.5°C emissions budget by 2030.

NDC 2.0[159]

Conditionality	Unconditional
Covers all sectors	✓

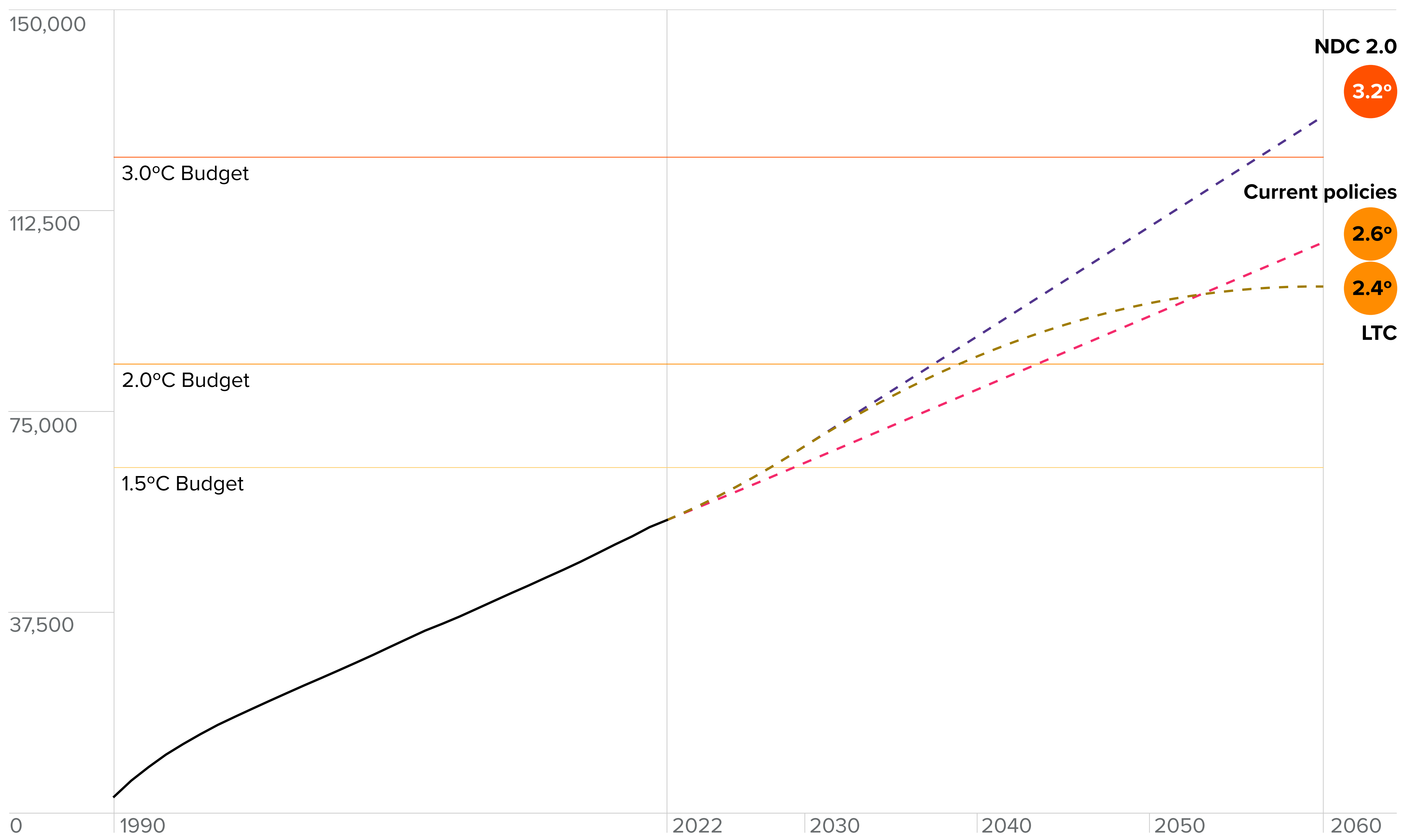
In 2020, Russia updated its NDC with a pledge to limit GHG emissions by up to 70% below 1990 levels by 2030. We calculate Russia's 2030 target to be 2.05 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[160]

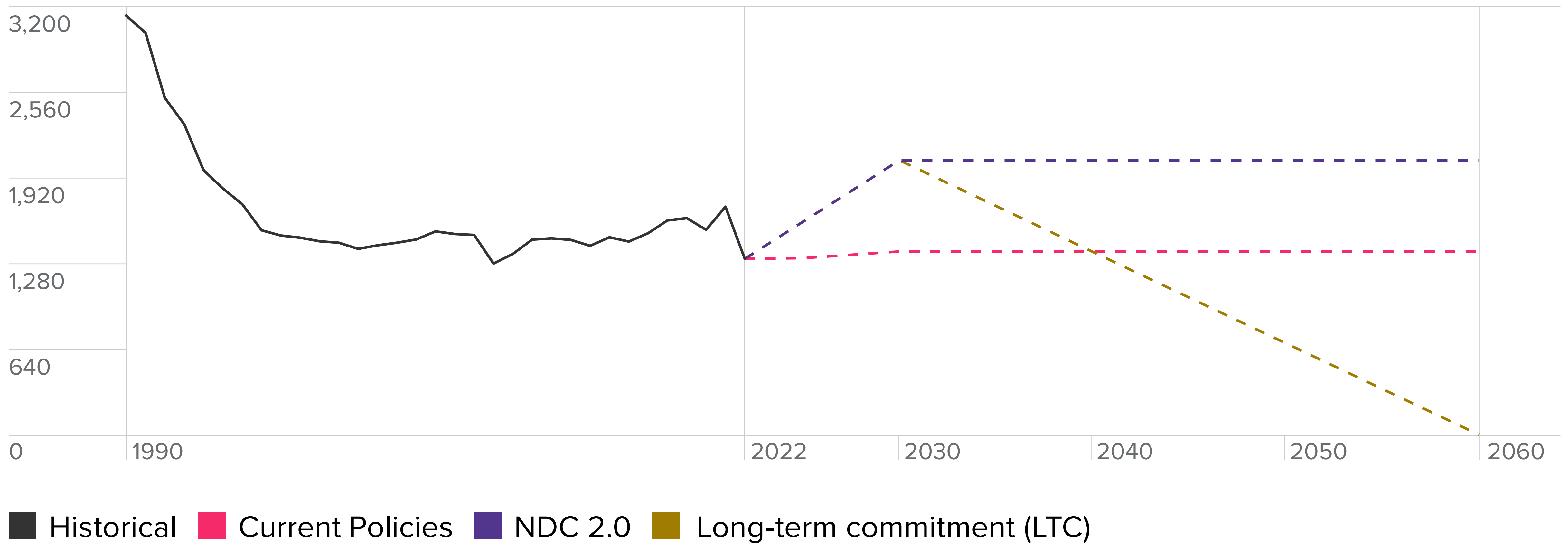
Covers all sectors[161]	(Assumption) ✓
Covers Kyoto gases	(Assumption) ✓

In 2022, Russia submitted its long-term strategy to the UNFCCC, stating that it intends to reach net zero GHG emissions by 2060. We have assumed this to mean 0 $MtCO_2e$ in 2060 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Russia

Policies overview

✓ **National adaptation plan[162]**	
Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

✗ **Commited to fossil fuel subsidies phase out**	
Annual amount spent on explicit fossil fuel subsidies[163]	4% of GDP

✗ **Carbon pricing system**

Climate finance	
3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Hydroelectric[164]	2.22	11th
Wind[165]	0.79	20th
Solar[166]	0.56	19th
Geothermal[167]	0	N/A

Russia

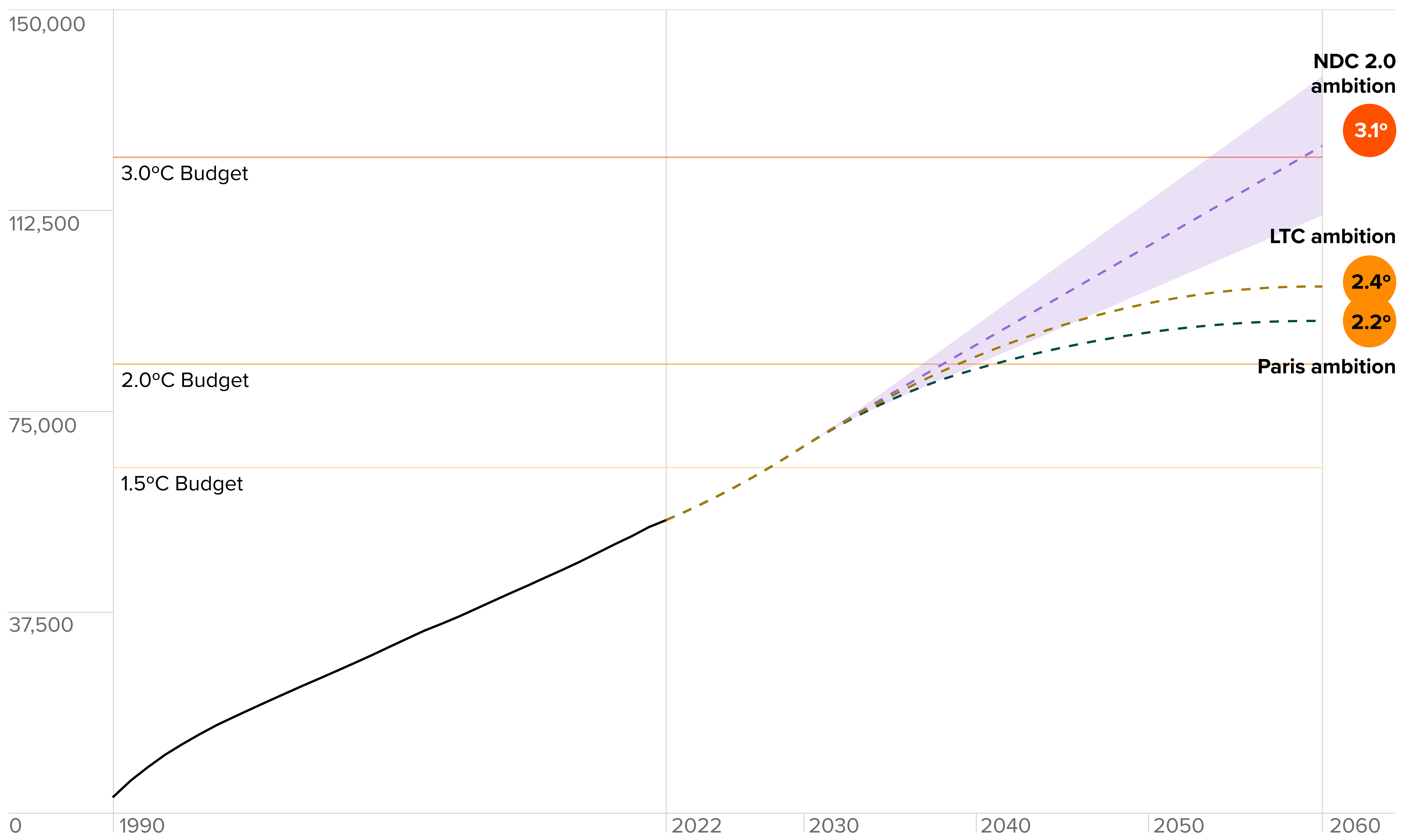
2035 targets

NDC 2.0 ambition: we estimate that, if Russia were to set targets based on the same ambition as its current NDC 2.0, it would set a target somewhere in the range of 1350–2350 $MtCO_2e$ for 2035. The median of this range would keep Russia on a greater than 3°C decarbonisation pathway.

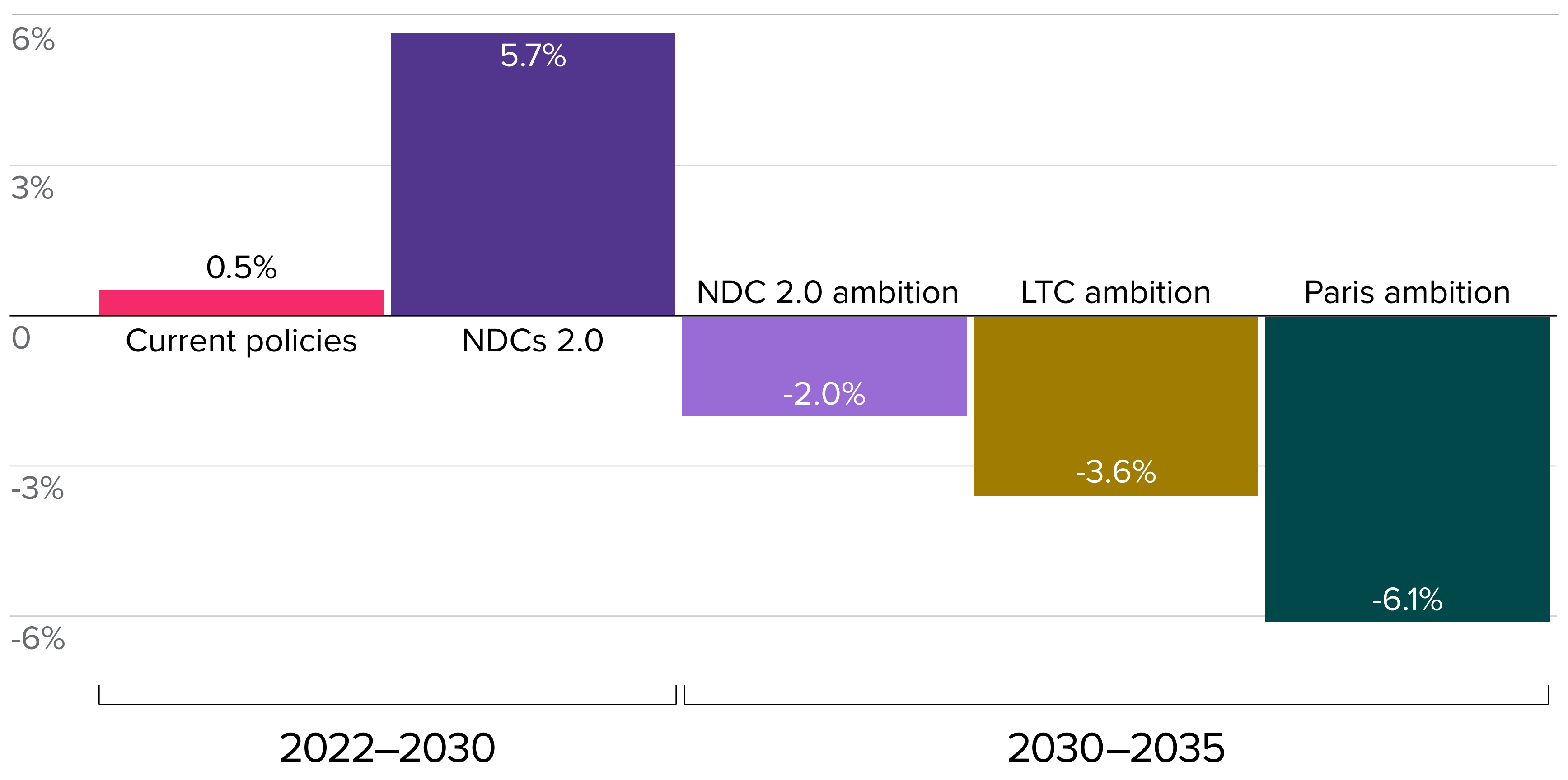
Even if Russia sets a 2035 target that is less than 1496 $MtCO_2e$ in 2035, we project that it will still be on a greater than 2°C pathway but have a good chance of achieving its 2060 net zero target.

Russia will have to ramp up its efforts to decarbonise, going from +0.5% growth in emissions under current policies from 2024-2030 to 4% year-on-year decarbonisation from 2030–2035 to reach its 2035 target under **LTC ambition** and 6% under **Paris ambition**.

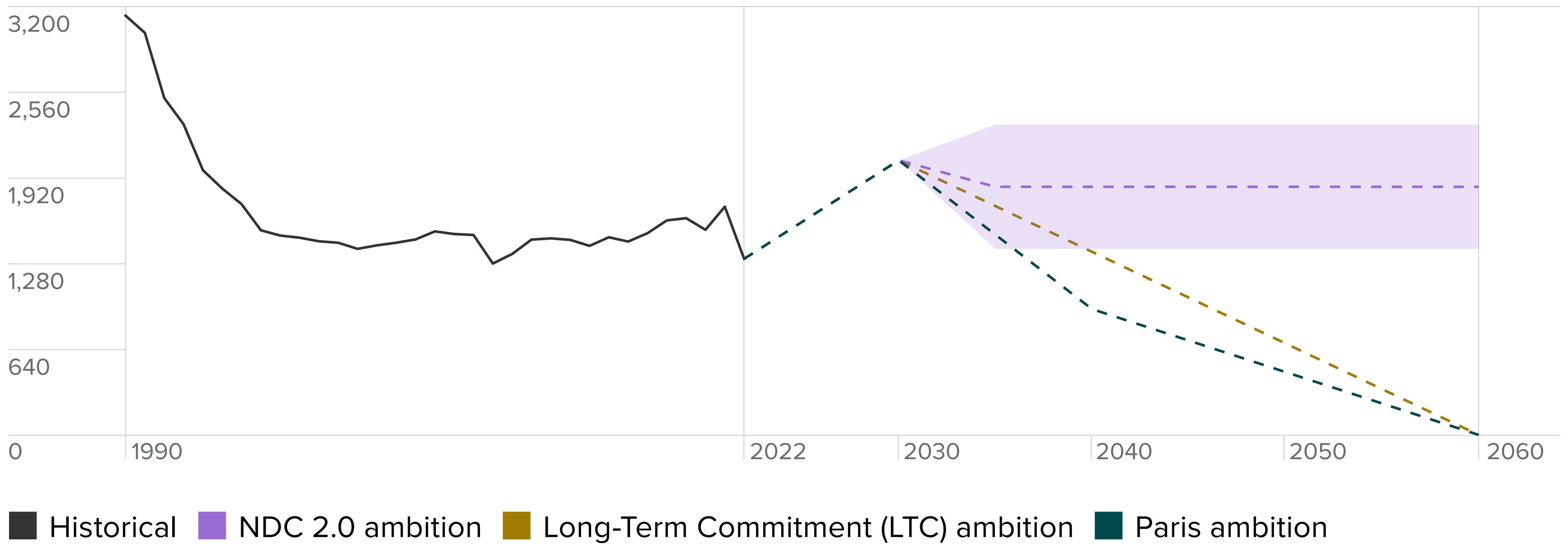
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



Saudi Arabia

Physical risk city insights

Jeddah

Urban population
4.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	+0%
Heatwaves	Low	Low	High	+218%
Water stress	High	High	High	+14%

Jeddah sits on the coast of the Red Sea, experiencing a hot desert climate with high humidity levels in the summer. Water is scarce, and desalination plants are used for its water supply. A 14% increase to the already high **water stress** risk is expected by 2050. **Heatwaves** are also expected to increase as a risk for the city, from 17 days of extreme heat for the city in 2024, to 54 by 2050.

Riyadh

Urban population
7.2 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Medium	High	High	+167%
Water stress	High	High	High	+13%

Riyadh, positioned in central Saudi Arabia, is vulnerable to extreme heat and water scarcity. Rapid city growth and arid conditions contribute to water scarcity, meaning it is already at a high risk of **water stress** in 2024, which is expected to increase by 13% in 2050. Riyadh is projected to face 87 days of extreme heat in 2050 (compared to 33 days in 2024) resulting in **heatwaves** being a high risk.

Projected temperature increase by 2050 (High-emissions scenario)

Saudi Arabia

We project that, by 2030, Saudi Arabia's current policies will result in the country overshooting its NDC by 18%, or 129 $MtCO_2e$.

We also estimate that Saudi Arabia will surpass its 1.5°C emissions budget by 2026.

NDC 2.0[168]

Conditionality	Unconditional
Covers all sectors	✔

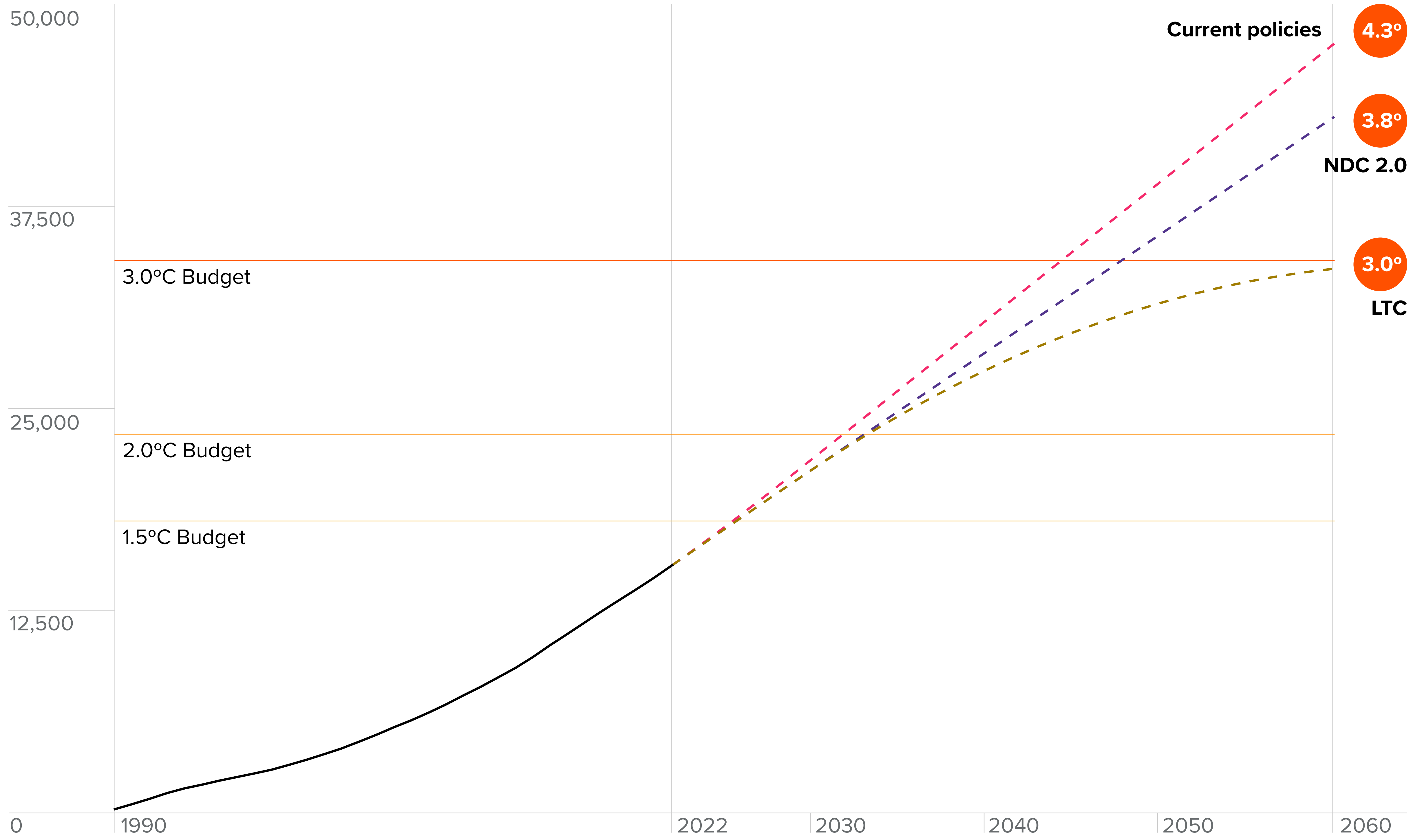
In 2021, Saudi Arabia updated its NDC, which aims 'at reducing and avoiding GHG emissions by 278 million tons of $MtCO_2eq$ annually by 2030' compared to 2019 levels. We calculate Saudi Arabia's 2030 target to be 728 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[169]

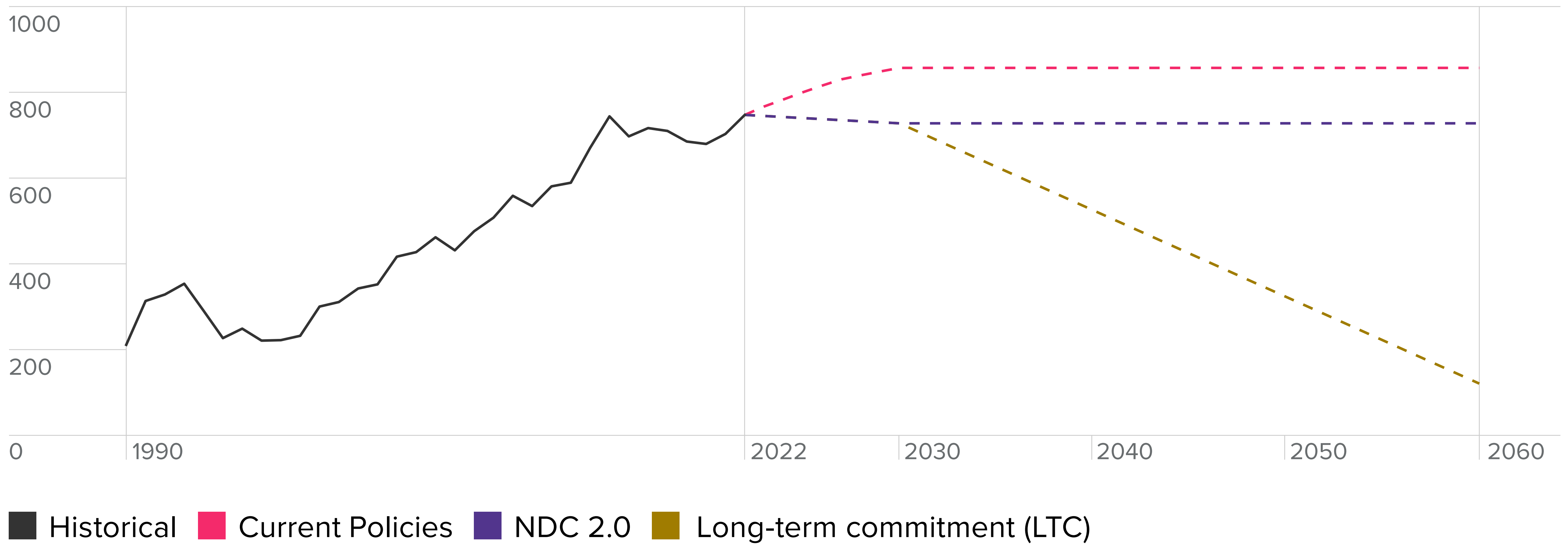
Covers all sectors	Unclear
Covers Kyoto gases[170]	Unclear

In 2021, Saudi Arabia announced that it would set 2060 as its net zero target year. However, Saudi Arabia has still not submitted a long-term strategy to the UNFCCC. In its net zero target, Saudi Arabia mentions Carbon Circular Economy to meet its target. Therefore, we assume the target is CO_2 only and calculate Saudi Arabia's 2060 target to be 121 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Saudi Arabia

Policies overview

✗ National adaptation plan	
Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

✗ Commited to fossil fuel subsidies phase out	
Annual amount spent on explicit fossil fuel subsidies[171]	13.8% of GDP

✗ Carbon pricing system

Climate finance	
3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Solar[172]	14.02	6th
Wind[173]	4.03	13th
Hydroelectric[174]	0	N/A
Geothermal[175]	0	N/A

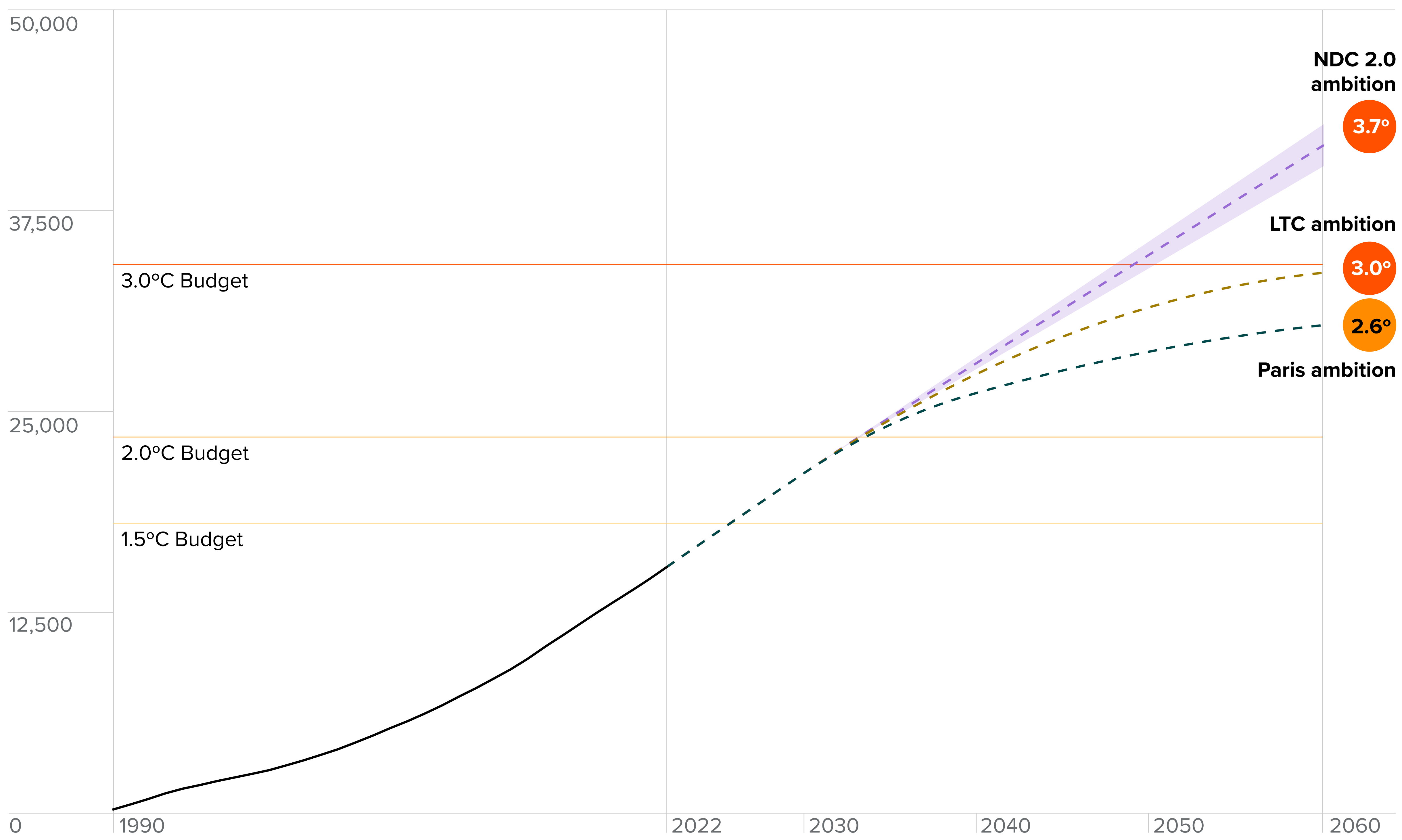
2035 targets

NDC 2.0 ambition: we estimate that, if Saudi Arabia were to set targets based on the same ambition as its current NDC 2.0, it would set a 620-730 $MtCO_2e$ target for 2035. The median of this range would keep Saudi Arabia on a greater than 3°C decarbonisation pathway.

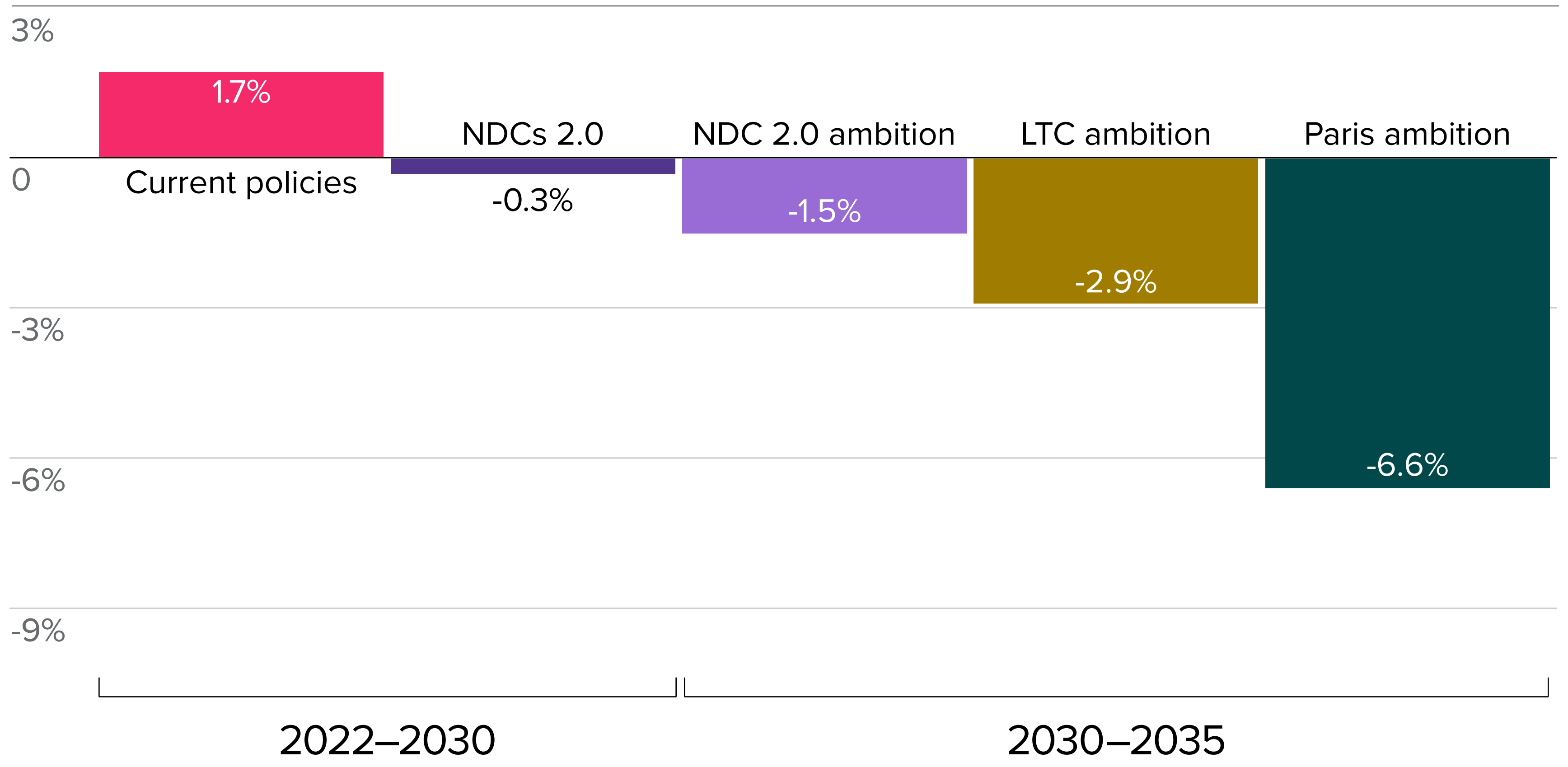
If Saudi Arabia sets a 2035 target that is less than 518 $MtCO_2e$ in 2035, then we project that it will still be on a greater than 2°C pathway but will have a good chance of achieving its 2060 long-term commitment.

Saudi Arabia will have to ramp up its efforts to decarbonise, going from +1.7% growth in emissions under current policies from 2024-2030 to 3% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 7% under **Paris ambition**.

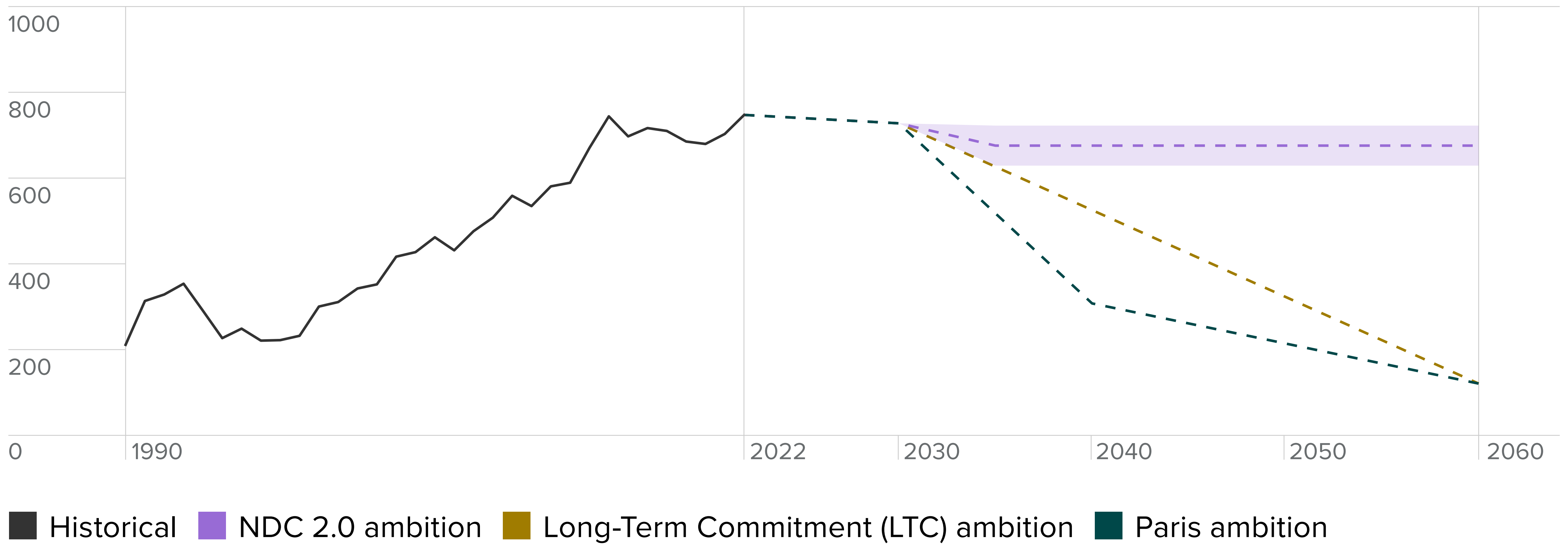
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



South Africa

Physical risk city insights

Cape Town

Urban population
4.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+66%
Water stress	Medium	Medium	High	+27%

Cape Town, positioned along the southwestern coast of South Africa, experiences significant seasonal variation in its climate. The city's prolonged dry periods and growing population are already putting pressure on its water resources. **Water stress** is a medium risk for Cape Town, which by 2050 is expected to become a high risk. Heatwaves are also projected to increase for the city, with 15 days of **extreme heat** in 2050 compared to 9 currently.

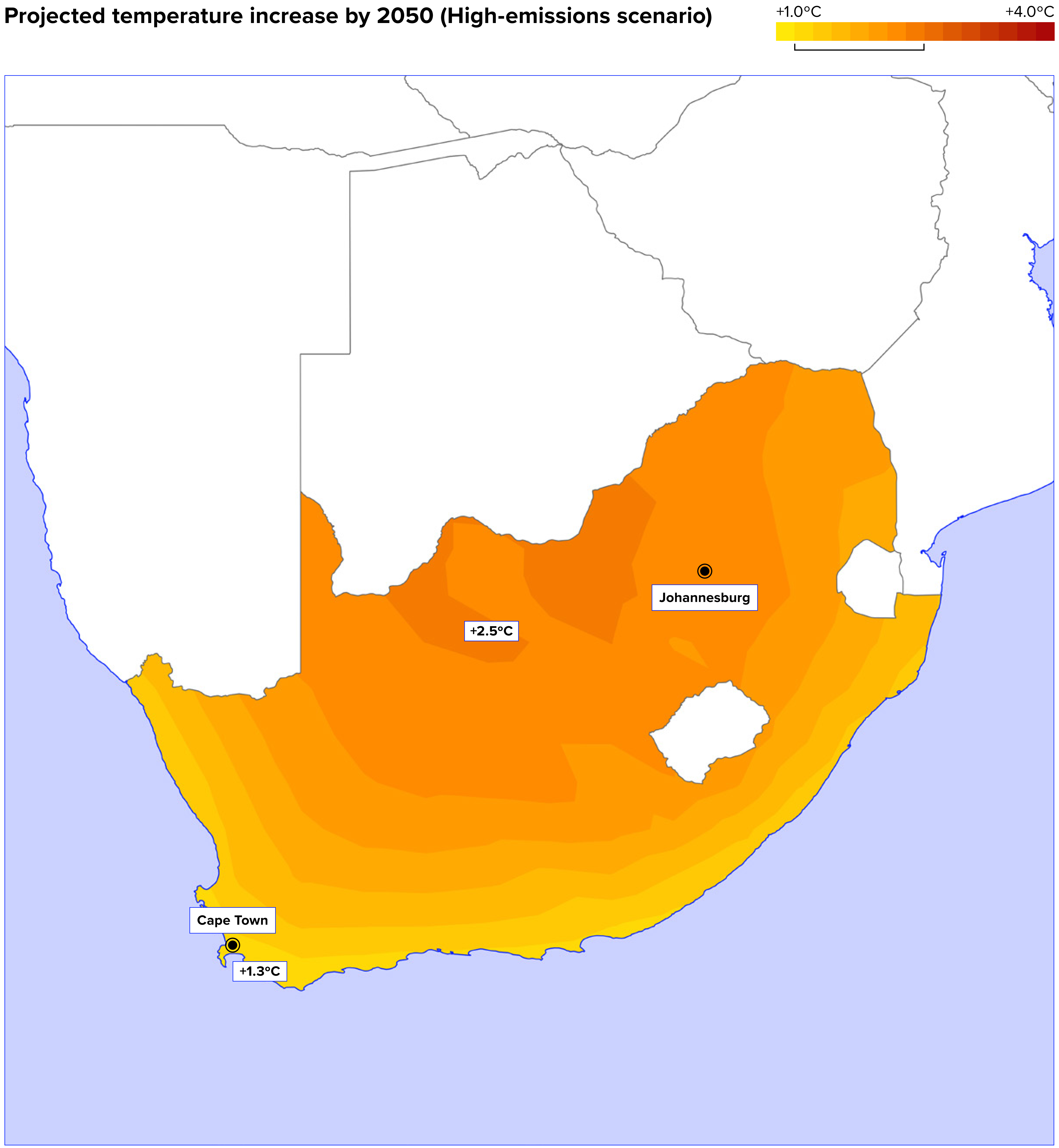
Johannesburg

Urban population
5.8 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Medium	+141%
Water stress	Low	Medium	Medium	+98%

Johannesburg, located on the Highveld plateau in South Africa, typically has warm summers and mild winters. The city faces limited water resources due to its inland location and seasonal rainfall. The projected 141% increase in **heatwaves** for Johannesburg would see days of extreme heat increasing from 12 to 30 per year by 2050. The city also faces an expected 90% increase in risk from **water stress**, going from a low to medium risk by 2035.

Projected temperature increase by 2050 (High-emissions scenario)



South Africa

We project that, by 2030, South Africa's current policies will result in the country overshooting its NDC by 26%, or 107 $MtCO_2e$.

We also estimate that South Africa will surpass its 1.5°C emissions budget by 2032.

NDC 2.0[176]

Conditionality	Unconditional
Covers all sectors	✓

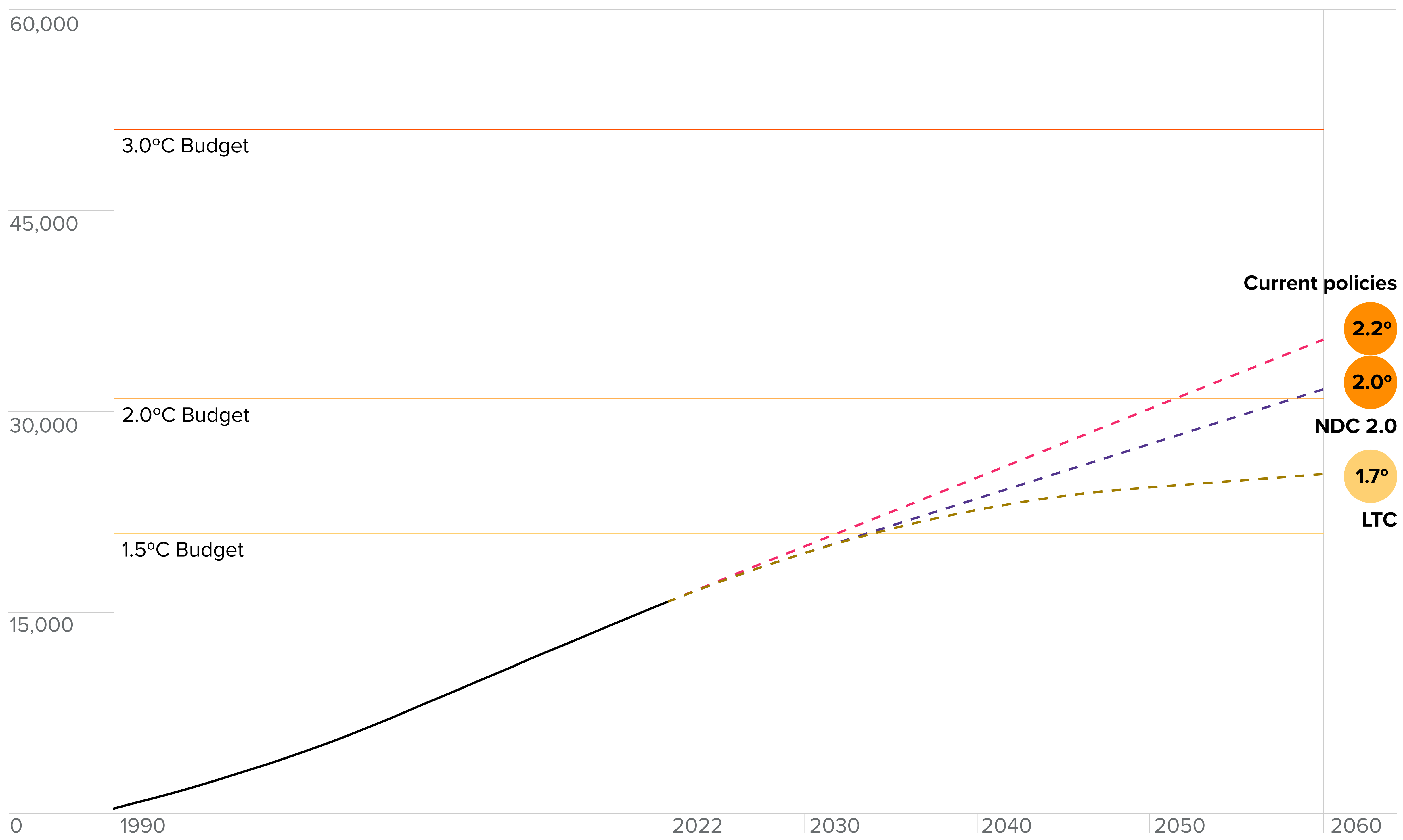
In 2021, South Africa updated its NDC with a pledge to reduce its GHG emissions to 350-420 $MtCO_2e$ in 2030. It is unclear which global warming potential values have been used. For our analysis, we assume South Africa's values are based on the Second Assessment Report (SAR) and take the middle of the range as the NDC target. Hence, we calculate the South Africa's 2030 target to be 408 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions)

Long-term commitment (LTC)[177]

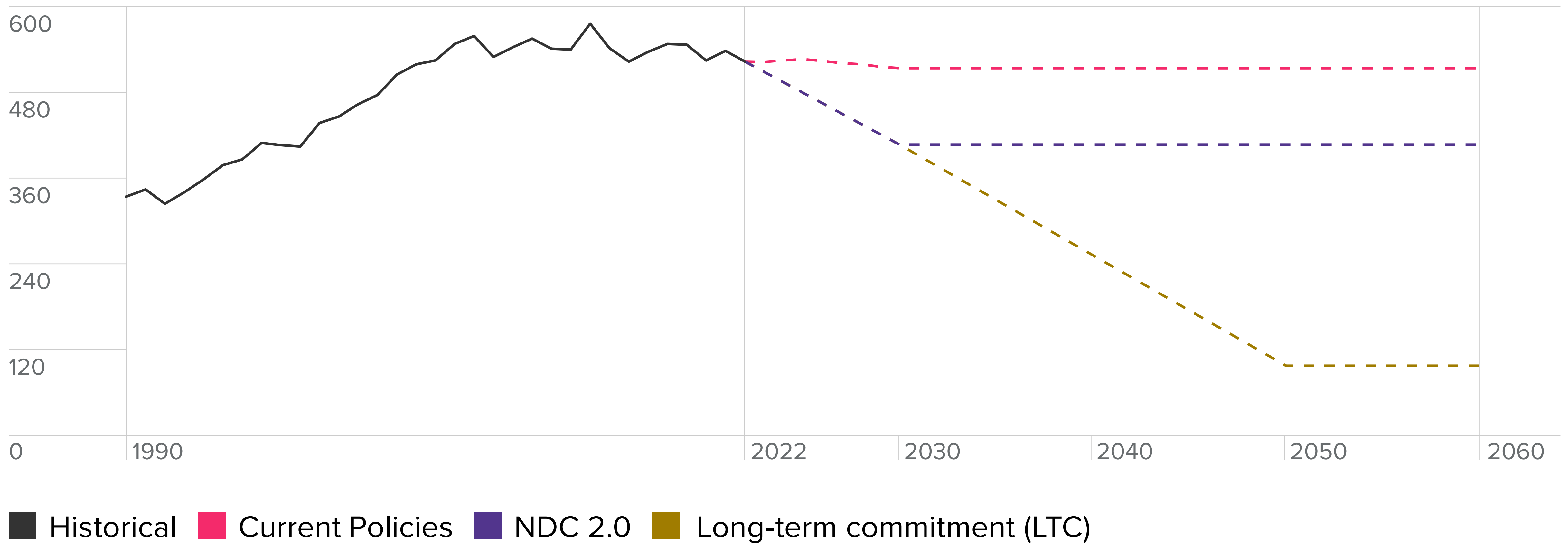
Covers all sectors[178]	✗
Covers Kyoto gases	✗

In its 2020 Low Emission Development Strategy, South Africa aims for 'net zero carbon emissions' by 2050. In our analysis, we take this to be a CO_2 only target, hence we calculate South Africa's long-term commitment to be 98 $MtCO_2e$ in 2060 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



South Africa

Policies overview

National adaptation plan[179]	✓
Regular published risk assessments	✗
Monitoring and evaluating report[180]	✓
Part of a sovereign catastrophe risk pool	✗

Commited to fossil fuel subsidies phase out	✗
Annual amount spent on explicit fossil fuel subsidies[181]	1.2% of GDP

Carbon pricing system[182]	✓
% of GHG emissions covered by carbon price	82%
Carbon price ($/t$CO_2$e)	10.09
Aligned with the global carbon price corridor[183]	✗

Climate finance	
3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Solar[184]	16.48	5th
Wind[185]	7.12	8th
Hydroelectric[186]	3.97	7th
Geothermal[187]	0	N/A

South Africa

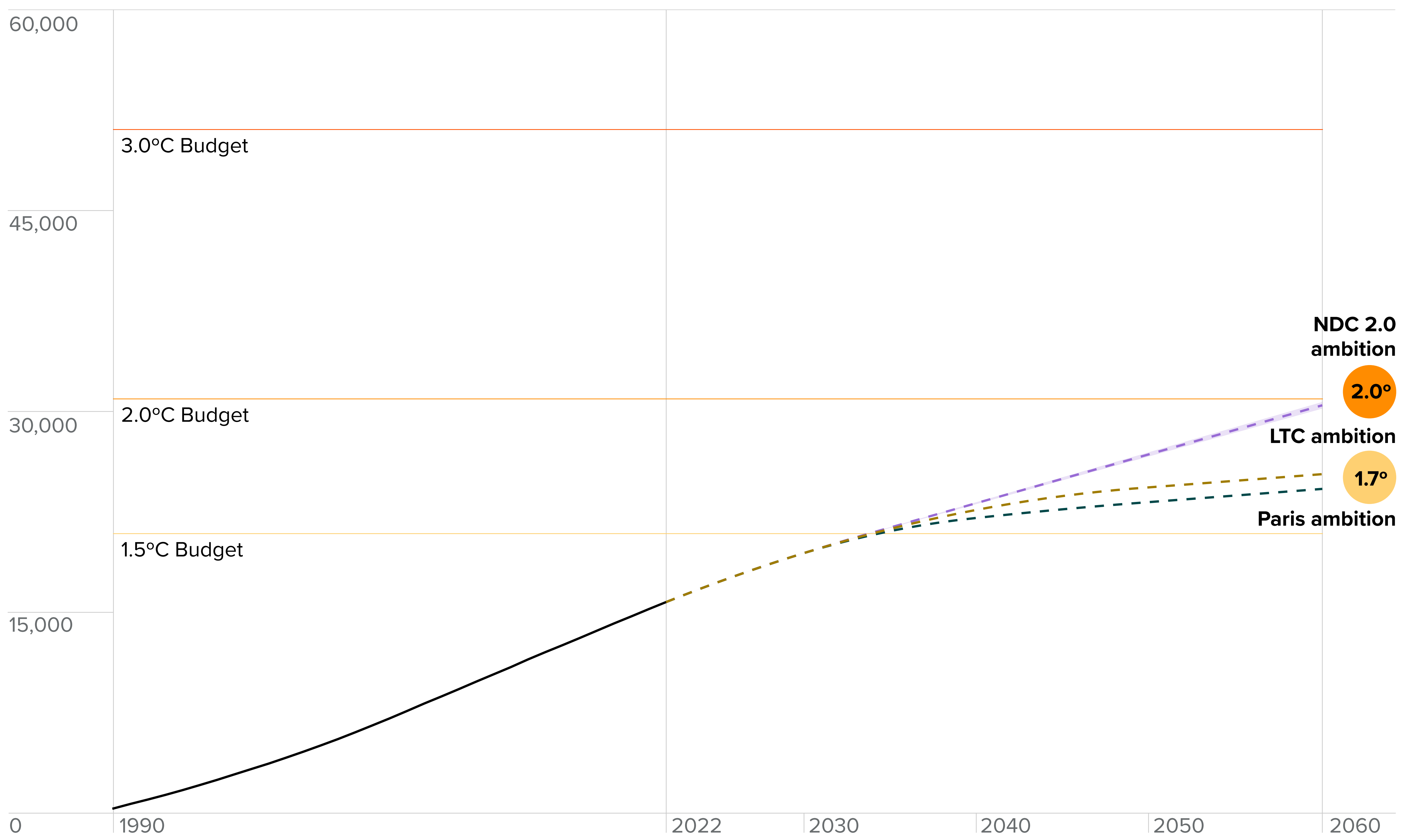
2035 targets

NDC 2.0 ambition: we estimate that, if South Africa were to set targets based on the same ambition as its current NDC 2.0, it would set a 350-380 $MtCO_2e$ target for 2035. The median of this range would keep South Africa on a 2°C decarbonisation pathway.

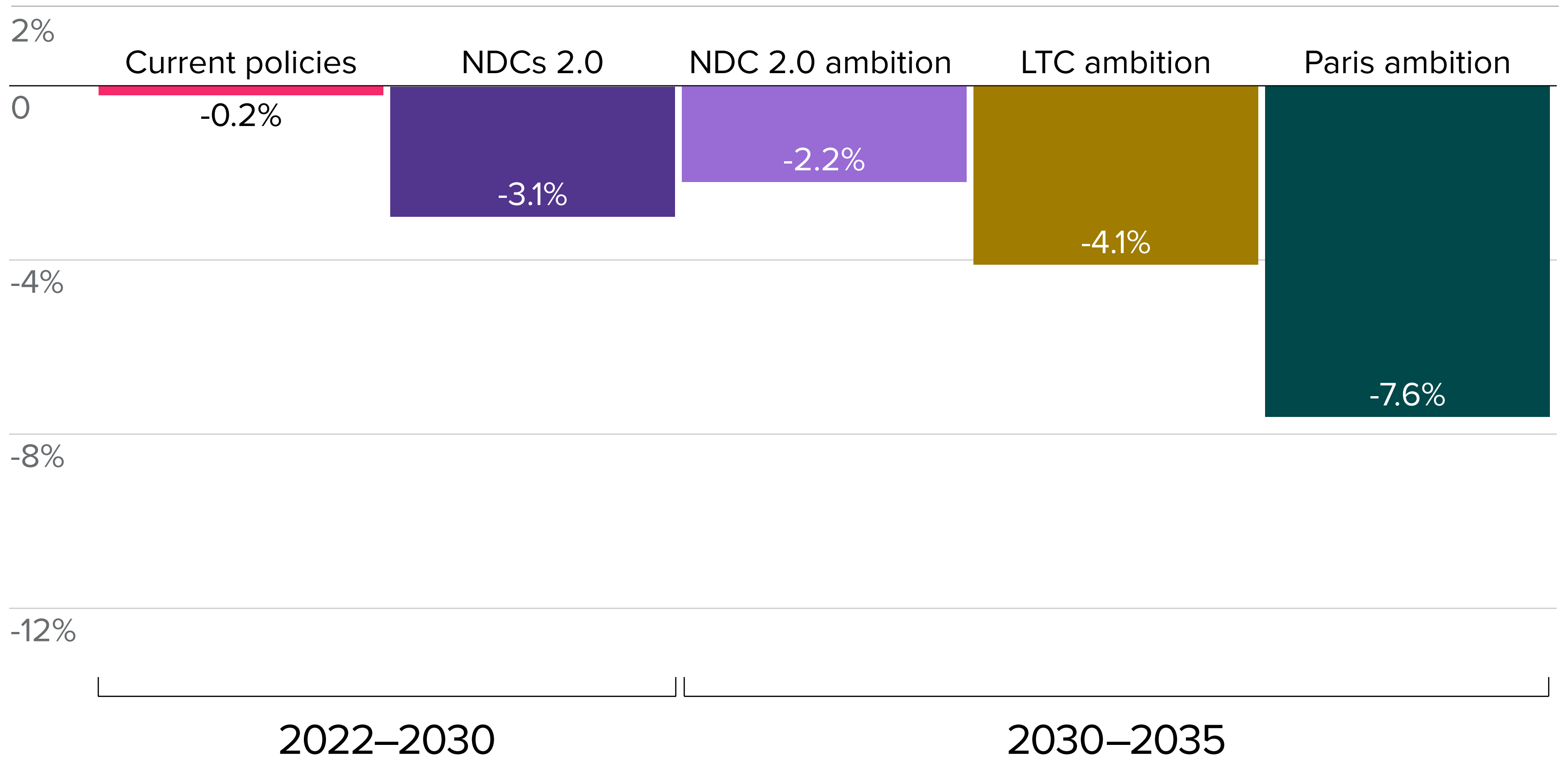
However, if South Africa sets a 2035 target that is less than 330 $MtCO_2e$ in 2035, then we project that it will be on a well below 2°C pathway and have a reasonable chance of achieving its 2050 net zero target.

South Africa will have to ramp up its annual rate of decarbonisation from 0.2% under current policies from 2024-2030 to 4% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 8% under **Paris ambition**.

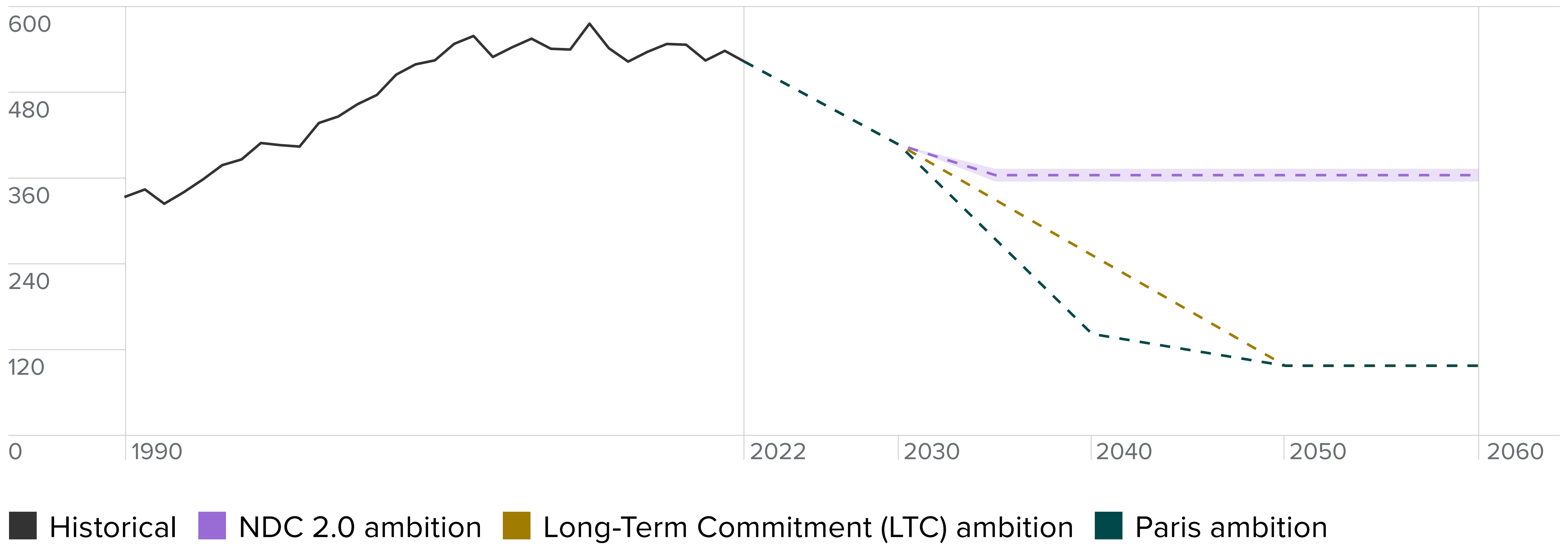
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



South Korea

Physical risk city insights

Busan

Urban population
3.4 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Sea level rise	Low	Low	Low	+253%
Cyclones	High	High	High	+51%
Heatwaves	Low	Low	Medium	+105%

Located on the southeastern coast of South Korea, Busan has a subtropical climate and faces hot humid summers. Busan already faces a high risk from **cyclones**, experiencing a category 1 cyclone an average of once every 13 years, which is anticipated to rise to once every 9 years by 2050. Days of **extreme heat** are also expected to rise from 18 to 36 days of extreme heat each year.

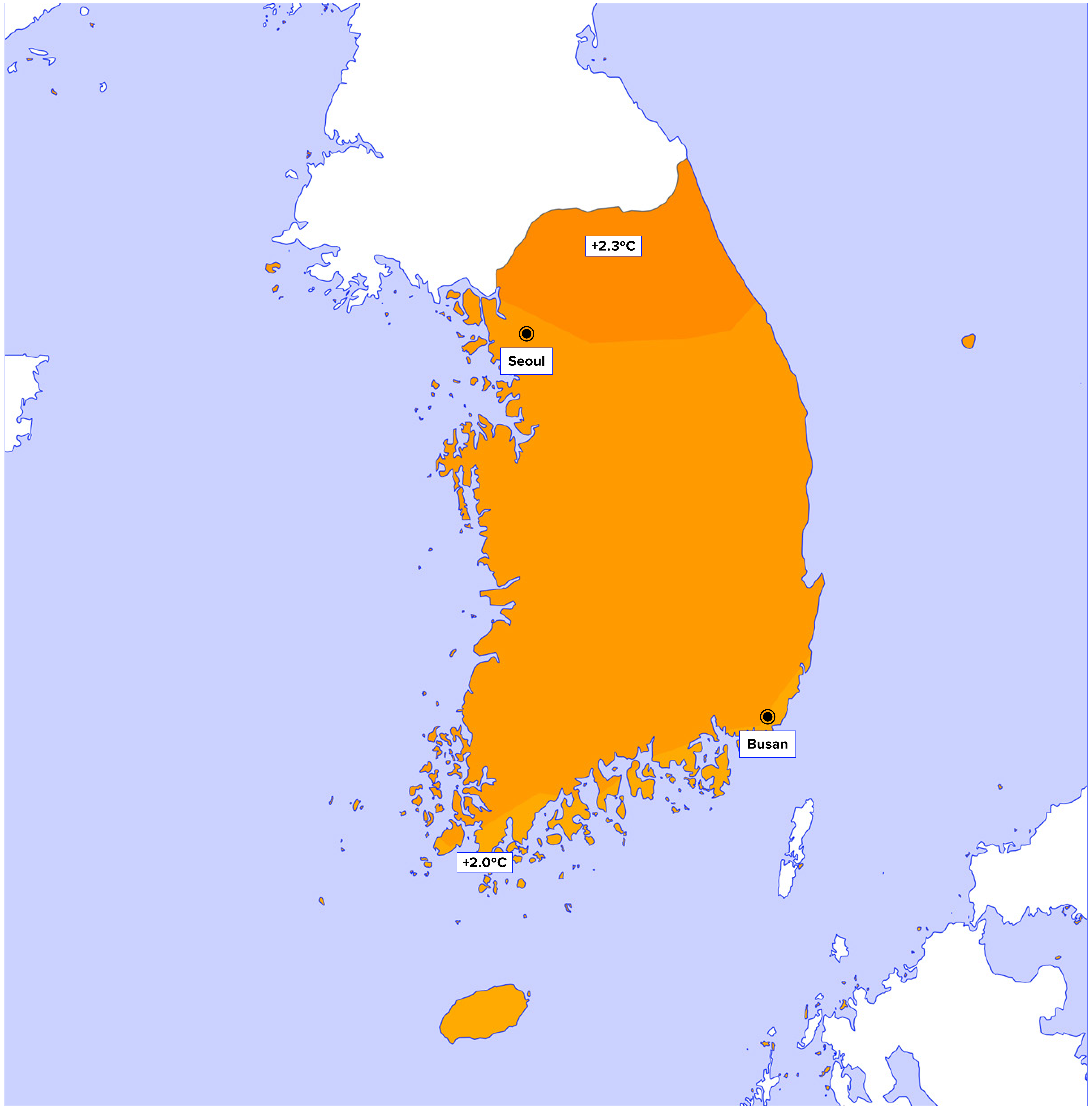
Seoul

Urban population
10 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Sea level rise	Low	Low	Low	+255%
Cyclones	Medium	Medium	High	+57%
Heatwaves	Low	Low	Medium	+133%

Situated near the northwest coast of South Korea, Seoul has a humid continental climate with dry winters and hot summers. **Cyclones** are expected to become a high risk for Seoul by 2050, experiencing at least a category 1 cyclone every 17 years in 2050, compared to once every 27 years today. **Heatwaves** are also expected see a 132% increase by 2050, with days of extreme heat growing from 16 to 37 annually.

Projected temperature increase by 2050 (High-emissions scenario)



South Korea

We project that by 2030, South Korea's current policies will result in the country overshooting its NDC by 27%, or 114 $MtCO_2e$.

We also estimate that South Korea will surpass its 1.5°C emissions budget by 2029.

NDC 2.0[188]

Conditionality	Unconditional
Covers all sectors	✓

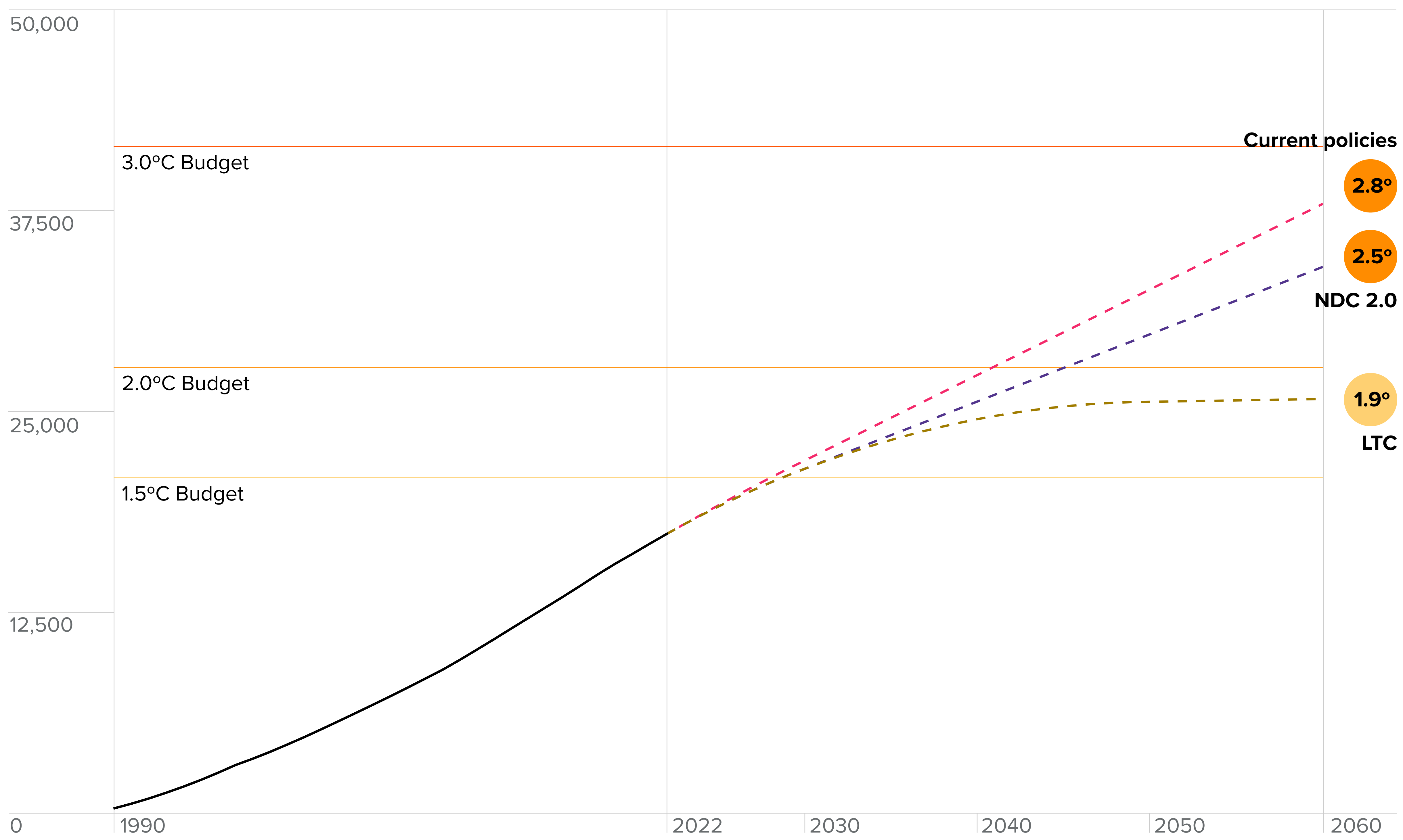
In 2021, South Korea updated its NDC with a pledged to reduce its GHG emissions by 40% below 2018 levels by 2030. We calculate the South Korea's 2030 target to be 420 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[189]

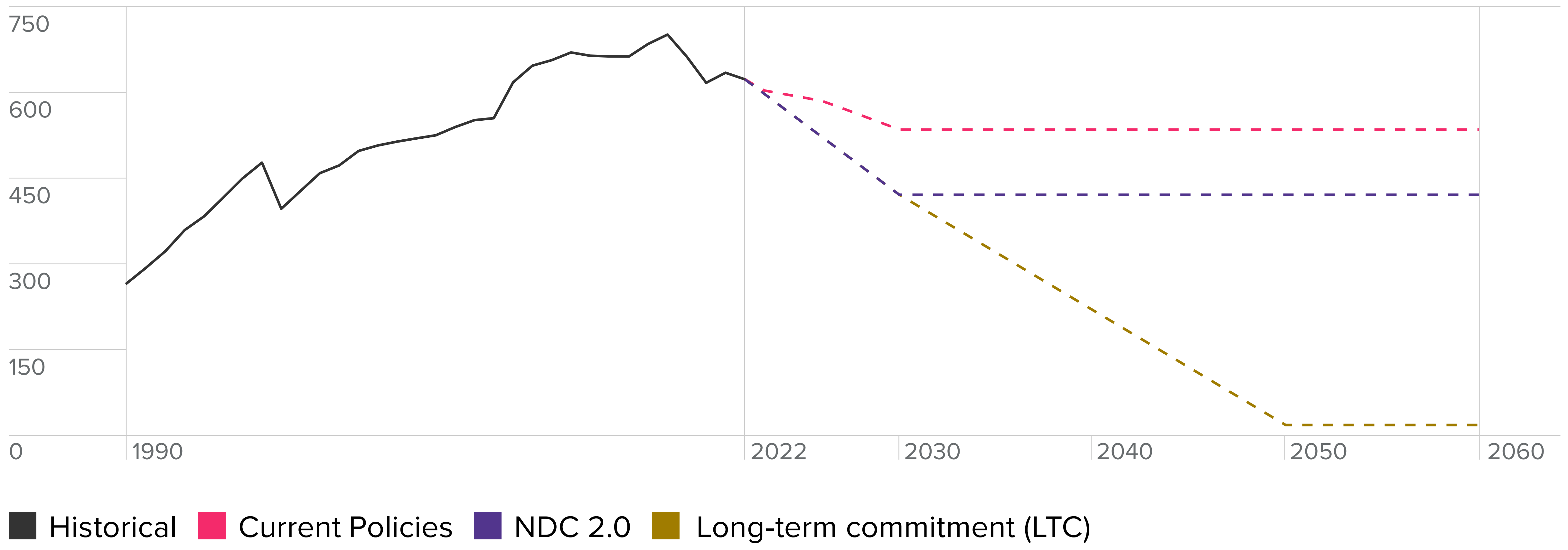
Covers all sectors	✗
Covers Kyoto gases[190]	✗

In its 2050 Carbon Neutrality Strategy, South Korea aims for carbon neutrality by 2050. In our analysis, we take this to be a CO2 only target, hence we calculate the South Korea's long-term commitment to be 18 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



South Korea

Policies overview

✓ National adaptation plan[191]

Regular published risk assessments[192]	✓
Monitoring and evaluating report[193]	✓
Part of a sovereign catastrophe risk pool	Exempt

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[194]	3.2% of GDP

✓ Carbon pricing system[195]

% of GHG emissions covered by carbon price	89%
Carbon price ($/t$CO_2$e)	6.30
Aligned with the global carbon price corridor[196]	✗

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[197]	40.11	3rd
Solar[198]	3.05	14th
Hydroelectric[199]	0	N/A
Geothermal[200]	0	N/A

South Korea

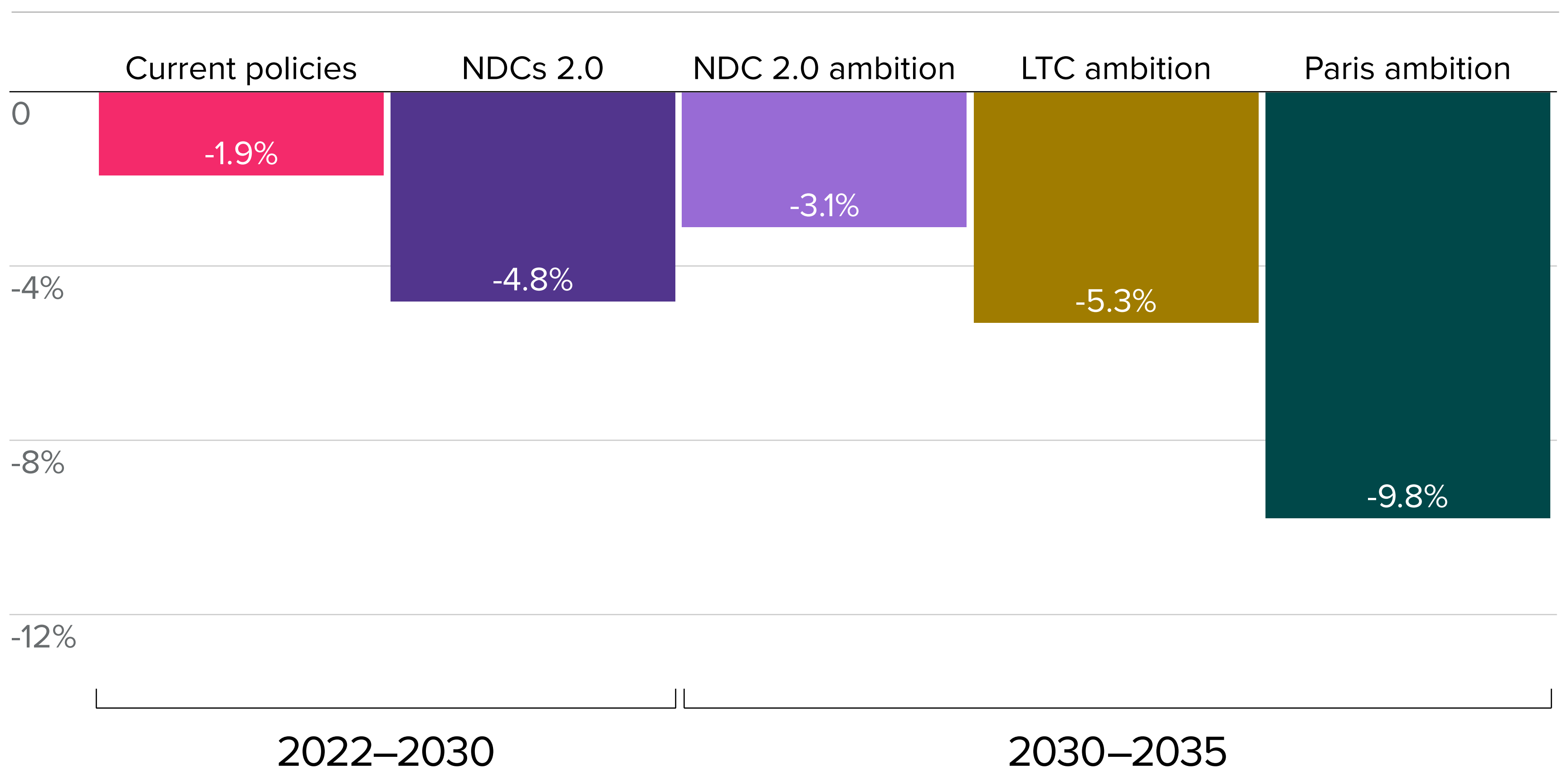
2035 targets

NDC 2.0 ambition: we estimate that, if South Korea were to set targets based on the same ambition as its current NDC 2.0, it would set a 350-370 $MtCO_2e$ target for 2035. The median of this range would keep South Korea on a greater than 2°C decarbonisation pathway.

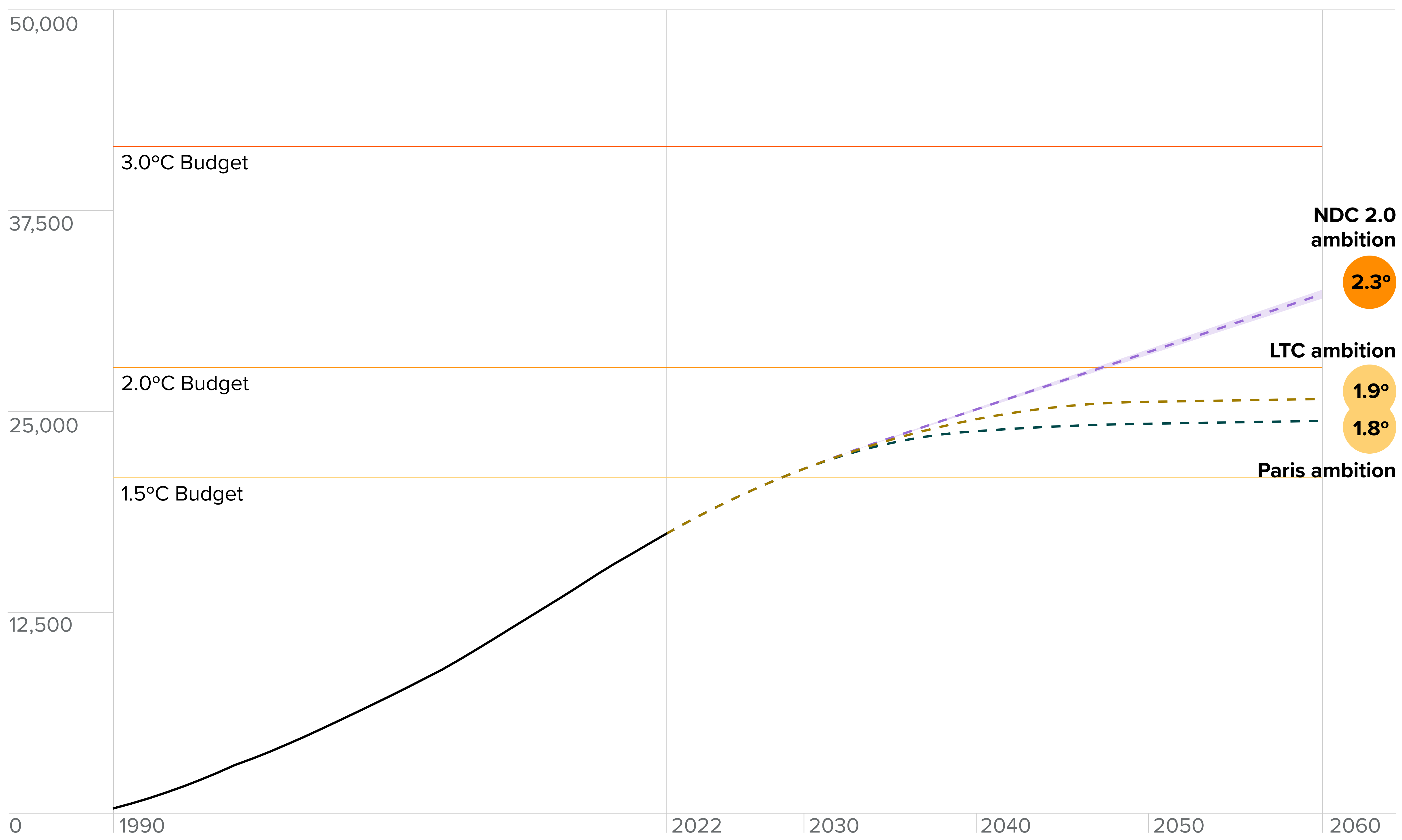
However, if South Korea sets a 2035 target that is less than 319 $MtCO_2e$ in 2035, then we project that it will be on a below 2°C pathway and have a reasonable chance of achieving its 2050 long-term commitment.

South Korea will have to substantially ramp up its annual rate of decarbonisation from 1.9% under current policies from 2024-2030 to 5% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 10% under **Paris ambition**.

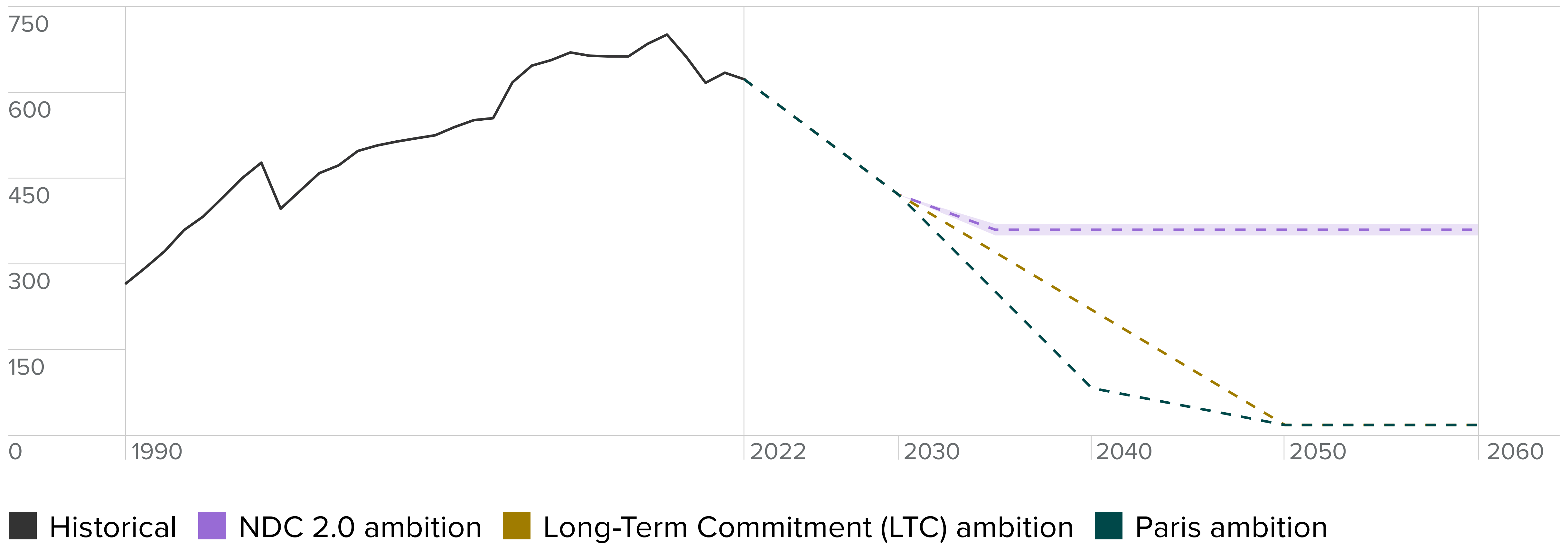
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Türkiye

Physical risk city insights

Ankara

Urban population
5.1 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	Low	Low	Low	-83%
Heatwaves	Low	Low	Medium	+104%
Water stress	Medium	Medium	High	+35%

Ankara, located in central Türkiye, has hot, dry summers and cold, snowy winters. The city faces medium **water stress** due to its inland location and limited water resources, which is projected to become high risk by 2050. **Heatwaves** are also a significant risk for the city, with days of extreme heat expected to increase from 16 to 32 days per year.

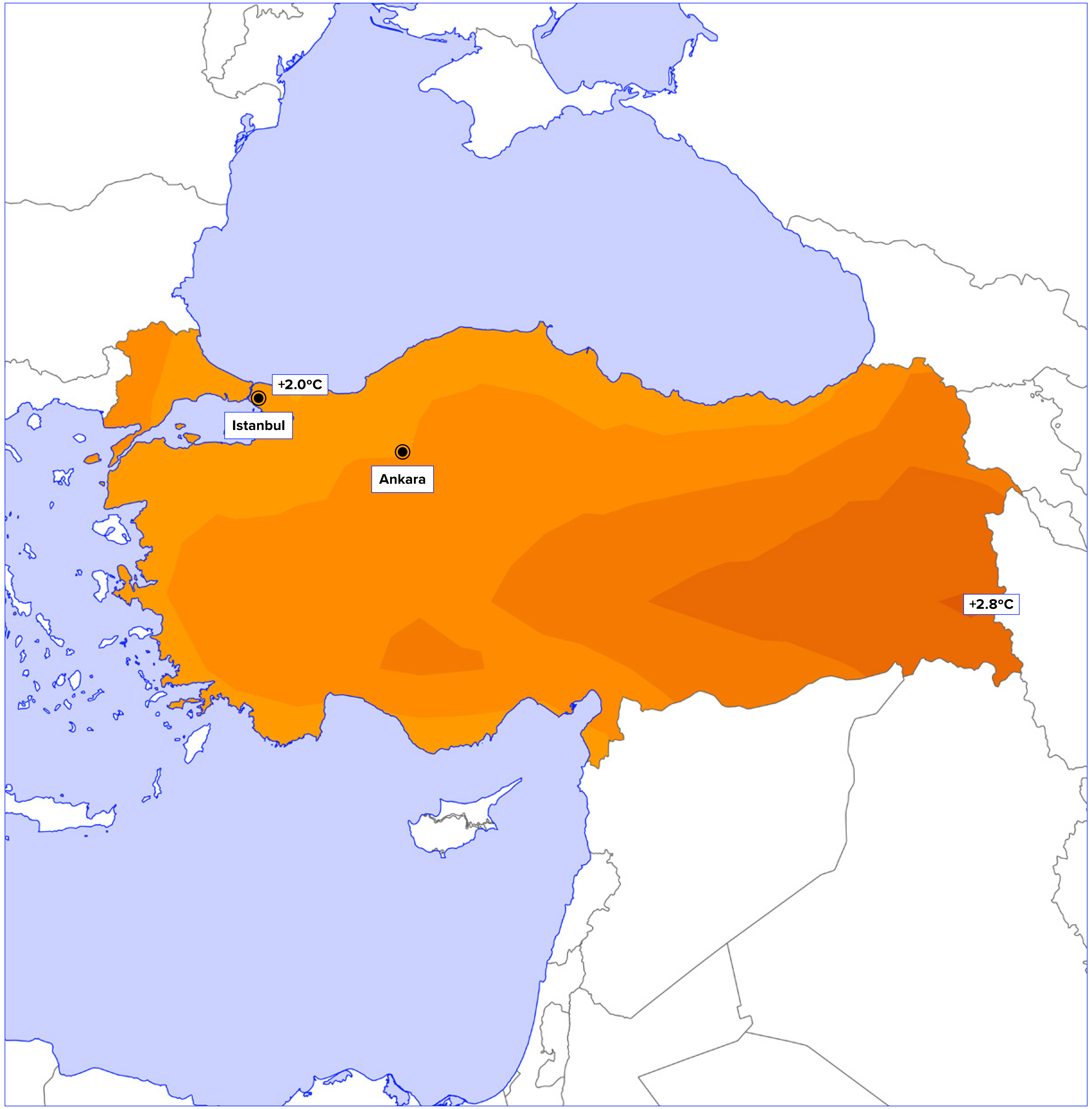
Istanbul

Urban population
15.2 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+102%
Water stress	Medium	Medium	High	+40%

Situated along the Bosphorus Strait, Istanbul experiences challenges from sea level rise and water stress. Like Ankara, Istanbul is expected to see an increase in **water stress** from medium in 2024 to high in 2050. **Heatwaves** are expected to double for the city, going from 15 days in 2024 to 30 in 2050, but remaining at a low risk.

Projected temperature increase by 2050 (High-emissions scenario)



Türkiye

We project that, by 2030, Türkiye's current policies will result in the country overshooting its NDC by 8%, or 47 $MtCO_2e$.

We also estimate that Türkiye will surpass its 1.5°C aligned emissions budget by 2033.

NDC 2.0[201]

Conditionality	Unconditional
Covers all sectors	✓

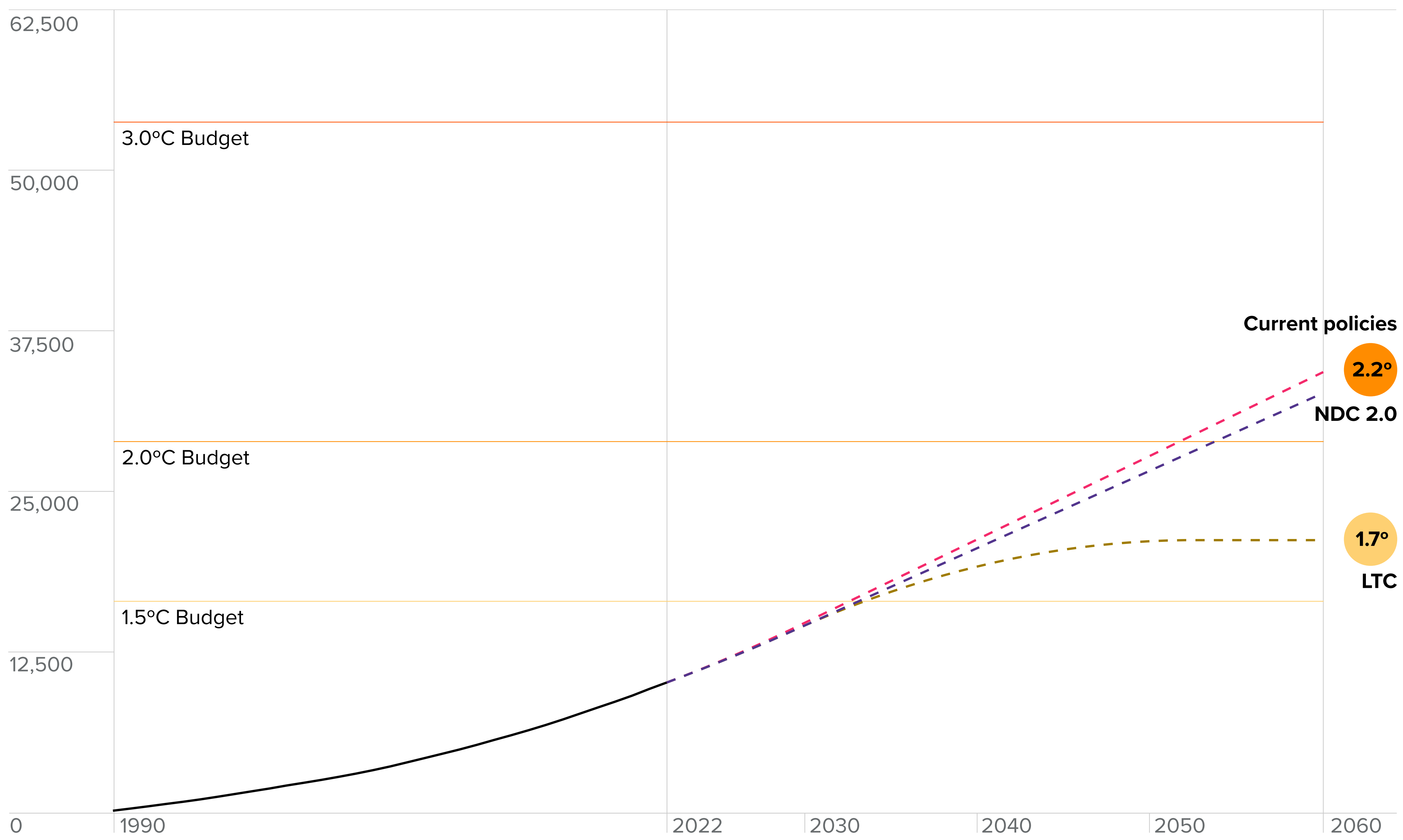
In 2023, Türkiye updated its NDC with a pledge to reduce its GHG emissions by 41% below business-as-usual levels by 2030. We calculate Türkiye's 2030 target to be 603 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[202]

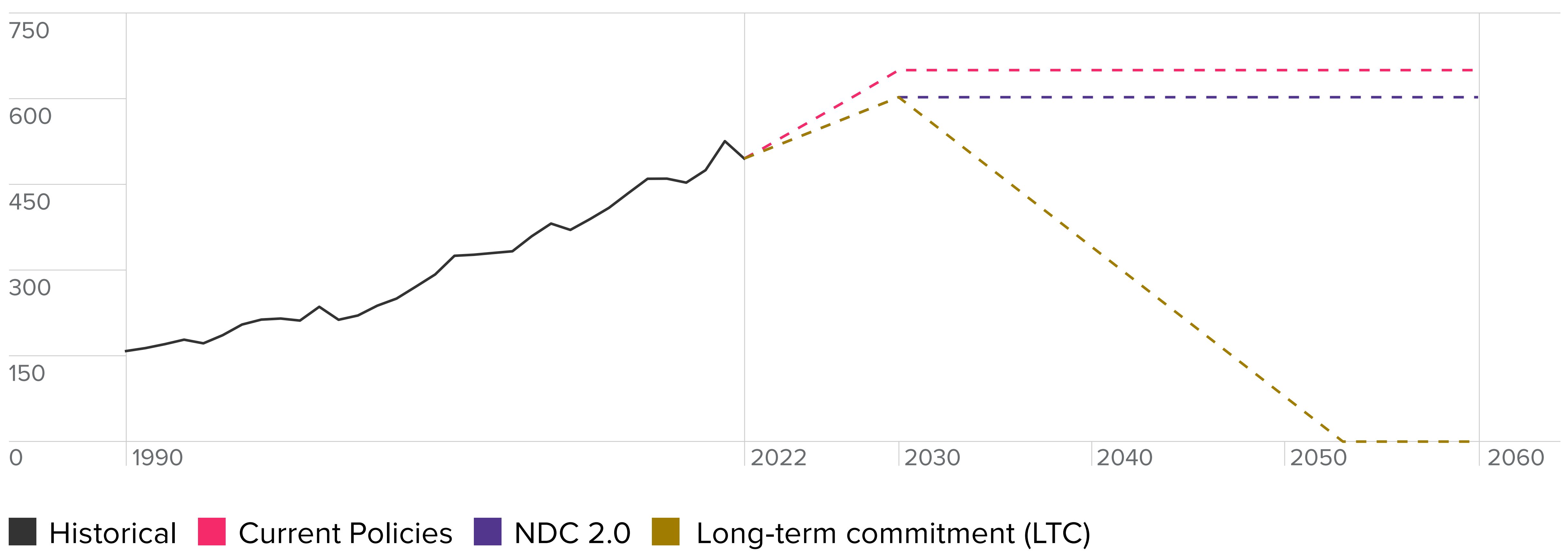
Covers all sectors[203]	Unclear
Covers Kyoto gases	Unclear

In 2021, Türkiye announced a net zero target for 2053, however, it is not clear which GHG are covered. Although Türkiye's Climate Council mentions methane and carbon dioxide, it does not provide quantified targets.[204] We have assumed this to mean 0 $MtCO_2e$ in 2053 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Türkiye

Policies overview

✓ National adaptation plan[205]

Regular published risk assessments	✗
Monitoring and evaluating report	✗
Part of a sovereign catastrophe risk pool	Exempt

Climate finance

3-year average climate finance contribution as a % of GDP	Exempt
Targeted level of international climate finance contribution as a % of GDP	Exempt

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[206]	5.9% of GDP

Energy opportunity
(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Solar[207]	3.15	12th
Wind[208]	3.10	17th
Hydroelectric[209]	2.92	8th
Geothermal[210]	0.38	2nd

✗ Carbon pricing system

Türkiye

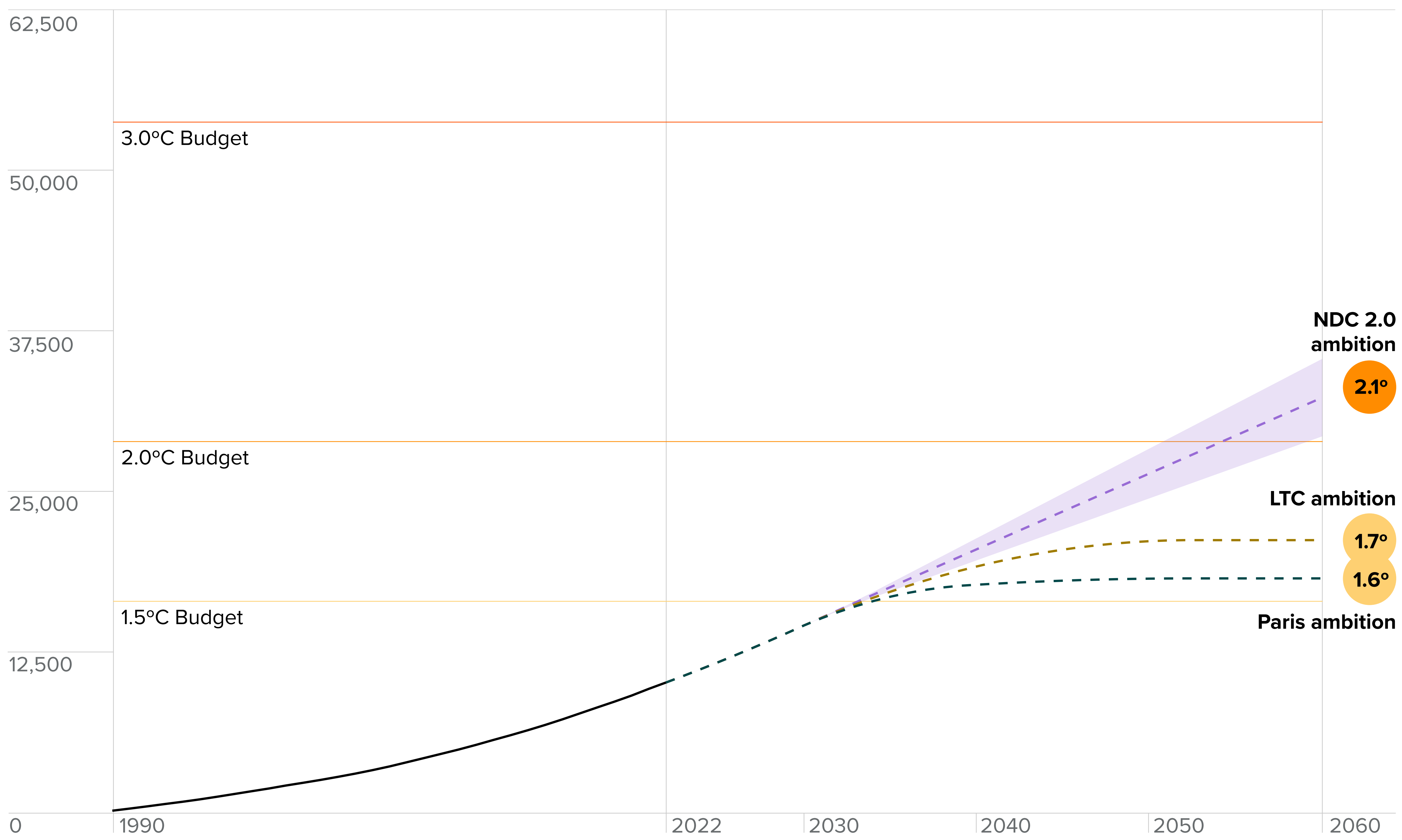
2035 targets

NDC 2.0 ambition: we estimate that, if Türkiye were to set targets based on the same ambition as its current NDC 2.0, it would set a 480-700 $MtCO_2e$ target for 2035. The median of this range would keep Türkiye on a greater than 2°C decarbonisation pathway.

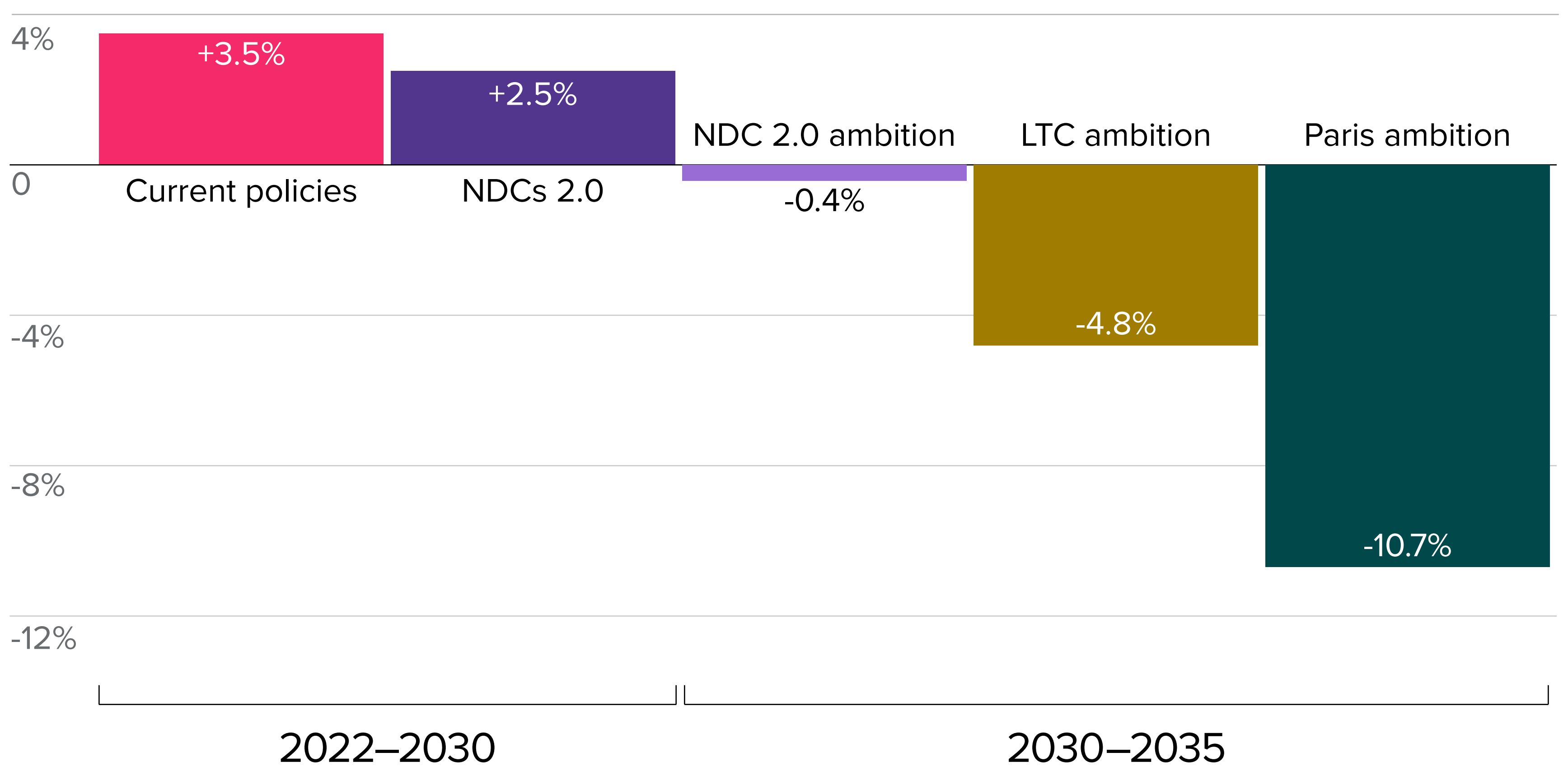
However, if Türkiye sets a 2035 target that is less than 472 $MtCO_2e$ in 2035, then we project that it will be on a well below 2°C pathway and have a reasonable chance of achieving its 2053 net zero target.

Türkiye will have to ramp up its efforts to decarbonise, going from +3.5% growth in emissions under current policies from 2024-2030 to 5% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 11% under **Paris ambition**.

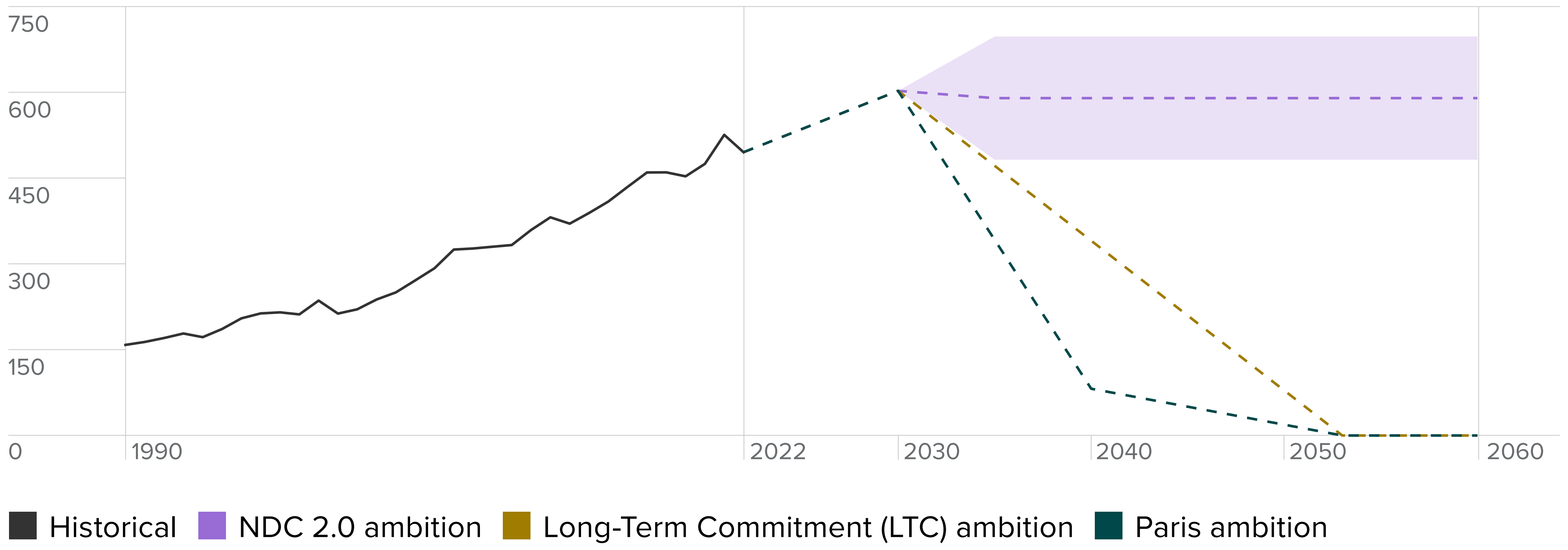
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



United Kingdom

Physical risk city insights

London

Urban population
9.3 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+133%
Water stress	Low	Medium	Medium	+22%

London, located in southeastern England along the River Thames, is considered low risk for major physical hazards. The city's temperate maritime climate contributes to its relatively stable environmental conditions. London is projected to be at a medium risk from **water stress** by 2050, with a 22% increase in risk. The city will also experience more than double the number of days of extreme heat in 2050, going from 11 days presently to 25 in 2050.

Manchester

Urban population
2.7 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Low	+93%
Water stress	Low	Low	Low	+45%

In northwestern England, Manchester benefits from a temperate oceanic climate that brings moderate temperatures throughout the year. Manchester has low physical risks under climate change. Even with a projected increase of 45% for **water stress**, and 93% for **heatwaves**, the city would still have low risk in 2050 for both.

Projected temperature increase by 2050 (High-emissions scenario)

United Kingdom

We project that, by 2030, the United Kingdom's current policies will result in the country overshooting its NDC by 44%, or 116 $MtCO_2e$.

We also estimate that the United Kingdom will surpass its 1.5°C emissions budget by 2036.

NDC 2.0[211]

Conditionality	Unconditional
Covers all sectors	✔

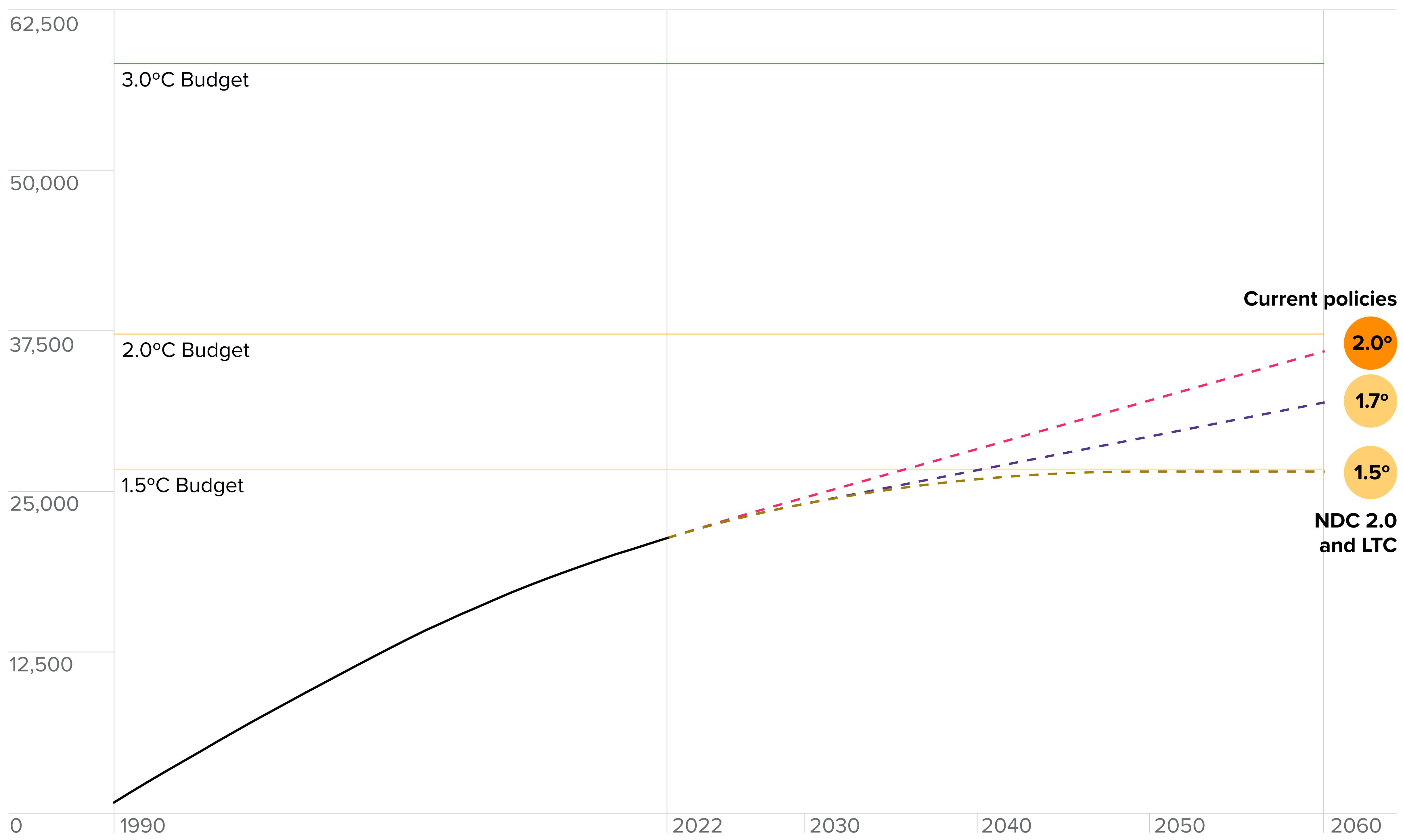
In 2021, the UK updated its NDC with a pledge to reduce its GHG emissions by 40% below 2018 levels by 2030. We calculate the UK's 2030 target to be 262 $MtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[212]

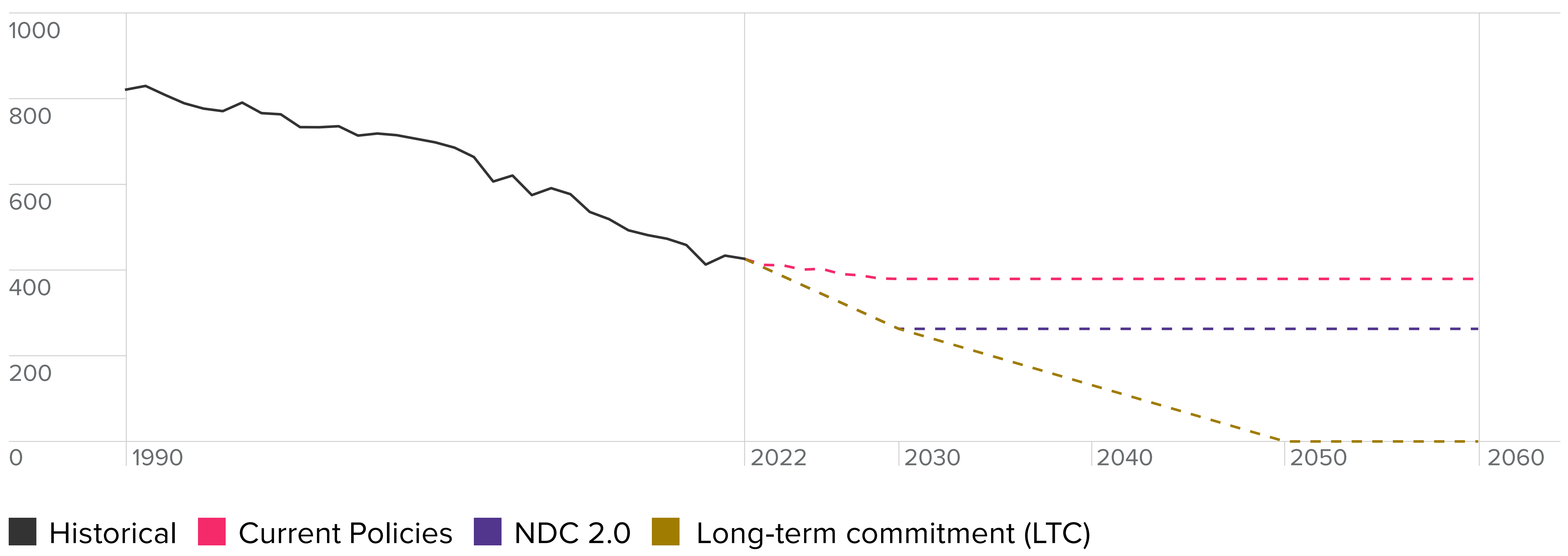
Covers all sectors[213]	✔
Covers Kyoto gases	✔

The UK submitted its net-zero strategy to the UNFCCC in 2021 with the target of achieving net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



United Kingdom

Policies overview

✓ National adaptation plan[214]

Regular published risk assessments[215]	✓
Monitoring and evaluating report[216]	✓
Part of a sovereign catastrophe risk pool	Exempt

✗ Commited to fossil fuel subsidies phase out

Annual amount spent on explicit fossil fuel subsidies[217]	0.6% of GDP

✓ Carbon pricing system

% of GHG emissions covered by carbon price	Tax	13%
	ETS	28%
Carbon price ($/t$CO_2$e)	Tax[218]	22.62
	ETS[219]	61.30
Aligned with the global carbon price corridor[220]	Tax	✗
	ETS	✓

Climate finance

3-year average climate finance contribution as a % of GDP[221]	0.01%
Proportional share of $100 billion global climate finance commitment[222]	✗
Targeted level of international climate finance contribution as a % of GDP[223]	0.08%
Target to increase global climate finance contributions	✓

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[224]	32.11	4th
Solar[225]	8.26	10th
Hydroelectric[226]	1.90	12th
Geothermal[227]	0.01	5th

United Kingdom

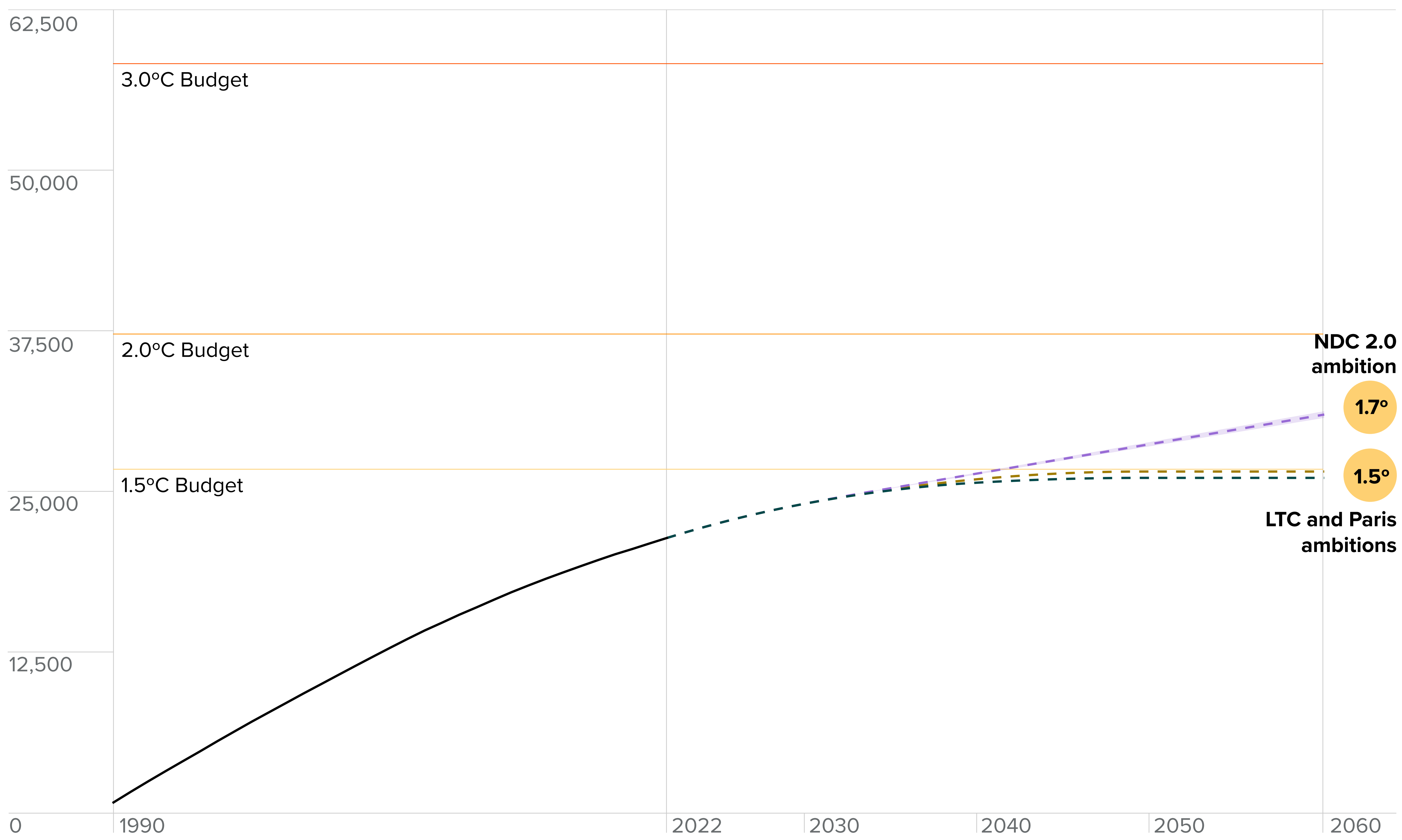
2035 targets

NDC 2.0 ambition: we estimate that, if the UK were to set targets based on the same ambition as its current NDC 2.0, it would set a 220-240 $MtCO_2e$ target for 2035. The median of this range would keep the UK on a well below 2°C decarbonisation pathway.

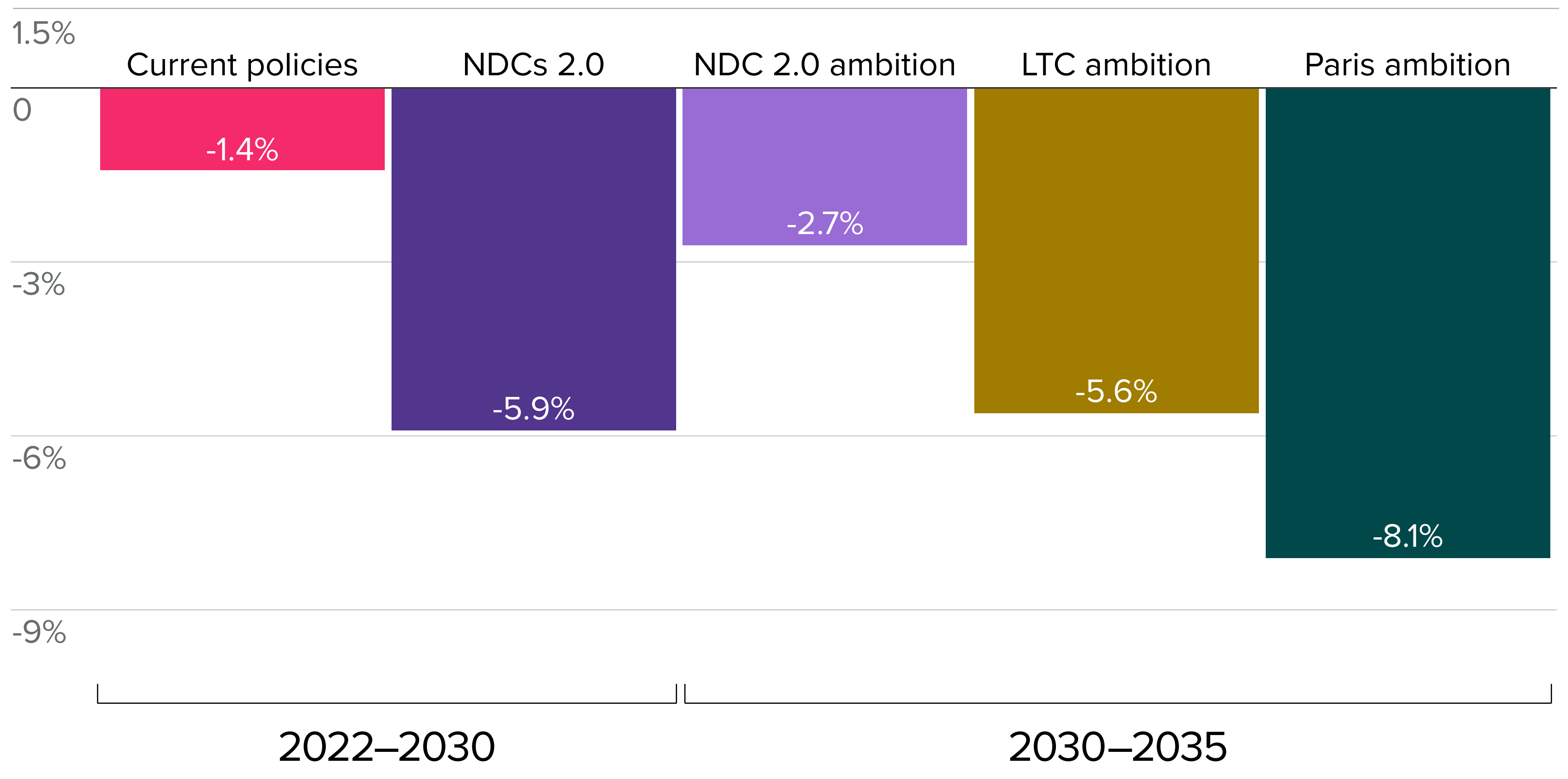
However, if the UK sets a 2035 target that is less than 197 $MtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a reasonable chance of achieving its 2050 net zero target.

The UK will have to substantially ramp up its annual rate of decarbonisation from 1.4% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 8% under **Paris ambition**.

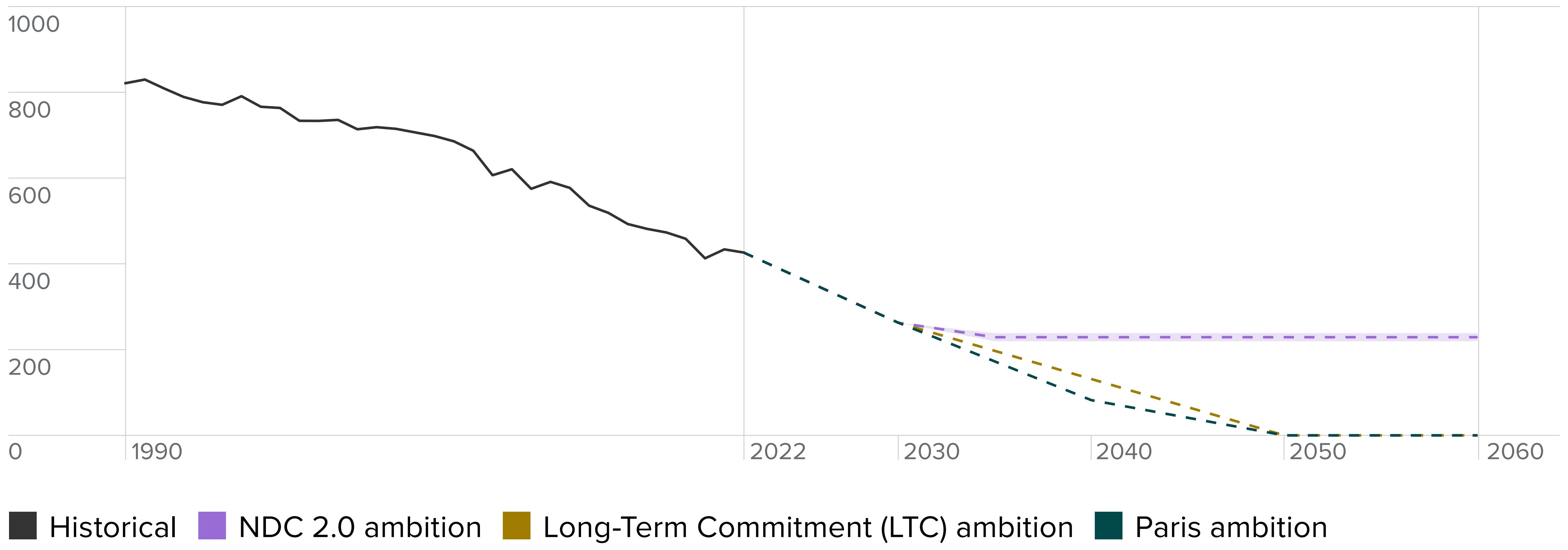
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



United States

Physical risk city insights

Los Angeles

Urban population
30 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Medium	+105%
Water stress	Medium	Medium	Medium	+9%

Situated along the Pacific coast, Los Angeles has long, dry summers and short, wet winters. The city currently faces challenges from periodic droughts which put it at a medium risk from **water stress**, but is not expected to increase significantly. In contrast, **heatwaves** are projected to become a medium risk for the city, with a 105% increase from 2024 levels. This would mean 34 days of extreme heat per year in 2050 on average.

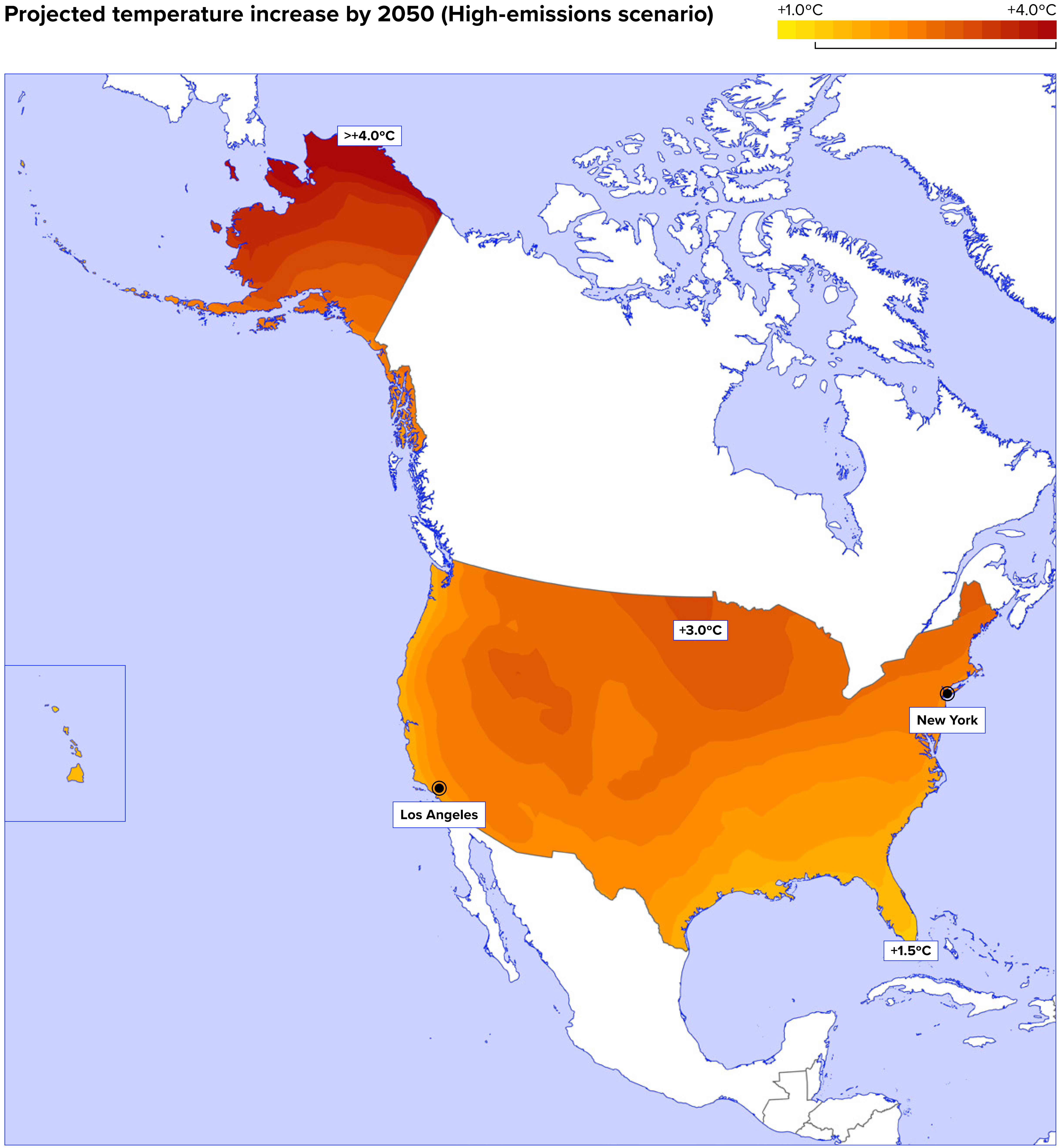
New York

Urban population
18.8 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Cyclones	High	High	High	+23%
Flooding	Medium	Medium	Medium	+21%
Heatwaves	Low	Low	Low	+89%
Water stress	Medium	Medium	Medium	+14%

New York City, located on the eastern coast of the United States, faces significant risks from flooding and sea level rise due to its extensive coastline. **Cyclones**, already a high risk for the city, are expected to increase 23%. This would be a change in frequency from one per 31 years to every 26 years on average. **Flooding** and **water stress** are both expected to remain medium risks, seeing a 21% and 14% increase respectively.

Projected temperature increase by 2050 (High-emissions scenario)



United States

We project that, by 2030, the United States' current policies will result in the country overshooting its NDC by 33%, or 1.06 $GtCO_2e$.

We also estimate that the US will surpass its 1.5°C emissions budget by 2028.

NDC 2.0[228]

Conditionality	Unconditional
Covers all sectors	✓

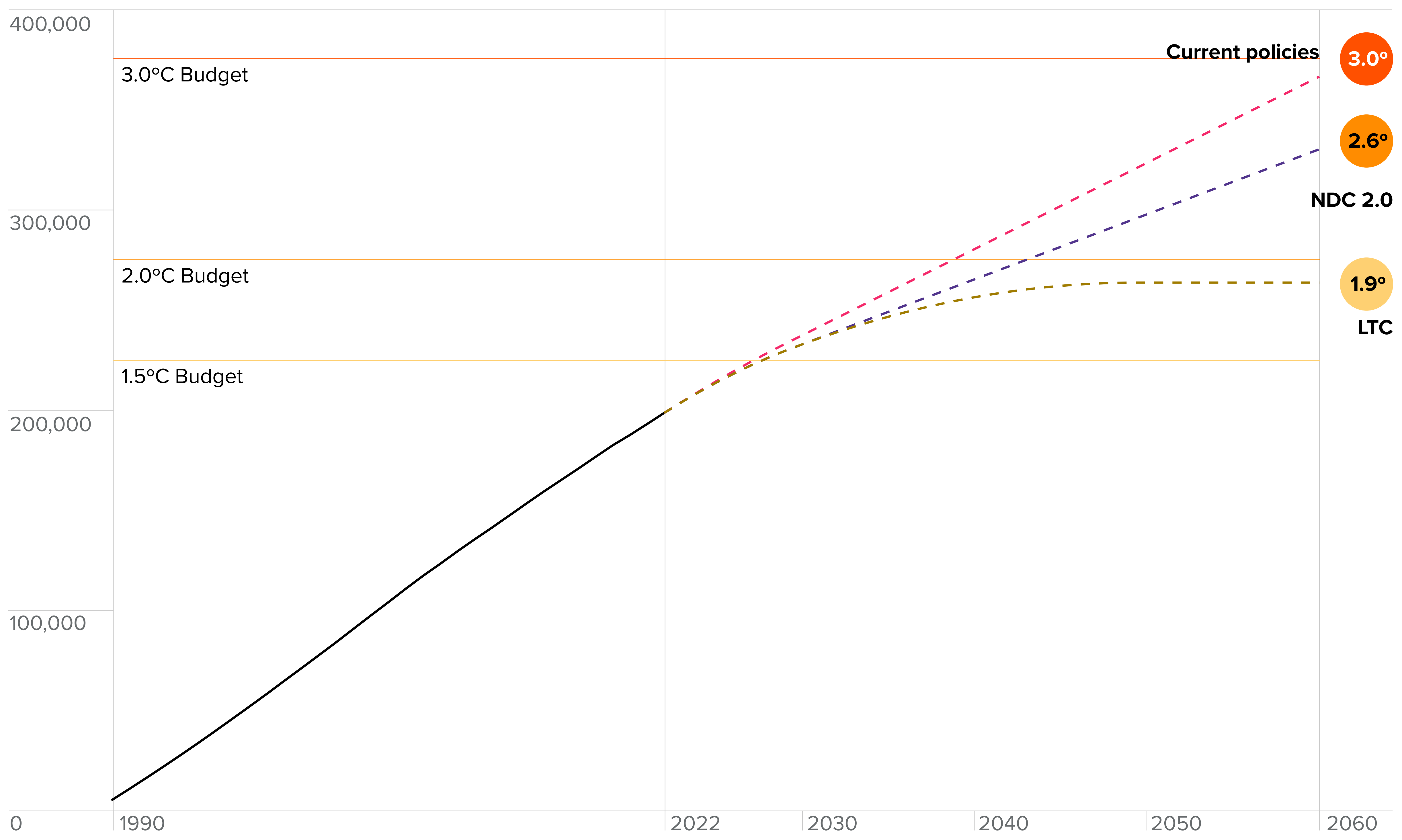
In 2021, the US submitted an updated NDC after re-joining the Paris Agreement. It has pledged to reduce its GHG emissions by 50-52% below 2005 levels by 2030. Taking the average of this target, we calculate the US' 2030 target to be 3.24 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions)

Long-term commitment (LTC)[229]

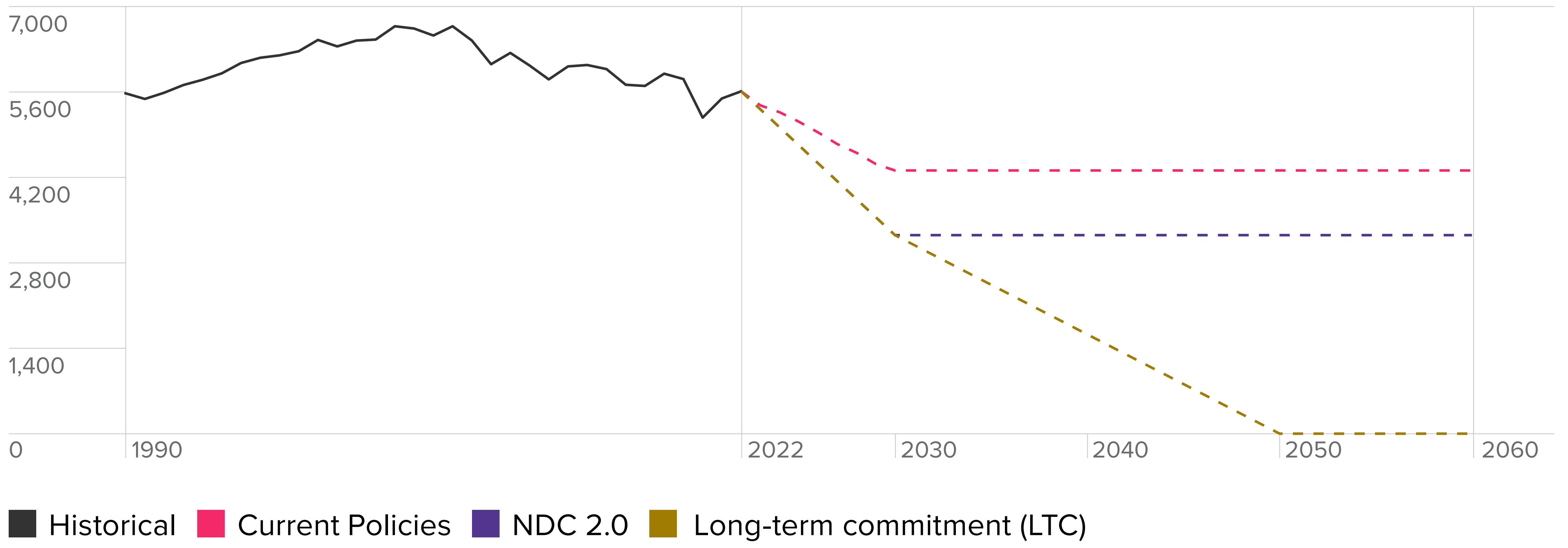
Covers all sectors[230]	✓
Covers Kyoto gases	✓

The US submitted its long-term strategy to the UNFCCC in 2021 with the target of achieving net zero GHG emissions by 2050. We have assumed this to mean 0 $MtCO_2e$ in 2050 (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



United States

Policies overview

✓ **National adaptation plan**[231]	
Regular published risk assessments[232]	✓
Monitoring and evaluating report[233]	✓
Part of a sovereign catastrophe risk pool	Exempt

✓ **Commited to fossil fuel subsidies phase out**[234]	2022
Annual amount spent on explicit fossil fuel subsidies[235]	0% of GDP

✗ **Carbon pricing system**

Climate finance

3-year average climate finance contribution as a % of GDP[236]	0.01%
Proportional share of $100 billion global climate finance commitment[237]	✗
Targeted level of international climate finance contribution as a % of GDP	0.04%
Target to increase global climate finance contributions[238]	✓

Energy opportunity
(Prospective energy capacity)

	MW/$bn GDP	G20 rank
Solar[239]	5.04	11th
Wind[240]	4.28	12th
Hydroelectric[241]	2.27	10th
Geothermal[242]	0.07	4th

United States

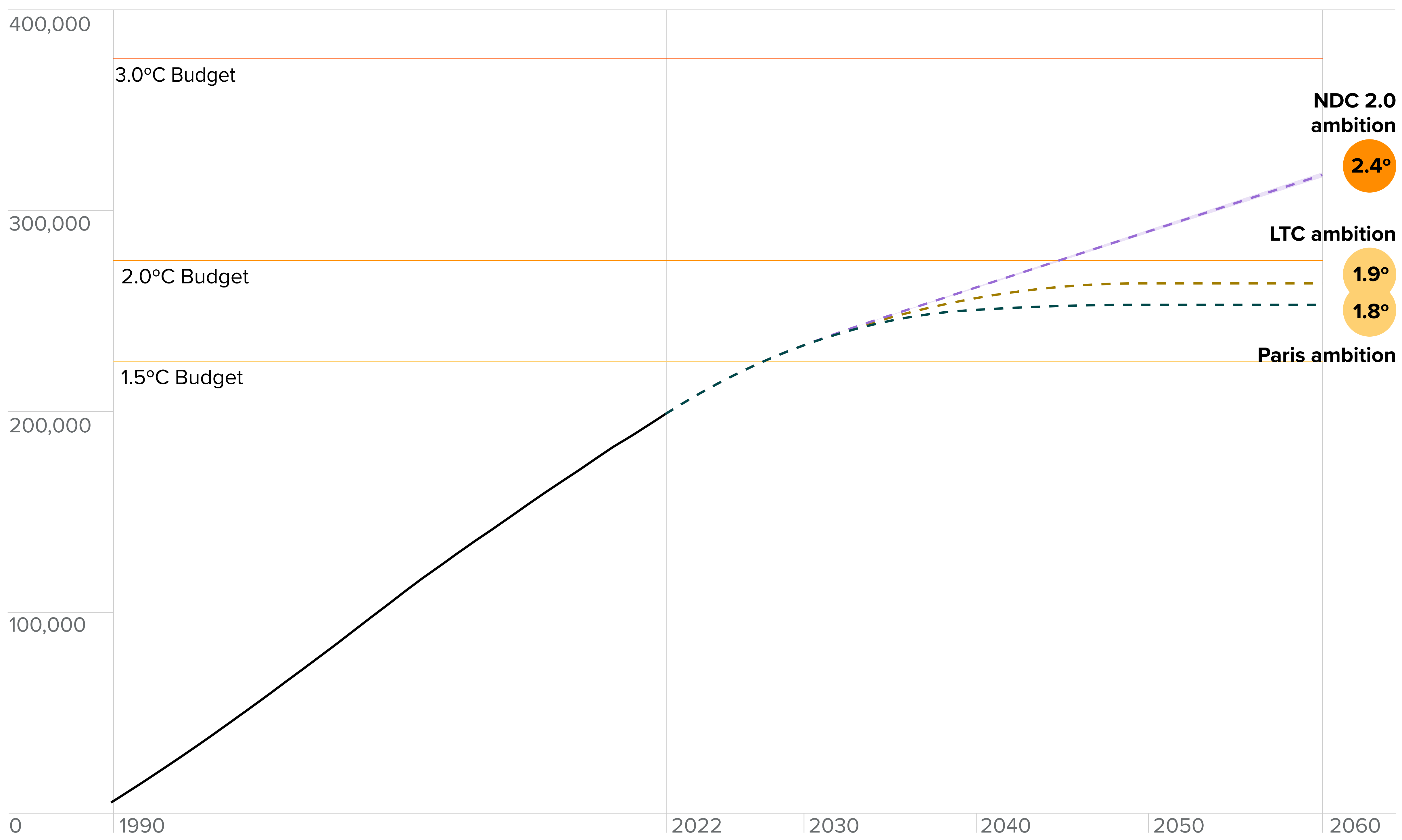
2035 targets

NDC 2.0 ambition: we estimate that, if the US were to set targets based on the same ambition as its current NDC 2.0, it would set a 2.75–2.85 $GtCO_2e$ target for 2035. The median of this range would keep the US on a greater than 2°C decarbonisation pathway.

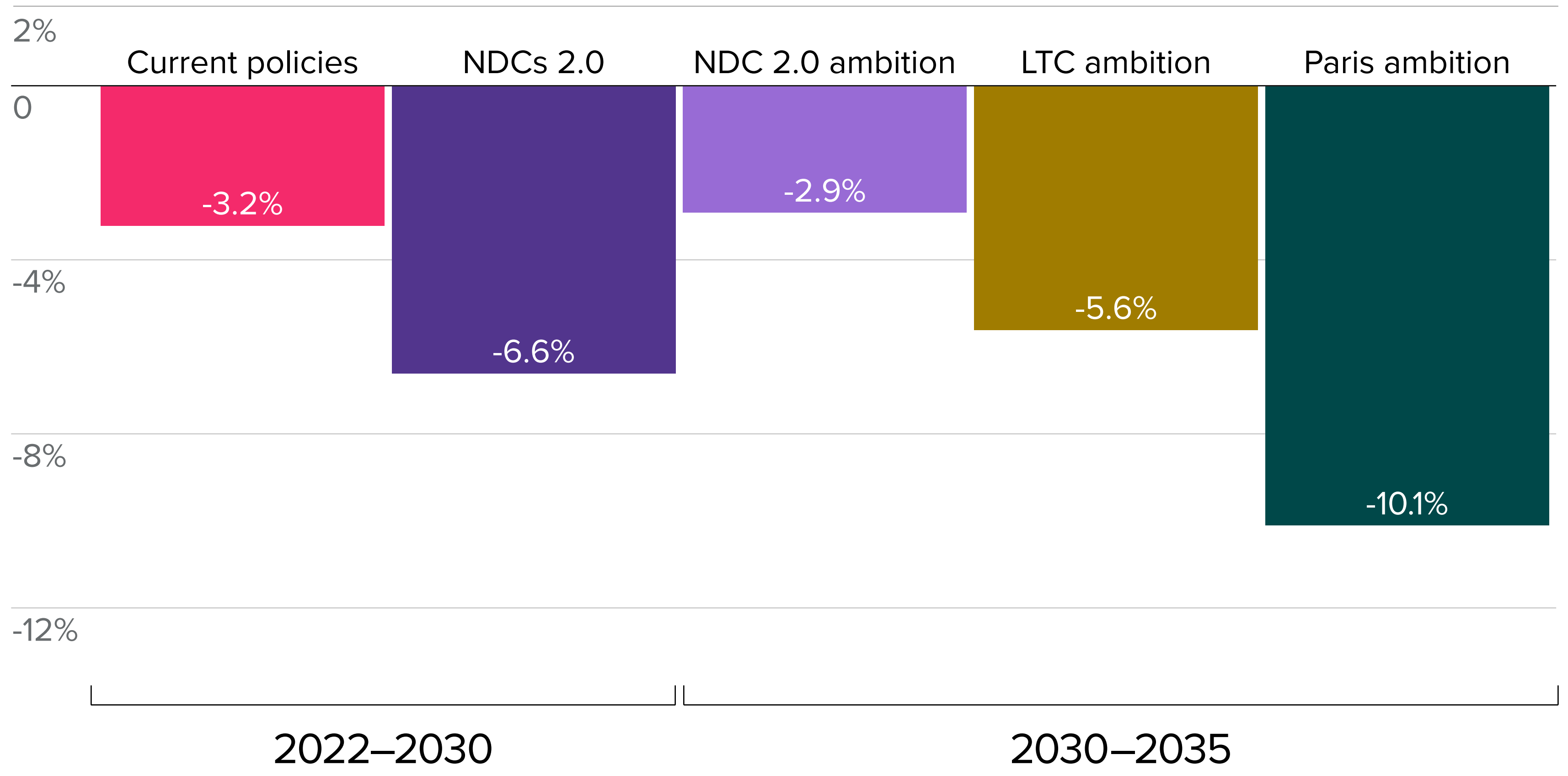
However, if the US sets a 2035 target that is less than 2.434 $GtCO_2e$ in 2035, then we project that it will be on a below 2°C pathway and have a reasonable chance of achieving its 2050 net zero target.

The US will have to ramp up its annual rate of decarbonisation from 3.2% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 10% under **Paris ambition**.

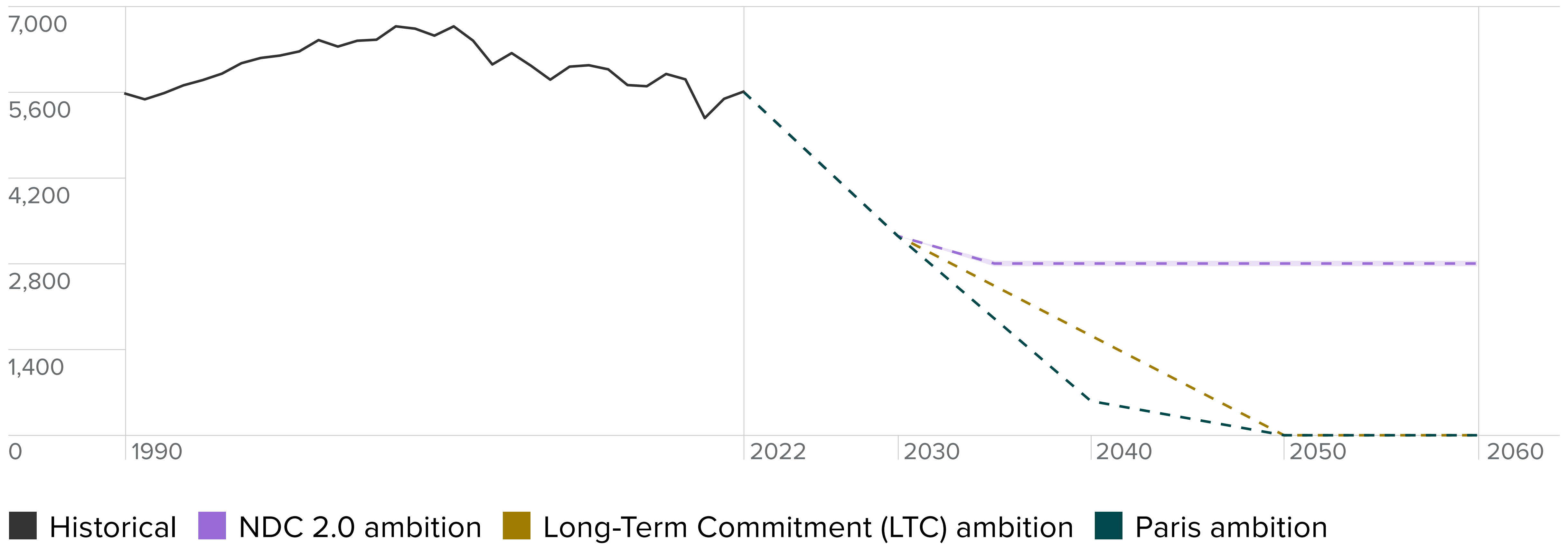
Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Projected annual decarbonisation rates



Historical and projected annual GHG emissions ($MtCO_2e$)



European Union

Physical risk city insights

Amsterdam

Urban population
1.1 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Flooding	High	High	High	+60%
Heatwaves	Low	Low	Low	+93%
Water stress	Low	Low	Low	+89%

Amsterdam, located in the Netherlands, faces risks from sea level rise and flooding due to its low-lying position. The city's temperate maritime climate brings mild winters and cool summers, with frequent rainfall. Amsterdam's primary risk from climate change is **flooding**, which the city has been well adapted to manage this risk. **Heatwaves** and water **stress** are expected to almost double, but remain low risk due to their low baseline levels.

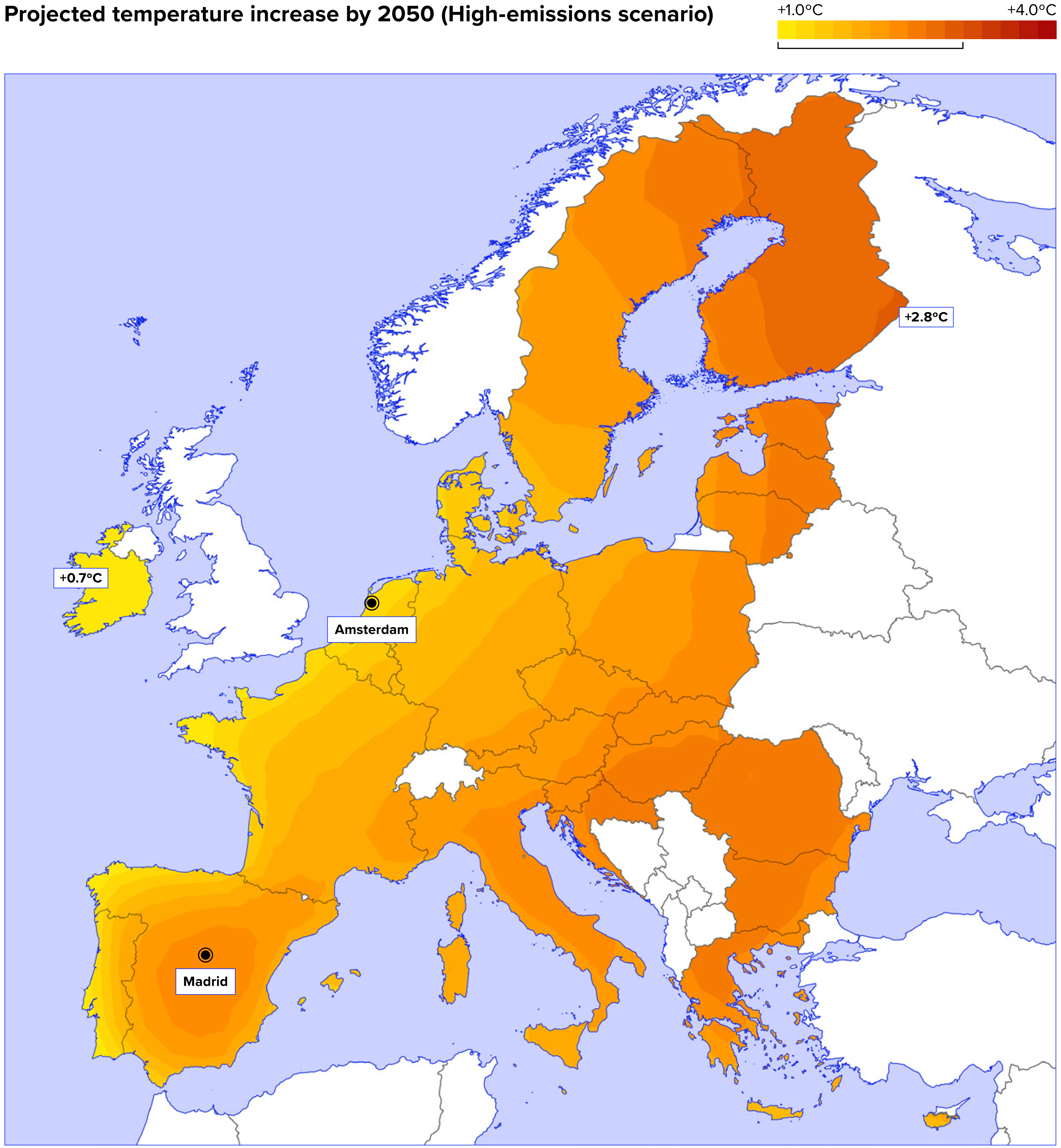
Madrid

Urban population
6.6 M

Physical hazard risk	2024	2035	2050	Change 2024–2050
Heatwaves	Low	Low	Medium	+135%
Water stress	Medium	Medium	High	+65%

Madrid, located in central Spain, faces risks from heatwaves and droughts. The city experiences hot, dry summers and mild winters, exacerbating these risks. **Heatwaves** are expected to rise to a medium risk in 2050, with the number of days of extreme heat rising from 18 to 41. **Water stress** is already a medium risk for Madrid, and is projected to increase by 65%, becoming high risk in 2050.

Projected temperature increase by 2050 (High-emissions scenario)



European Union

We project that, by 2030, the European Union's current policies will result in the country overshooting its NDC by 22%, or 444 $MtCO_2e$.

We also estimate that the EU will surpass its 1.5°C aligned emissions budget by 2035.

NDC 2.0[243]

Conditionality	Unconditional
Covers all sectors	✓

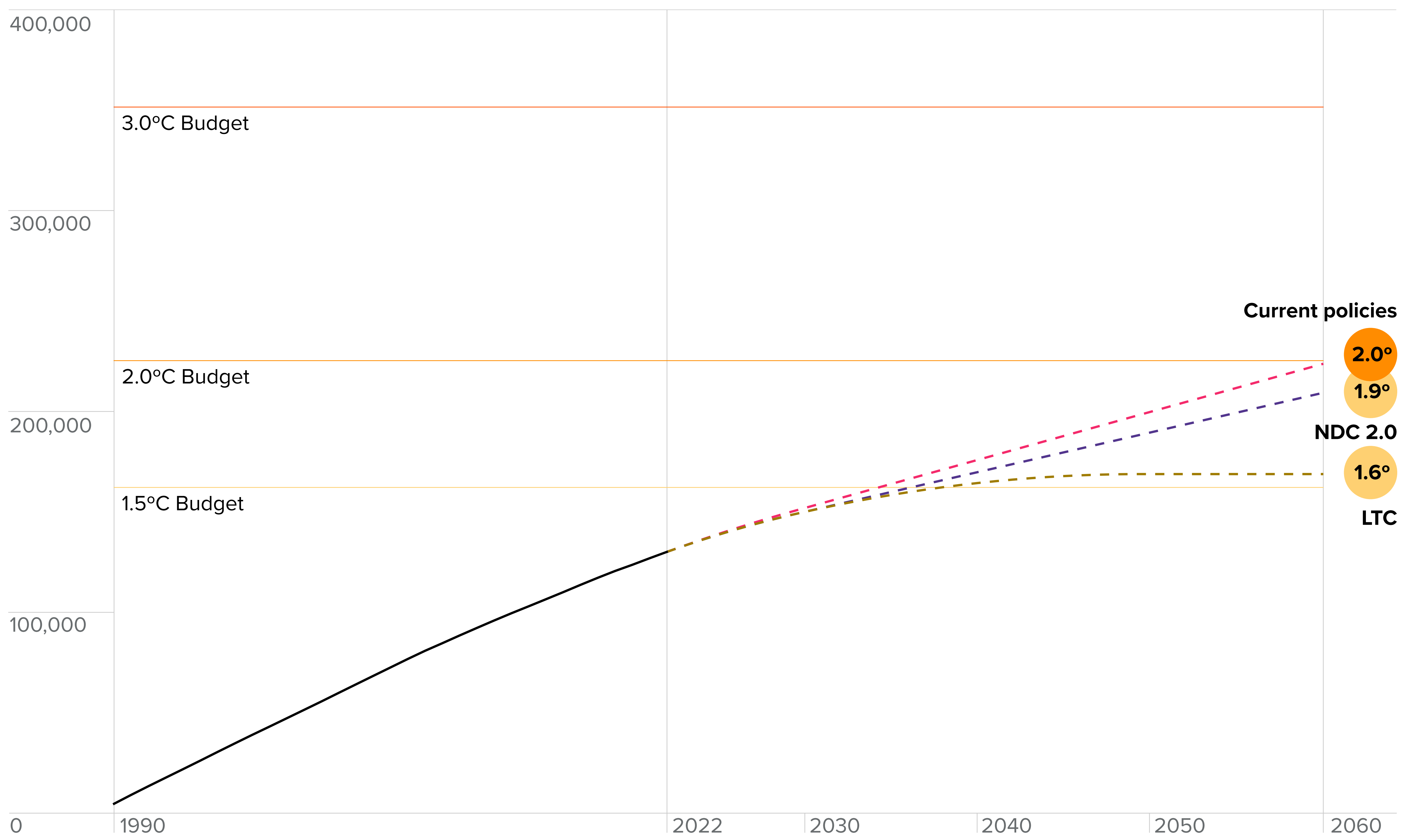
In 2023, the European Union updated its NDC with a pledge to reduce its GHG emissions by at least 55% below 1990 levels by 2030. We calculate the EU's 2030 target to be 1.97 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Long-term commitment (LTC)[244]

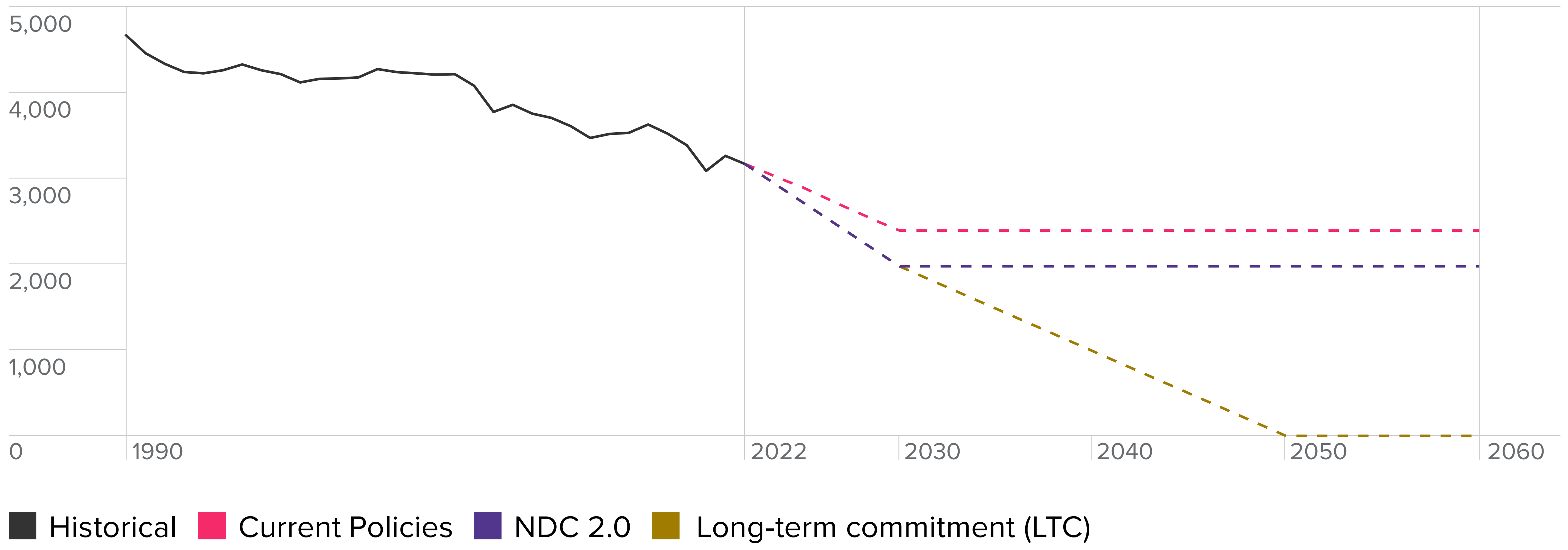
Covers all sectors[245]	✓
Covers Kyoto gases	✓

In 2023, the European Union updated its NDC with a pledge to reduce its GHG emissions by at least 55% below 1990 levels by 2030. We calculate the EU's 2030 target to be 1.97 $GtCO_2e$ using Assessment Report 4 (AR4) GWP values (including LULUCF emissions).

Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



European Union

Policies overview

✓ National adaptation plan[246]	
Regular published risk assessments[247]	✓
Monitoring and evaluating report[248]	✓
Part of a sovereign catastrophe risk pool	Exempt

✓ Carbon pricing system[249]	
% of GHG emissions covered by carbon price	38%
Carbon price ($/t$CO_2$e)	61.30
Aligned with the global carbon price corridor[250]	✓

Climate finance

3-year average climate finance contribution as a % of GDP[251]	0.16%
Proportional share of $100 billion global climate finance commitment[252]	✗

Energy opportunity (Prospective energy capacity)	MW/$bn GDP	G20 rank
Wind[253]	28.45	5th
Solar[254]	13.53	7th
Hydroelectric[255]	0.86	13th
Geothermal[256]	0	N/A

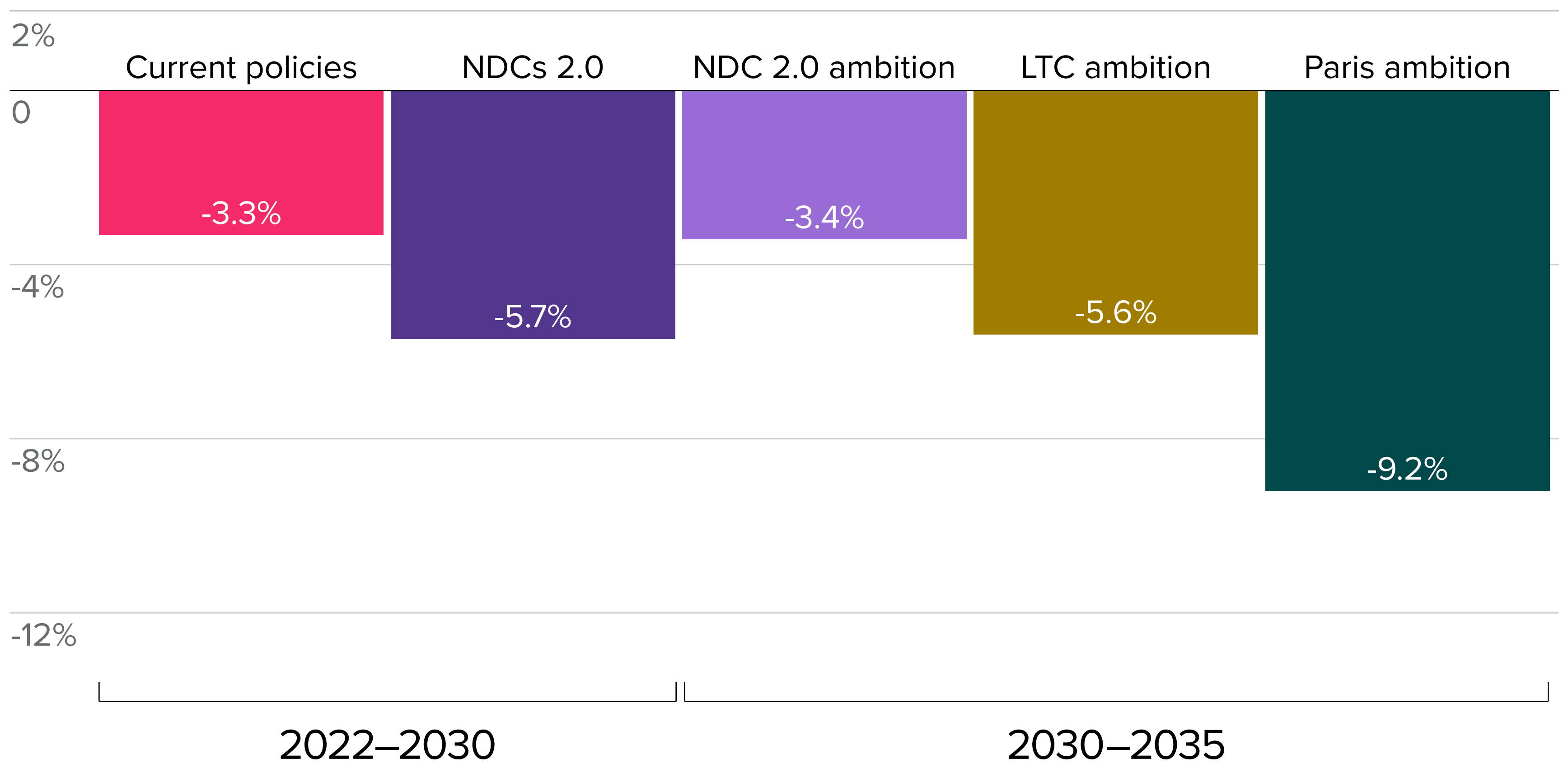
2035 targets

NDC 2.0 ambition: we estimate that, if the EU were to set targets based on the same ambition as its current NDC 2.0, it would set a 1.6-1.7 $GtCO_2e$ target for 2035. The middle of this range would keep the EU on a below 2°C decarbonisation pathway.

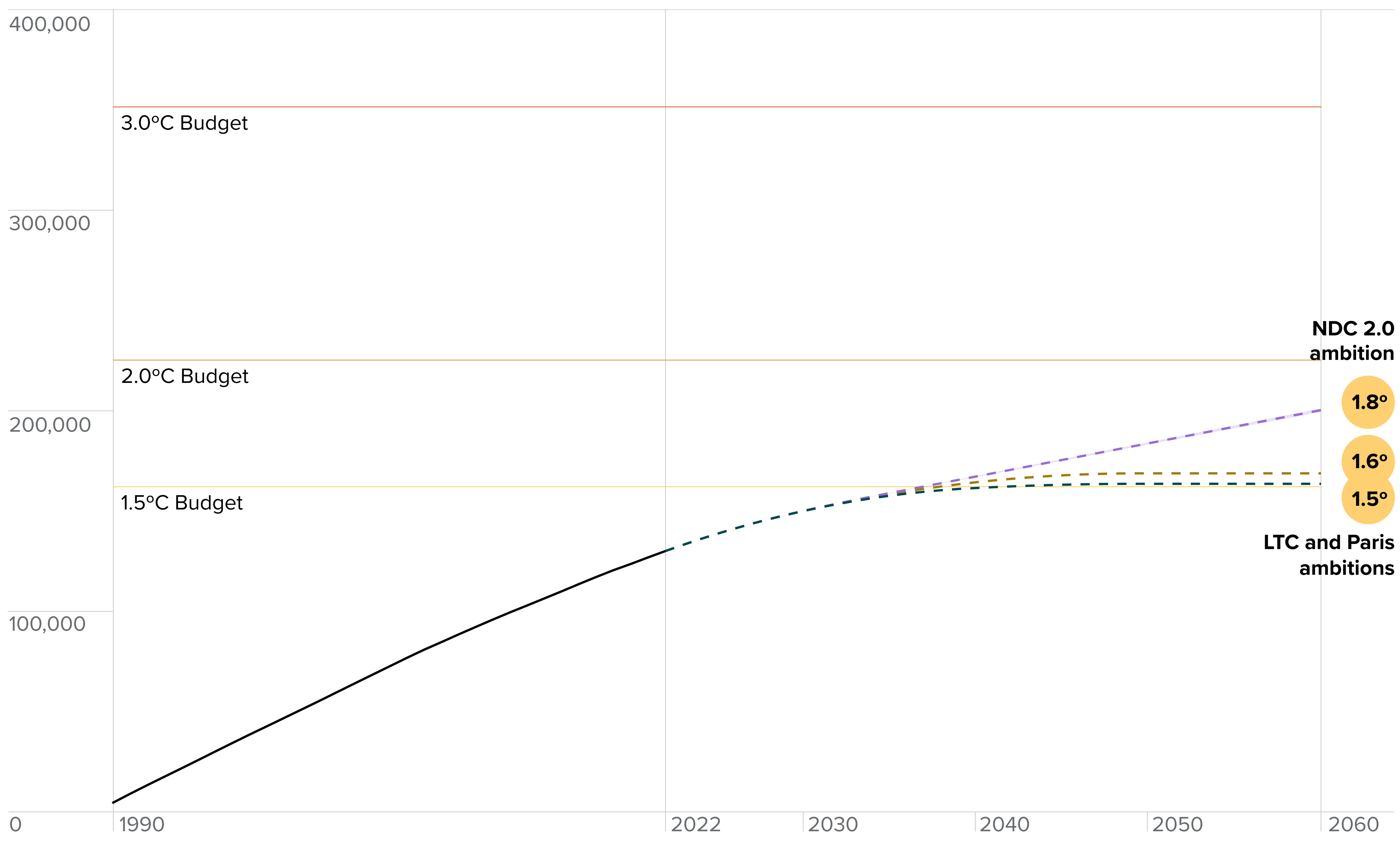
However, if the EU sets a 2035 target that is less than 1.221 $GtCO_2e$ in 2035, then we project that it will be on a 1.5°C pathway and have a good chance of achieving its 2050 net zero target.

The EU will have to substantially ramp up its annual rate of decarbonisation from 3.4% under current policies from 2024-2030 to 6% year-on-year decarbonisation from 2030-2035 to reach its 2035 target under **LTC ambition** and 9% under **Paris ambition**.

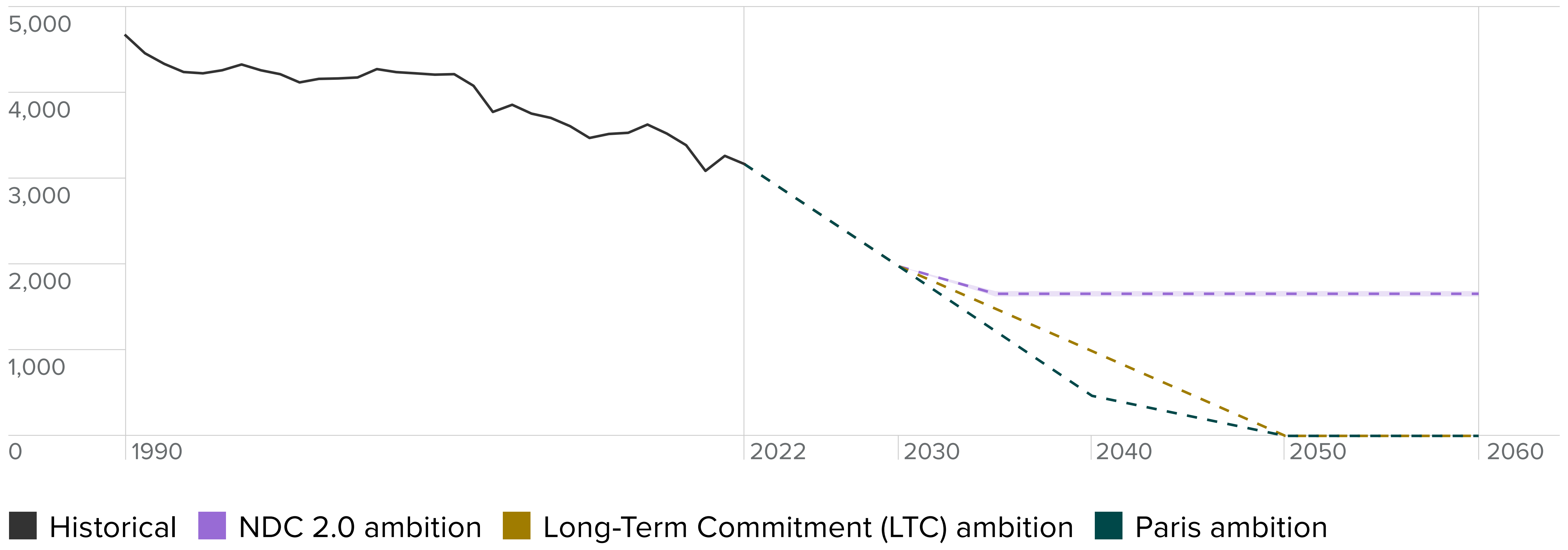
Projected annual decarbonisation rates



Implied Temperature Rise based on cumulative GHG emissions ($MtCO_2e$)



Historical and projected annual GHG emissions ($MtCO_2e$)



Annex

Data & Methodologies

Chapter 1: Transition Risk

This annex includes a description of the data, methodologies and references used in our Implied Temperature Rise (ITR) evaluations and physical risk assessments.

A) Climate Liabilities Assessment Integrated Methodology (CLAIM) model

The methodology to define national greenhouse gas (GHG) budgets is critical in calculating the Implied Temperature Rise (ITR) for a country. We rely on the Climate Liabilities Assessment Integrated Methodology (CLAIM) model developed by LSEG.[1] It enables the computation of national GHG budgets compliant with any global temperature target and time horizon (for this report a 1.5°C scenario is selected, see ITR section to the right).

Allocating shares of global emissions budget between countries is a source of scientific and diplomatic controversy. There are two main methodologies: 1. the egalitarian approach and 2. the grandfathering approach. Hybrid approaches are also possible (see Giraud et al. 2017 for further details[2]). The egalitarian approach allocates the same right to GHG emissions to every human being, while the grandfathering approach relies on the idea that the global GHG budget should be divided along the criterion of current emissions, meaning that the weight of each country in global emissions remains stable over time. The CLAIM model does not assign a national budget following a unique criterion, such as "capacity" or "responsibility." Instead, it offers a statistical, and non-normative, approach, which avoids choosing between egalitarian or grandfathering sharing.

B) Implied Temperature Rise (ITR) model

In the first two editions of our Net Zero Atlas (ahead of COP26 and COP27), we measured the temperature associated with sovereign climate commitments and policies according to an approach and equation adapted from IPCC (2018[3]) and Rogelj et al. (2019[4]), and laid out in a 2019 paper.[5] In last year's COP28 report, we updated this approach to better reflect:

1. The relationship between country-level GHG budgets and temperature due to CO_2 emissions.

2. The relationship between CO_2 and non-CO_2 emissions in the context of global warming.[6]

In this year's report, we continue to draw on fundamentally the same high-level approach, but have updated our methodology to reflect:

i. Updated modelling of future emissions pathways under specific temperature scenarios.

ii. The impact of cumulative emissions on implied temperature rise – detailed below.

The adjustments to our ITR values result in changes that are typically 0.2°C or less, though there are some larger changes, particularly for countries with higher implied temperature rise values for their targets and policies.

Chapter 1: Transition Risk

2024 updates

A key component of the ITR methodology is calculating the gap ("GAP") between a country's projected emissions (for their NDC 2.0, Net Zero Target, and/or current policies individually) and their 'allowable' emissions under a specific warming scenario (e.g., 1.5°C) as assigned by the CLAIM model. This gap is then translated into a global budget equivalent (assuming that all countries have the same gap as the specified country) used to determine a corresponding global temperature variation. The implied temperature rise is given by the equation: [6]

$$T_i = T_{CO2} + T_{non\text{-}CO2}(T_{CO2})$$

With $T_{CO2} = TCRE * (GAP_i * B_{tot,1.5}) + T_{hist}$

and $T_{non =\text{-}CO2} = 0.4085 * T_{CO2} – 0.3942$

Where T_i is the implied temperature rise of a country, and T_{CO2} and $T_{non–CO2}$ are the implied temperature rise due to CO_2 and non-CO_2 greenhouse gases respectively.

1. **Updating modelling of future emissions pathways under specific temperature scenarios:**

   In this year's report, we have updated the benchmark 'emissions pathway' which is used – in conjunction with CLAIM - to derive the 'allowable' emissions under a 1.5°C scenario – denoted by B_{tot}. This scenario, which is now based on the latest Net Zero 2050 NGFS scenario, defines the global emissions pathway that would keep globally averaged temperature rise to 1.5°C above pre-industrial levels in the year 2100.

2. **Updating calculation of 'emissions gap' to a cumulative-based emissions approach**

   This year, ITR is based on a comparison between cumulative emissions of a given policy or target and a 1.5°C benchmark from the present year until 2060 – denoted by GAP_i. Last year's report considered instead the emissions gap between target/policy and benchmark in a year, i.e. in 2030 or 2050.

   The updated GAP calculation is given by:

$$GAP_i = \frac{\sum_{y}^{2060} E_{p,i,y}}{\sum_{y}^{2060} E_{1.5,i,y}}$$

Where i is the given country, y is the current year, p is the projected emissions and 1.5 is the 1.5°C GHG emissions budget as calculated using CLAIM and the global 1.5°C emissions pathway.

Chapter 1: Transition Risk

C) Database of decarbonisation targets, trajectories, policies and sectoral abatement potentials

The ambition assessments presented within this report focus on the G20 countries.

Historical emissions

Our historical GHG emissions inventories includes the land use, land-use change and forestry (LULUCF) sector. The emissions inventories from this sector are collected by the International Institution for Applied Systems Analysis (IIASA) based on the United Nations Framework Convention on Climate Change (UNFCCC) and the Food and Agriculture Organization (FAO) reported emissions.[7] The emissions from the other sectors are based on the PRIMAP-hist[8] database of the Potsdam Institute (mostly emissions from energy-use, industry and agriculture).

Long term commitments (LTC)

Our database currently covers 130 countries that have already set long-term commitments, representing 87% of global GHG emissions.[9] The database builds on information from 'Net Zero Tracker' from ClimateWatch.[10]

These long-term commitments can appear in a number of forms, with most countries presenting them as formal submissions to the UNFCCC or as national policy documents. However, commitments from several countries are currently only based on verbal pledges from political leaders.

Our LTC emissions trajectories are calculated based on the target year in the country's long-term commitment (this is most often 2050, but some countries committed to achieve net zero emissions by 2060, like China, or 2045, like Germany).

NDCs 2.0 (2030 targets)

The 195 parties to the Paris Agreement have submitted a Nationally Determined Contribution (NDC), as required. However, only 132 of the 2030 NDCs (NDCs 2.0) are concrete enough to be quantifiable, representing 95% of global emissions. The commitments of some developing countries have both conditional (to financing) and unconditional parts. In our assessments, we consider only the unconditional component of the NDC targets.

For NDCs that are based on a percentage reduction from a base year, we calculate the 2030 target using the percentage reduction provided by the country and applied to our own historical inventories for the base year.

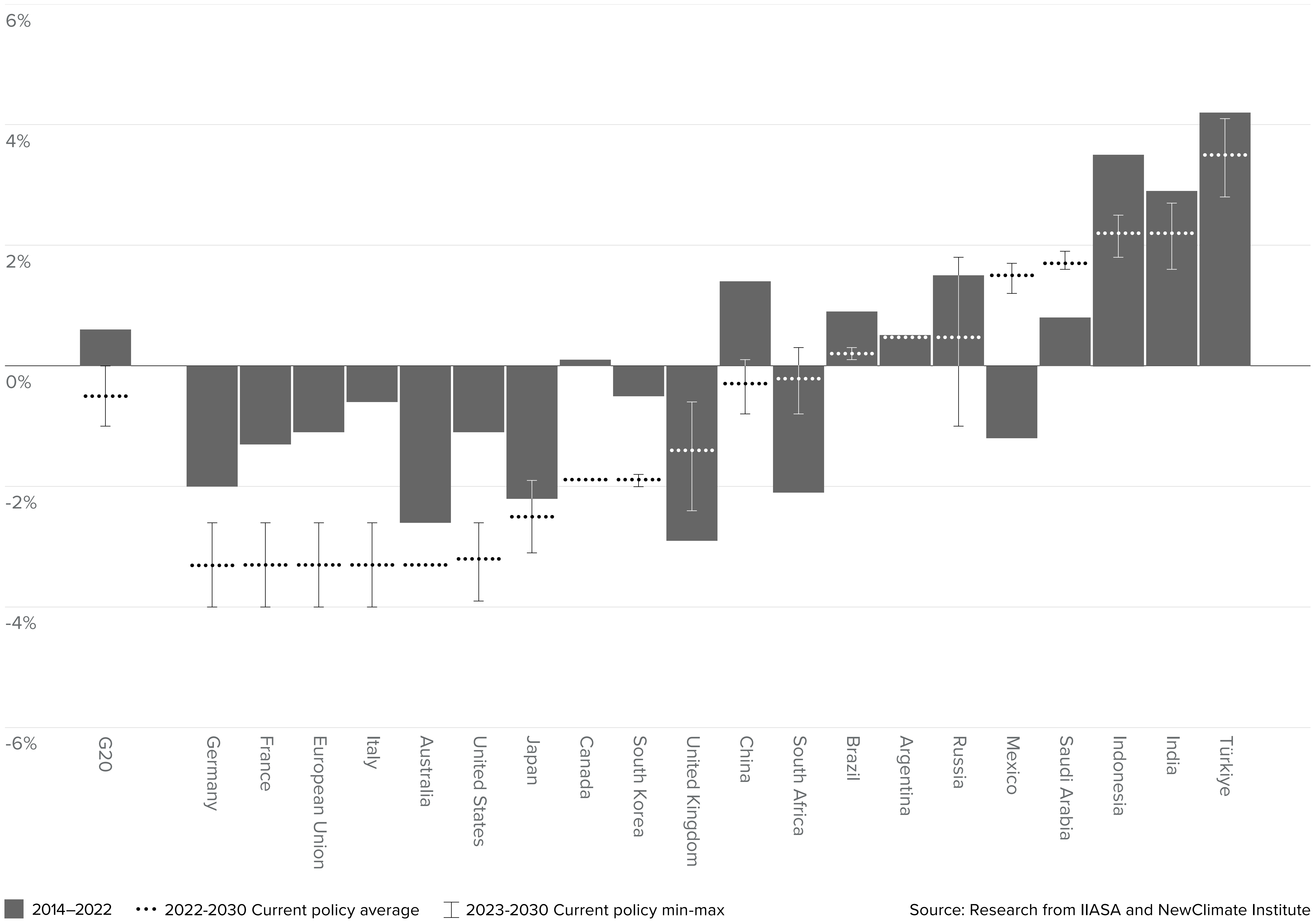
Current policies

In this report, we use 'current policies' emissions trajectories constructed by the NewClimate Institute and IIASA that provide annual emissions estimates from 2023 to 2030. Both institutes have a long history in estimating the impact of current policies on future GHG emissions. The methods used for developing the current policy scenarios are presented in detail in Nascimento et al. (2021)[11] and described in detail elsewhere (Nascimento, L., et al., 2023[12], Kuramochi et al., 2021[13]; den Elzen et al., 2019[14] ; Fekete et al., 2021[15]); see also our COP26 Net Zero Atlas[16].

The NewClimate Institute/IIASA database of current policy trajectories update for this report covers the G20 countries, accounting for 79% of global emissions. Our 'current policies' emissions trajectories are based on the growth rates (between 2023 and 2030) deduced from the trajectories provided by NewClimate and IIASA and harmonised on our historical inventories. See Figure 12.

Chapter 1: Transition Risk

Figure 12: Comparing projected emissions growth in the G20 countries based on current policies with historical trends



Source: Research from IIASA and NewClimate Institute

Chapter 1: Transition Risk

Figure 13: Scenarios breakdown

Scenario	Description
'NDC 2.0 ambition'	• We first calculate the annual emissions reduction (growth) rate for 2015-30, based on the countries' latest NDC and assume that its 2035 target will be set to reduce (grow) emissions at the same rate. • Secondly, we use the ITR associated with our current policies projections for 2030; and assume that countries 2035 targets will align to the same temperature outcome. • We use the average of both as the estimate for a 2035 target that is consistent with the 2030 NDCs. • A country's full emissions pathway is therefore a linear progression from current levels to its 2030 NDC, then to the calculated 2035 NDC. We assume post-2035 emissions remain constant until 2060, the end of our time domain.
'Long-term commitment (LTC) ambition'	• We assume a linear decrease in emissions from a country's 2030 NDC to its long-term commitment and assume that the 2035 NDC lies on this pathway. • For the LTC ambition, the full pathway is a linear progression from current levels to its 2030 NDC, followed by the linear decrease to its LTC. If the LTC is before 2060, then we assume emissions remain constant after its LTC until 2060, the end of our time domain.
'Paris ambition'	• We assume a level of ambition required to keep implied temperature rise in the G20 to approximately 1.8°C; however the rate of decarbonisation is specific to the long-term commitments made by G20 members. • The decarbonisation trajectory results in 2040 emissions that are equivalent to a 90% reduction for countries with 2050 LTCs, 70% reduction with 2060 LTCs, and a 30% reduction in emissions in 2040 for India, which has a 2070 LTC. We calculate a country's 2035 NDC from where it intersects this pathway. • If the LTC is before 2060, then we assume emissions remain constant after its LTC until 2060, the end of our time domain.

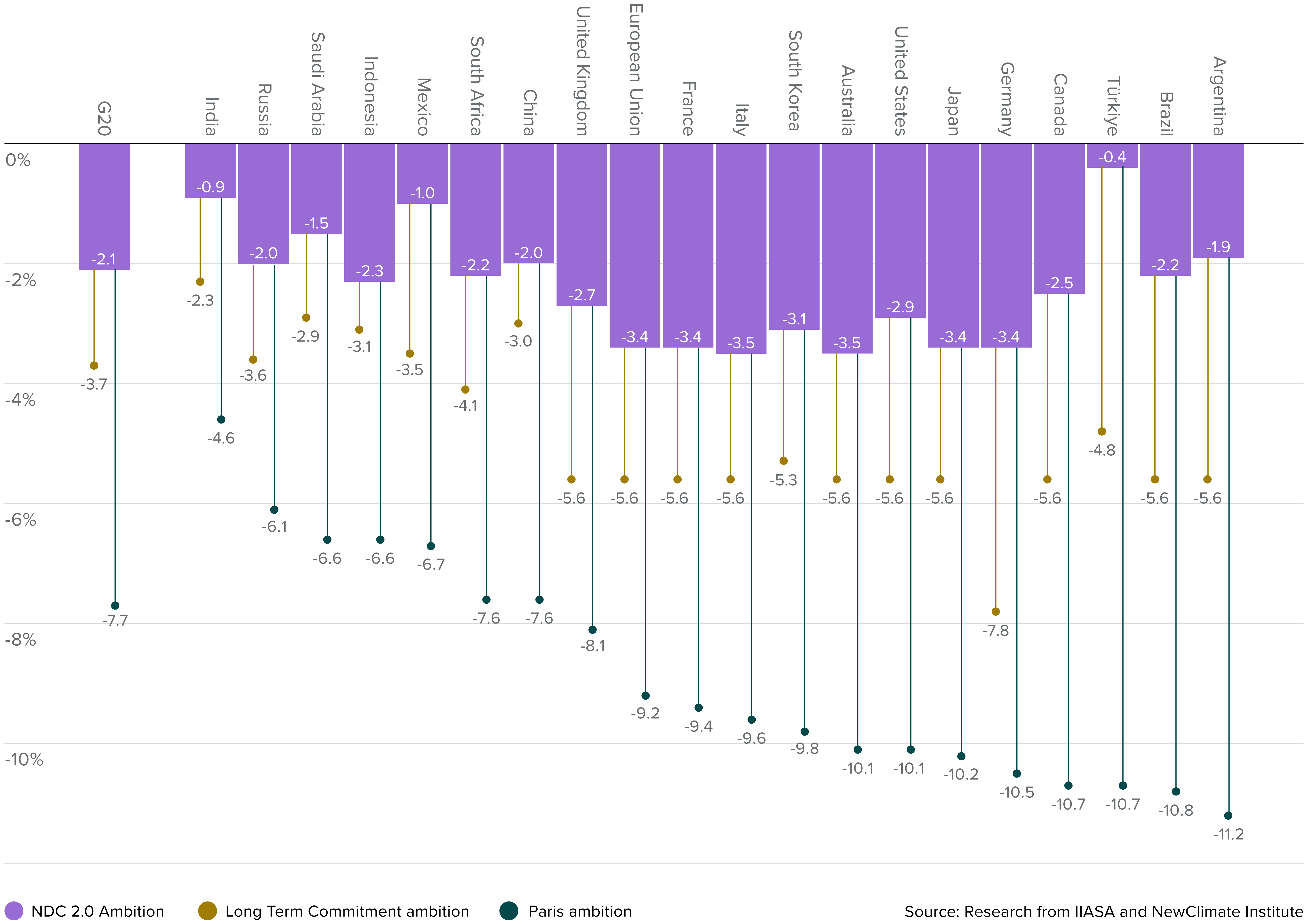
Source: LSEG

NDCs 3.0 (2035 targets)

For the COP29 Net Zero Atlas, we construct a series of scenarios that allow us to estimate the emissions levels and associated ITR that a country might track towards in 2035. Explained in Figure 13, we build three scenarios based on a number of growth (reduction) assumptions, resulting in country-specific implied decarbonisation trajectories between 2030 and 2035 (see Figure 14).

Chapter 1: Transition Risk

Figure 14: Comparing projected annual emissions growth in G20 countries between 2030 and 2035



Source: Research from IIASA and NewClimate Institute

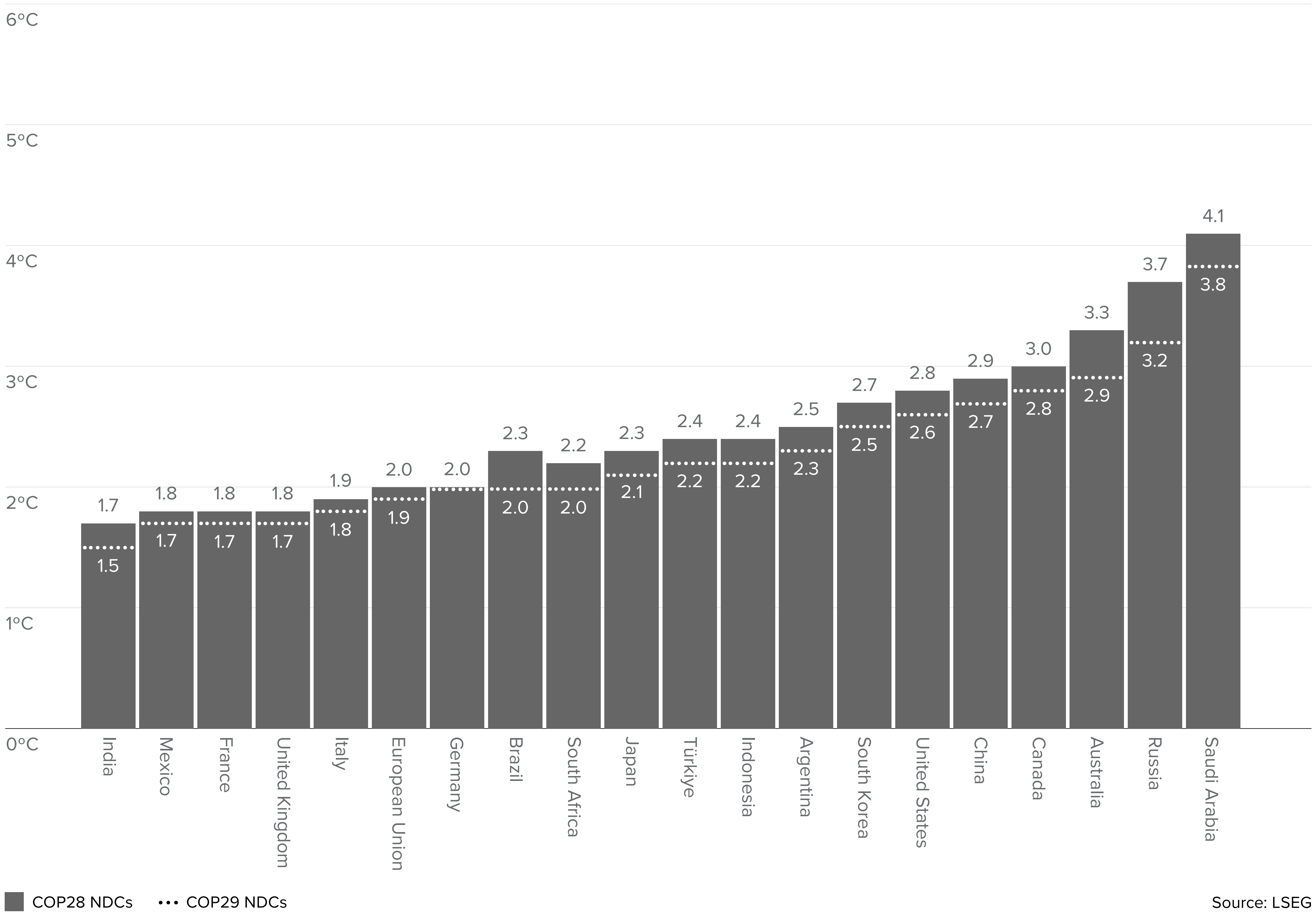
Figure 15: Implied Temperature Rise for G20 countries for COP29 (°C)

Country names	NDC 2.0	Current policies	Long-term commitments
India	1.5	1.6	1.5
France	1.7	1.8	1.5
United Kingdom	1.7	2.0	1.5
Italy	1.8	2.0	1.5
European Union	1.9	2.0	1.6
Mexico	1.7	1.9	1.6
Germany	2.0	2.2	1.6
Brazil	2.0	2.2	1.6
Japan	2.1	2.4	1.7
Türkiye	2.2	2.2	1.7
South Africa	2.0	2.2	1.7
Argentina	2.3	2.5	1.7
Indonesia	2.2	2.3	1.9
South Korea	2.5	2.8	1.9
United States	2.6	3.0	1.9
Canada	2.8	3.4	2.0
Australia	2.9	2.9	2.0
China	2.7	2.6	2.2
Russia	3.2	2.6	2.4
Saudi Arabia	3.8	4.3	3.0
G20	2.5	2.6	2.0

Source: LSEG

Chapter 1: Transition Risk

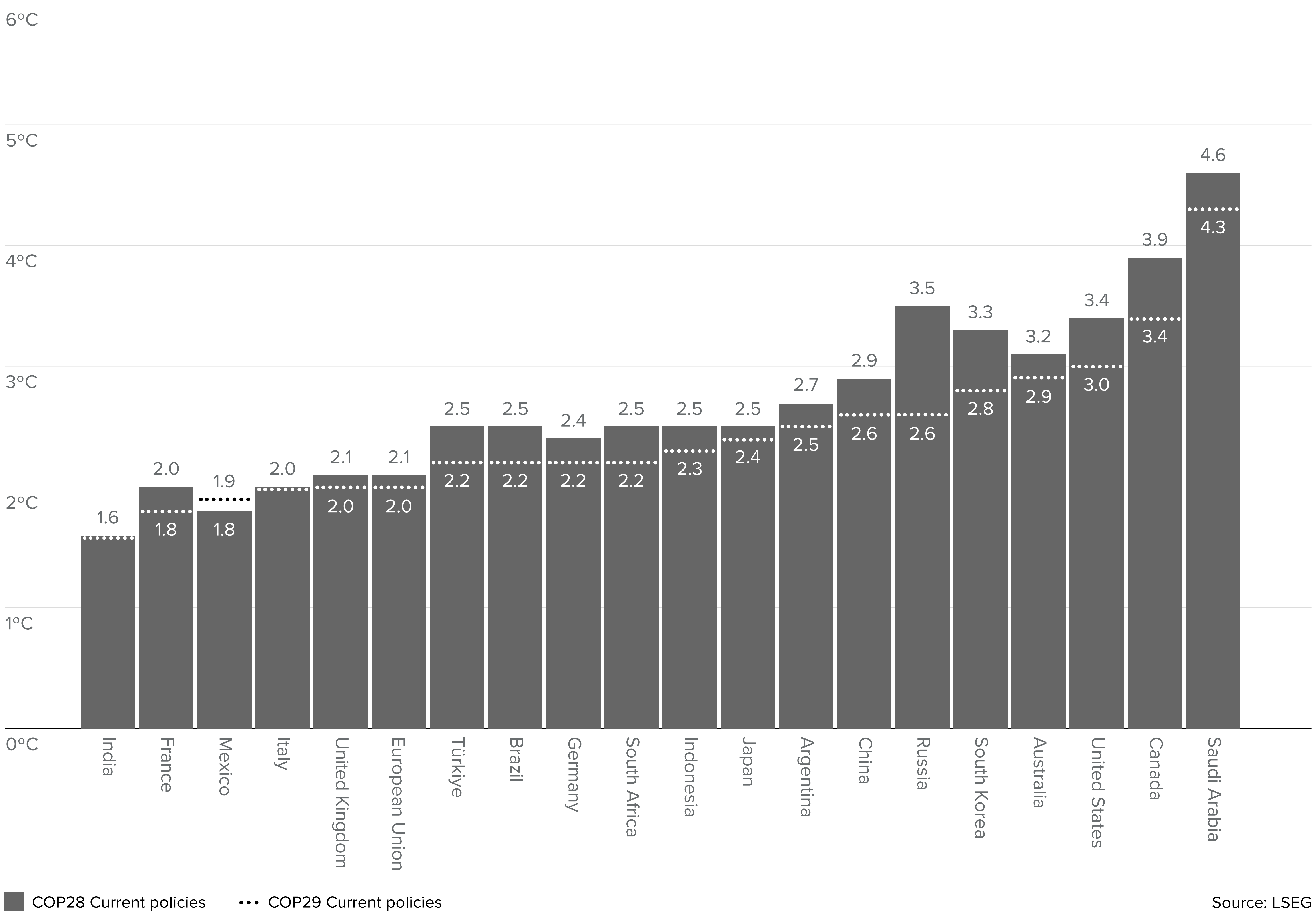
Figure 16: Implied temperature rise based on 2030 NDCs for COP28 and COP29 for the G20 countries (°C)



Source: LSEG

Chapter 1: Transition Risk

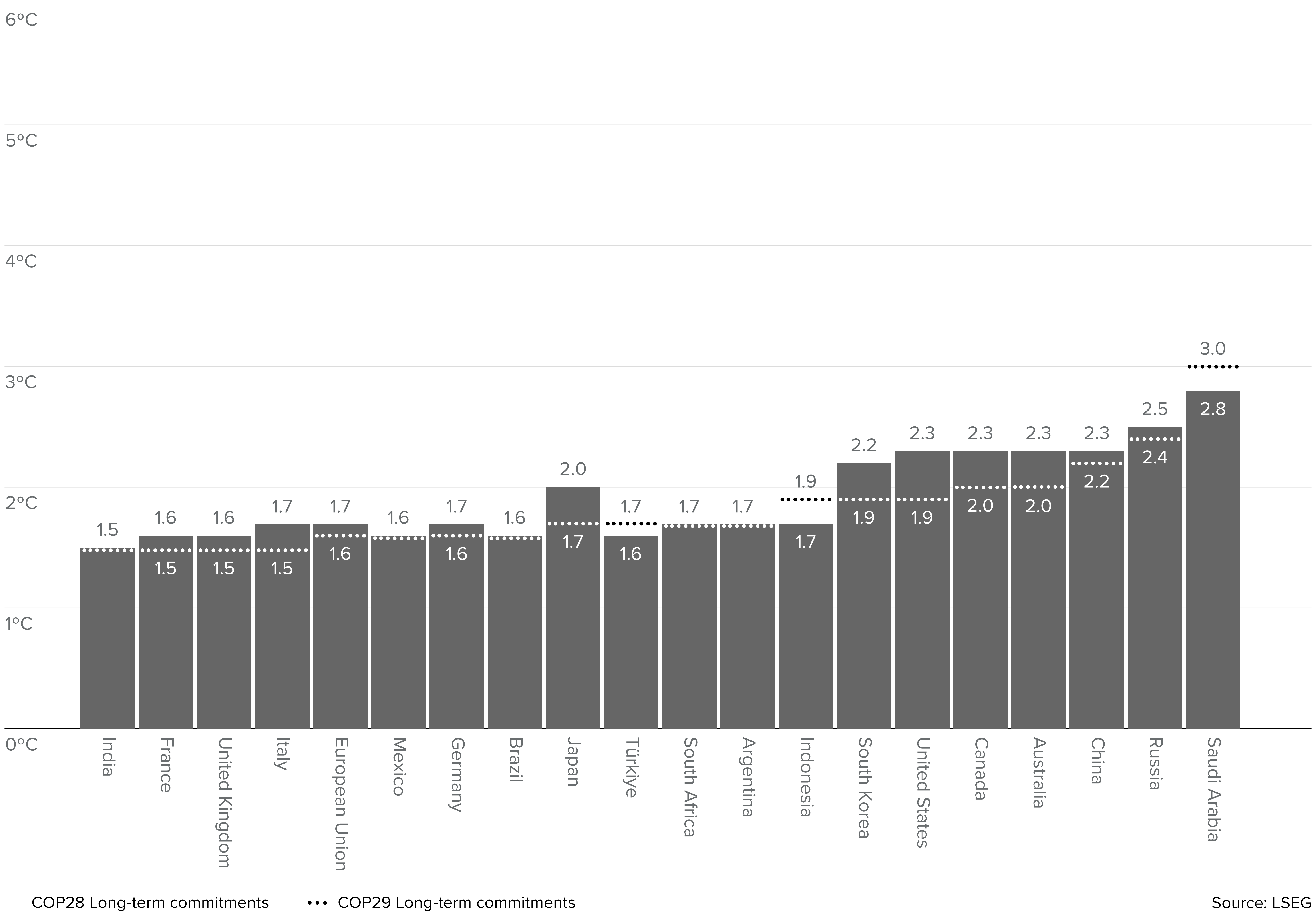
Figure 17: Implied temperature rise based on current policies from COP28 and COP29 for the G20 countries (°C)



Source: LSEG

Chapter 1: Transition Risk

Figure 18: Implied temperature rise for selected countries based on long-term commitments from COP28 and COP29 for the G20 countries (°C)



Source: LSEG

Chapter 1: Transition Risk

Figure 19: Climate policy KPIs from ASCOR[18]

ASCOR Indicator ID	Indicator title
CP2.a	Does the country have a carbon pricing system?
CP2.b	Does the country's carbon pricing system cover at least 50% of national greenhouse gas emissions?
CP2.b.i	What percentage of national greenhouse gas emissions is covered by an explicit carbon price?
CP2.c	Is the carbon price at least at the floor of a global carbon price corridor aligned with the Paris Agreement?
CP2.c.i	What is the country's most recent explicit carbon price?
CP3.a	Has the country committed to a deadline by which to phase out fossil fuel subsidies?
CP3.a.i	By what year has the country committed to phase out fossil fuel subsidies?
CP3.b.i	How much is spent annually on explicit fossil fuel subsidies as a percentage of GDP?
CP5.a	Has the country published a National Adaptation Plan?
CP5.b	Does the country regularly publish national climate risk assessments?
CP5.c	Has the country published a monitoring and evaluation report on implementing adaptation?
CP5.e	Is the country part of a sovereign catastrophe risk pool?
CF1.a	Does the country contribute at least a proportional share of the $100 billion commitment to climate finance?
CF1.a.i.	What is the country's 3-year average climate finance contribution as a % of GDP?
CF1.b	Has the country set a target for further increasing its international climate finance contributions?
CF1.b.i.	What is the country's targeted level of international climate finance contributions as a % of GDP?
CF4.a.i.	What is the country's prospective solar energy capacity?
CF4.a.ii.	What is the country's prospective wind energy capacity?
CF4.a.iii.	What is the country's prospective geothermal energy capacity?
CF4.a.iv.	What is the country's prospective hydroelectric energy capacity?

Source: ASCOR

Climate policy KPIs

In this COP29 Net Zero Atlas, we display a sub-set of indicators within the Country Profiles section that are adapted from Assessing Sovereign Climate-related Opportunities and Risks (ASCOR), an initiative backed by asset owners, asset managers and investor networks.[17]

Chapter 2: Physical Risk

Figure 20: Hazard summary

Hazard	Risk metric	Risk metric description
Cyclones	Annual probability of a Category 1 or higher cyclone at a location.	This indicator quantifies the projected cyclone likelihood, expressed as timeseries of annual expected probability at the asset level. It is derived from the STORM cyclone model, which simulates future hurricane generation under climate change. The likelihood of any cyclone (Category 1 and above) occurring in a given year is estimated.
Flooding	Annual probability of a flood with depth greater than 0.5 meters at a location.	This indicator quantifies the projected flood likelihood, expressed as timeseries of annual expected probability of flooding greater than 0.5 meters at the asset level. This is derived from a combination of World Resource Institute (WRI)'s Aqueduct Flood Hazard Maps product, high-resolution elevation data, and local information on flood zones.
Heatwaves	Total days in a given year exceeding the historic 98th percentile for temperature.	This indicator utilises NASA Global Downscaled Daily Projections (GDDP) to estimate the number of days exceeding the historic 98th percentile of annual temperatures at an asset location. This temperature threshold varies spatially, based on the 98th percentile of a given location during the years 1980 to 2010. The heatwave metric indicates anomalously high temperatures relative to each location's historical temperature distribution.
Water Stress	Unitless water stress score.	Combines the Standardized Precipitation Evapotranspiration Index (SPEI) and WRI Aqueduct's water stress scores. Higher values indicate greater water stress, with values greater than 0.6 and 0.8 generally considered to be at high and severe water stress, respectively. This indicator combines the water stress score and the drought indicator to one single indicator for water stress, using a weighted mean. The indicator captures both meteorological factors and anthropogenic factors associated with water stress.

Source: LSEG, adapted from Sust Global

City-level physical risk assessments

This year's COP29 Net Zero Atlas presents analysis of 49 cities' (see Figure 22) physical risk exposure between now and 2050. We rely on physical risk modelling from Sust Global, a provider of climate risk analytics and APIs to investors.[19] For each hazard – floods, cyclones, heatwaves and water stress – a specific measure of risk is generated to describe the hazard's frequency or intensity (see Figure 20). This may be an average or a maximum of risk exposure across a city; these outputs are also translated into a general classification of risk (high/medium/low/minimal) – see Figure 21.

The data within our report is based on IPCC SSP5-8.5 climate scenario, following a 'hope for the best, plan for the worst' type of approach.

Chapter 2: Physical Risk

Figure 21: Sust Global hazard data specifications and labels

Hazard	Unit	Low range	Medium range	High range
Flooding	Probability	0.0–0.01	0.01–0.05	0.05–1.0
Cyclones	Probability	0.0–0.01	0.01–0.05	0.05–1.0
Water stress	Score	0.0–0.3	0.3–0.6	0.6–1.0
Heatwaves	Number of days in year	0.0–30	30–50	50–366

Source: Sust Global

Risk classification

To create summarisation labels (or 'risk classifications'), Sust Global analyse a representative sample of global points, and define breakpoints that best represent the overall risk distribution. Summarisation labels are calculated based on the maximum risk over the 2023-2052 period, and bucketed using the values in Figure 21.

Chapter 2: Physical Risk

Figure 22: Cities in our analysis

Country	City
Argentina	Buenos Aires Córdoba
Australia	Melbourne Sydney
Belgium	Brussels
Brazil	Rio de Janeiro São Paulo
Canada	Montréal Toronto
China	Hong Kong Shanghai Beijing
France	Marseille Paris
Germany	Berlin Frankfurt Hamburg
India	Mumbai New Delhi
Indonesia	Jakarta Surabaya
Italy	Milan Rome
Japan	Tokyo Yokohama
Luxembourg	Luxembourg City
Malaysia	Kuala Lumpur
Mexico	Mexico City Tijuana
Netherlands	Amsterdam
Poland	Warsaw
Russia	Moscow Saint Petersburg
Saudi Arabia	Jeddah Riyadh
Singapore	Singapore
South Africa	Cape Town Johannesburg
South Korea	Busan Seoul
Spain	Madrid
Türkiye	Ankara Istanbul
United Arab Emirates	Dubai
United Kingdom	London Manchester
United States	Chicago Los Angeles New York

Source: Sust Global

Country level physical risk

The country-level physical risk profiles within this year's Net Zero Atlas show projected temperature increase by 2050 for a country under a high-emissions scenario (as for the city-level analysis, this is based on IPCC SSP5-8.5 climate scenario). To account for short-term variations of the climate system, long-term average values are equired to adequately represent past and future climate. Here, we use averages over 20-year time segments: the temperature indicators for the historical and 2050 periods are the result of the average over 1995-2014 and 2041-2060, respectively. Average annual temperatures are based on 2050 projections from the CMIP6 climate modelling initiative.

Endnotes

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Australia

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20 Values are based on total climate-specific contributions and normalised by GDP information from the World Bank. Australia's Fourth and Fifth Biennial Reports – Annex I [BR4, BR5]

21 We base our assessment on the work of The Assessing Sovereign Climate-related Opportunities and Risks (ASCOR) project, which calculates a proportional share of the $100 billion climate finance commitment to be 0.2% of GDP

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Brazil

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China

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France

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75 We base our assessment on the work of The Assessing Sovereign Climate-related Opportunities and Risks (ASCOR) project, which calculates a proportional share of the $100 billion climate finance commitment to be 0.2% of GDP

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142 Values are based on total climate-specific contributions. Japan's Fourth and Fifth Biennial Reports – Annex I [BR4, BR5]

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149 Mexico's Climate Change Mid-Term Strategy, 2016 [UNFCCC]

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Russia

159 Russian Federation's First Nationally Determined Contribution, 2020 [UNFCCC]

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South Africa

176 South Africa's First Nationally Determined Contribution (Updated Submission), 2021 [UNFCCC]

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Türkiye

201 Türkiye's Updated First Nationally Determined Contribution, 2023 [UNFCCC]

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221 Values are based on total climate-specific contributions. The UK's Fourth and Fifth Biennial Reports – Annex I [BR4, BR5]

222 We base our assessment on the work of The Assessing Sovereign Climate-related Opportunities and Risks (ASCOR) project, which calculates a proportional share of the $100 billion climate finance commitment to be 0.2% of GDP

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European Union

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Annex: Data & Methodologies

1 Note that when calculating the ITR for an entity including multiple countries, such as the EU or the G20, we compute an average of each country's ITR, weighted by the country's emissions ratio within the group. See FTSE Russell, How to measure the temperature of sovereign assets, 2021 [FTSE Russell]

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