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Comparing the ambition of EU companies with science-based targets to EU regulation-imposed reductions

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Companies can support governments in bridging the emissions gap between current policies and the Paris goals by adhering to voluntary greenhouse gas (GHG) emission reduction targets that align with or surpass those implied by domestic policies. To this end, we assessed the potential impact of EU companies that set targets through the Science Based Targets Initiative (SBTi) in 2020 relative to an EU reference policies scenario that represents the estimated impact of the ETS and ESR policy instruments applicable at that time, with the aim of achieving a 40% reduction relative to 1990 by 2030. Two scenarios were assessed that incorporate the SBTi targets under these instruments: one assuming no additional reductions in the ETS sector due to the waterbed effect, and one with flanking measures to ensure additional emissions reductions regulated by ETS are materialised. Depending on the assumption made about these flanking measures, EU companies with SBTi-approved targets are projected to achieve a 4% or 14% reduction by 2030 compared to the EU 2020 policies scenario. Our findings illustrate that companies with SBTi-approved targets in 2020 were at most in line or modestly more ambitious than the 40% reduction target. This study highlights that voluntary reductions from SBTi companies regulated by ETS display higher estimated reductions than those solely regulated by ESR. Furthermore, this analysis indicates that more policy details are crucial for assessing the potential additional reduction of voluntary targets, and additional reductions under ETS should be assumed zero if a conservative estimate is required.

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INTRODUCTION

Companies are increasingly taking climate actions and making commitments to showcase their climate ambitions[1,2]. These companies can play an important role in supporting national governments to realise their climate policy goals, enabling them to set more ambitious targets and accelerate progress in closing the emissions gap with well below 2 or 1.5 °C pathways[3]. Furthermore, disclosing information about companies' implementation plans could enhance the government's confidence in achieving their climate mitigation policies. In this context, national governments regulate companies by implementing climate policy instruments that encompass industry emissions. However, these companies also establish voluntary targets for reducing greenhouse gas emissions in response to escalating operation costs, litigation, and reputation risks[4]. In addition, corporate responsibility principles encourage companies to create shared value as part of the social contract with society[5].

However, the potential impact of company climate actions remains uncertain due to the lack of transparency in how targets are established[6] and frequently the quality of reporting is poor[7]. This raises the question of whether these actions align with domestic policies and the goals of the Paris Agreement[8,9]. At the same time, determining the impact of voluntary company actions is challenging due to their interaction with national policy instruments[3]. If companies set more ambitious voluntary targets than those implied by national policies, additional reductions beyond those estimated from current policies could be anticipated.

Several recent studies have focused on the potential GHG impact of climate actions from multiple non-state actors on a broader economy-wide scale[8–11]. Apart from companies, also investors, civil society organisations, and subnational actors such as city, state and regional governments are considered non-state actors[3]. These studies make general assumptions about the added impact of non-state actors' climate actions on national policies based on economy-wide emissions projections. Kuramochi et al.[9] and Lui et al.[10] suggest additional reductions if non-state or subnational targets are more ambitious than those implied by current national policies (the exact additionality calculations are more complex and can be found in the literature references). However, interactions between government and companies are likely dependent on local sectoral circumstances and the design and characteristics of policy instruments. Better insights into these interactions can provide a more accurate quantification of progress and ambition[12]. The impact of companies considering specific geographical contexts and the specific policy instruments they encounter has not yet been investigated.

This article aims to examine whether the climate commitments made by companies within the EU are aligned with or complementary to national EU policies. We look specifically to targets validated by the Science Based Targets Initiative (SBTi) and evaluate the situation in 2020, during which the EU implemented climate policies aimed at achieving a 40% emission reduction by 2030 relative to 1990 in response to the global 2 °C temperature threshold[13]. Similarly, most of the SBTi companies were validated in 2020 for alignment with the 2 °C goal. As a result, we define the research question as follows: *what is the potential impact by 2030 on GHG emissions resulting from climate actions taken in 2020 by EU companies with emission reduction targets approved by the Science Based Targets initiative, in the context of policies implemented in the EU?*

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The EU is the object of this study as it has traditionally been a frontrunner on climate policy[14] and has the most advanced bottom-up reporting system[15]. Furthermore, we limit ourselves to companies with targets approved by SBTi, referred to as 'SBTi companies' henceforth, because data is readily available as these companies report to CDP (formerly known as Carbon Disclosure Project) and have gone through a validation process. We discuss the potential broader insights for other actors and geographies in the Discussions section.

Two steps were taken to determine the impact of EU companies with approved SBTi targets. First, the linkages between EU policy-induced reductions applicable to companies and voluntary SBTi company climate actions were examined. Second, this information was input to the scenario analysis with the aim to estimate the additional impact (see the "Methods" section on Additionality for definition) of voluntary SBTi targets in comparison to implied EU policy reductions.

The EU in 2020 aims to reduce total GHG emissions excluding land-use, land-use change and forestry (LULUCF) by 40% relative to 1990 levels and considers this adequate for a pathway to keep global temperature below 2 °C[13,16,17]. In 2020, the EU had three policy instruments in place to achieve this goal, although more specific instruments were also implemented for individual sectors or GHG emissions. This analysis considers the emission trading system (ETS) and effort sharing regulation (ESR) that together cover all GHG emissions excluding LULUCF. LULUCF emissions are treated separately by the EU[17] and fall outside the scope of this analysis. The EU ETS in 2020 sets a sector-wide cap for all power generators, energy-intensive industries and aircraft operators located in the 27 EU Member States (EU27) and enables these companies to buy and sell emission allowances. The ESR sets Member State targets for the other sectors: light-industry, transport, and buildings sectors. In parallel, the Science Based Targets initiative has the goal to support companies in setting emissions reduction targets and take the lead on climate action[18]. Companies that have an SBTi-approved target disclose their emissions and reduction targets to CDP through the annual questionnaire[19,20].

GHG inventory emissions and emissions reduction targets for ETS and SBTi are retrieved from European Energy Environment Agency (EEA), CDP and EUTL.INFO[21–23]. The scope 1 emissions from SBTi companies are regulated by ETS if they originate from activities such as electricity/heat production, energy-intensity industrial processes, or aviation. Furthermore, Scope 1 emissions from other activities and scope 1 emissions from companies not regulated by ETS fall under the ESR regulation. This shows that companies can be categorised into those with ETS installations (including aviation companies) and those without ETS installations. The scope 2 emissions are always regulated by ETS given that they are emitted by electricity companies operating large installations.

Starting from the collected 2020 emissions data divided into ETS and ESR, GHG emissions are projected through 2030 (see the "Methods" section for details). This analysis serves to calculate the potential impact of SBTi companies on EU GHG emissions. Potentially additional reductions by 2030 from voluntary SBTi targets are calculated relative to the emissions levels companies would realise if they would follow EU regulation represented by EU ETS and ESR trends. We have defined three scenarios with distinct pathways that encompass the policies and targets that apply to SBTi companies up to 2020: (1) EU 2020 policies scenario (PS), (2) EU 2020 policies + SBTi scenario (PS + SBTi), (3) EU 2020 policies + SBTi scenario + flanking measures (PS+SBTi+). The PS is based on the with existing measures (WEM) scenario from EEA[21] and projects the impact of EU policies that were implemented in 2020, while the second and third scenarios additionally assume the implementation of voluntary targets from SBTi companies. The two additional scenarios assume SBTi targets are fully implemented and achieved, and if the target year is before 2030, emissions thereafter evolve in line with EU policy trends. In general, additional emissions reductions under ETS would not yield any additional GHG impact as additional measures solely impact which company emits, rather than altering the total reduced emissions as the ETS cap remains the same. However, flanking measures could be incorporated (see the "Methods" section) to ensure the ETS cap is tightened. The second scenario assumes these flaking measures are not implemented, while the third scenario does.

The main results of the scenario analysis show that voluntary emissions reductions from SBTi companies in 2020 could add a 4–14% reduction relative to the 2020 policies scenario by 2030, depending on whether flanking measures are implemented to materialise ETS reductions. If a conservative estimate is required, it should be assumed that voluntary targets covering emissions under ETS do not lead to additional reductions. In addition, especially companies regulated by ETS seem more ambitious than those only regulated by ESR. Furthermore, the results show that in total these company reductions are at most in line with or modestly more ambitious than a 2 °C pathway by 2030. The analysis demonstrates that incorporating voluntary company targets in addition to domestic policies, especially emission trading instruments should be explicitly accounted for. If a conservative estimate is required, additional reductions under emission trading regulation should be assumed zero.

EU regulation and the Science-Based Targets Initiative

To determine the linkages between voluntary SBTi targets and EU regulation, detailed insights into the process and characteristics of targets and policy instruments are needed.

The key policy target in the EU 2030 climate and energy framework which was in effect in 2020, aimed to cut GHG emissions by 40% relative to the 1990 level, addressing the long-term goal to keep the temperature increase below 2 °C compared to pre-industrial levels[13,24]. This target was to be implemented by the EU ETS, the ESR and regulation for LULUCF, where the EU ETS in 2020 covers ~40% of total EU GHG emissions excluding[13,17]. The GHG emissions regulated by ETS are emitted by heavy industry, energy supply and aviation companies residing in the EU, Iceland, and Norway. The EU ETS is a cap-and-trade system that sets a maximum amount of total annual emissions emitted by all companies participating in the system. The total cap in 2020 for the period 2021–2030 is 43% below the 2005 level by 2030. The annual cap that determines the number of allowances is based on a linear reduction factor that represents the annual reduction of allowances relative to the average annual allowances in the period 2008–2012 for stationary installations[25,26] and relative to 2020 for the free allocations concerning aviation[27]. This factor is set for each ETS trading period and was 1.74% in the previous period (2012–2020), but is 2.2% relative to 2008–2012 from 2021 onwards. The companies emitting CO_2, N_2O or PFCs from electricity and heat generation, energy-intensive industry sectors, or aviation (within the EU) have mandatory participation in ETS. Smaller installations or small operators are generally excluded. Each installation needs to surrender allowances each year to cover its emissions. By default, these companies acquire allowances from a periodical auction or by trading on the European Energy Exchange or ICE Futures Europe. However, certain industries with high risks of leakage receive free allowances. To improve the resilience of the ETS system, the EU operates the Market Stability Reserve (MSR) that withholds or releases allowances in case of major shocks. ETS emissions allowances, verified emissions and transactions from auctioning and trading are registered in the European Union Transaction Log (EUTL)[28]. The accountholders in this system are the companies with mandatory participation and other entities or actors that trade ETS allowances such as banks.

The EU effort sharing regulation (ESR) adopted in 2018 covers GHG emissions that are not covered by ETS and LULUCF and encompass ~60% of total EU emissions excluding LULUCF. These emissions include those from companies not covered by the ETS (light industry), citizens, and national and local government operations. The overall ESR reduction target in 2020 was 30% by 2030 compared to 2005 levels[29] and is translated into binding emissions targets for Member States based on the principles of fairness, cost-effectiveness and environmental integrity[30,31]. Norway and Iceland have similar reduction targets with the same obligations as EU Member States[32]. The ESR reduction targets need to be achieved through the implementation of policies by each Member State and overlap with several EU policy instruments, such as the CO_2 performance standards for cars and trucks and the Building Code Directive.

Note that the situation since 2020 has changed due to the adoption of the Green Deal which includes a 55% reduction of total GHG relative to 1990. Since 2022, the ETS cap for 2030 has increased to 62% and the EU ESR target to 60% relative to 2005. In addition, since 2023 shipping is agreed to be included from 2027 onwards, and a second ETS system was created for buildings and transport that will be launched in 2027. These updates are excluded from our assessment as it was not in effect in 2020.

The SBTi operates as a partnership between CDP, the UN Global Compact, the World Resources Institute and the World Wide Fund for Nature (WWF). Companies that participate in SBTi are required to meet the criteria established by the initiative. SBTi experts provide technical assistance and conduct an independent assessment and validation of the set targets. In addition to long-term targets, often set for 2050, they are required to establish shorter-term targets either before or by 2030. It was only in the course of 2019 that companies started to be encouraged to establish emissions targets beyond 2 °C[33]. While a company typically has a central headquarters, it can have various country branches. Although a target encompasses the entire company, it is also allowed to set targets at different levels, such as the business division, business activity or even individual countries. Consequently, the target coverage they provide indicates the percentage of total company emissions covered by the target. Targets may encompass scope 1 emissions (direct GHG emissions) and scope 2 emissions (electricity consumption-related emissions). They may also incorporate scope 3 emissions originating from the supply chain but external to the company. However, these are not included in our assessment.

RESULTS

The discussion of the results is divided into the situation at the end of 2019 showing the landscape of SBTi company targets, emissions and coverage by ETS and ESR policy instruments, and the emissions projections and anticipated reductions by 2030 based on scenario analysis.

ETS and ESR coverage of company emissions

The starting point of our scenario analysis was based on a 2020 dataset that included data for the end of the year 2019 that encompassed 200 companies, amounting to 1063 country branches located within EU Member States, Norway and Iceland, all of which pledged SBTi-approved targets. These targets collectively contributed to 6.4% of the total EU emissions (excluding LULUCF). Of this total, 58 SBTi companies with 354 EU branches owned installations covered by ETS. This selection did not include any aircraft operators. Together, these companies covered 217 ETS account holders and 443 installations (see Supplementary Methodology for details).

Among the collected voluntary SBTi targets, a majority—53%—had target years spanning between 2016 and 2030, 31% were between 2020 and 2025, and the remaining extended beyond 2030 (see Fig. 1a). Furthermore, most of these voluntary targets were set in 2019, with an average time since target inception (at the end of 2019) of 3.3 years (see Fig. 1b).

The total SBTi emissions for EU branches in 2019 amounted to 243 $MtCO_2eq$, with 64 $MtCO_2eq$ stemming from companies without ETS installations, and 179 $MtCO_2eq$ from companies with ETS installations (see Table 1). Within the latter group, 86 $MtCO_2eq$ of the emissions were emitted by ETS installations, while the remaining 93 $MtCO_2eq$ were the results of operations subject to ESR. In total, the coverage of ETS emissions is 40%, leaving the remaining 60% covered by ESR. The SBTi companies with ETS installations, but also having emissions covered by ESR, accounted for 74% of total EU SBTi company emissions.

The impact of voluntary SBTi targets from EU companies in the context of the EU regulation

By evaluating the resulting pathways in each scenario, the additional voluntary reductions from SBTi companies in relation to EU policies are calculated by comparing the 2030 emissions from the reference PS scenario with those from the PS + SBTi and PS + SBTi+ scenarios, each incorporating different assumptions regarding flanking measures (see the "Methods" section). Our analysis suggests that EU SBTi companies by 2030 are projected to deliver relatively modest emissions reductions of 8 $MtCO_2eq$ in addition to ETS/ESR implied trends, assuming ETS emissions are not materialised due to the waterbed characteristics of the ETS (see Table 2 and Fig. 2). However, implementation of flanking measures to counteract the waterbed effect could increase this reduction to 31 $MtCO_2eq$. Consequently, the voluntary SBTi targets could lead to a 3.8% decrease in emissions compared to the PS reference scenario, which is a reduction of 12.6% relative to 2019 levels within the first SBTi scenario (PS + SBTi scenario). In the same manner, this amounts to a 14.2% reduction compared to the PS reference scenario, and a 22.1% decrease relative to 2019 emissions within the second SBTi scenario (PS + SBTi+ scenario).

The total additional reductions can be allocated to the two categories of SBTi companies: (1) those without ETS installations, projected to increase emissions by 12 $MtCO_2eq$ by 2030 in comparison to the PS scenario and (2) those with ETS installations, estimated to reduce emissions by 21–43 $MtCO_2eq$ compared to the PS scenario (see Table 2 and Fig. 2). The results clearly illustrate that companies with ETS installations and approved SBTi targets, based on their 2030 projected emissions, exhibit higher ambition than those that do not own ETS installations. Note that historical ambition and reductions were not accounted for (see the "Discussion" section). The results suggest that governmental policies might serve to increase the mitigation ambitions of companies. This finding is complementary to prior research by Baie et al.[34] and SBTi[35], which more broadly demonstrated that SBTi companies tend to set more ambitious targets than other companies. Furthermore, it underscores the synergistic effects of interlinking government regulations and voluntary targets, as each approach brings its own strengths and weaknesses[36]. The convergence of ambitious governments and bold business leadership can foster an 'ambition loop' pushing each party to accelerate climate actions[37]. However, more evidence is needed to substantiate the existence of the ambition loop, yet its potential is promising in terms of increasing the likelihood of attaining long-term goals.

Furthermore, the question was raised whether the company targets align with the Paris goals. The EU considers the 40% emissions reduction target to be aligned with the threshold of a 2 °C temperature increase[13] based on a cost-effective pathway towards 2050[16]. In addition, Van Soest et al.[38] find a 45% reduction by 2030 relative to 1990 as a medium estimate of cost-effective EU

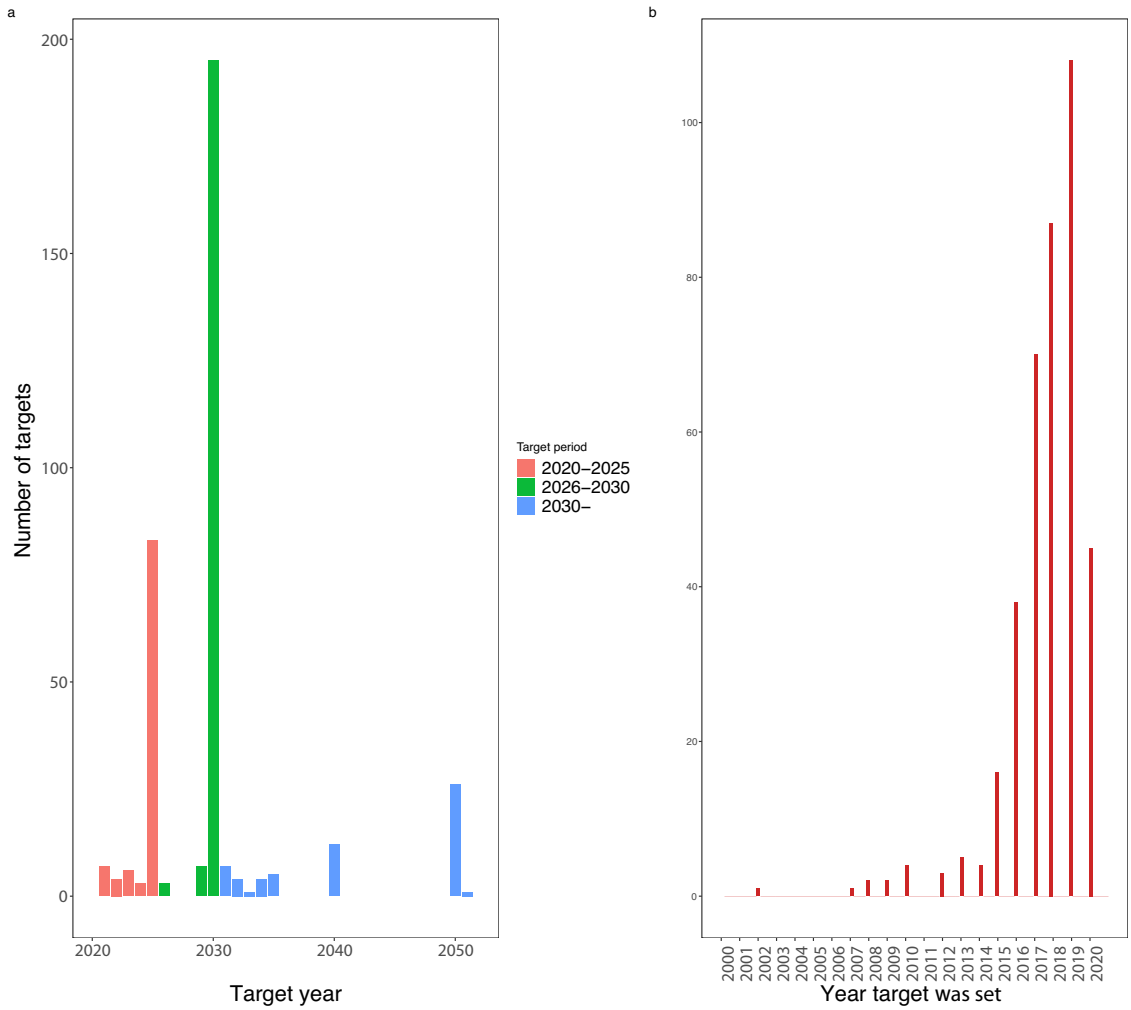

Fig. 1 Target assessment EU companies in Science Based Targets Initiative. Number of targets per target year (panel **a**) and year target was set (panel **b**). For each company, two targets were selected if available (see the "Methods" section).

Table 1. Total GHG emissions for companies in this assessment, categorised into SBTi companies with/without ETS installations, and emissions divided into those regulated by ETS/ESR coverage and scope 1 and 2 in 2019 ($MtCO_2eq$).

Source	Policy instrument coverage	Scope 1 emissions	Scope 2 emissions	Total emissions
SBTi companies without ETS installations	EU ESR	52	(NA)	52
	EU ETS (electricity consumption)	(NA)	12	12
	Sub-total (%-of total)	52	12	64 (26%)
SBTi companies with ETS installations	EU ESR	93		93
	EU ETS	72	14	86
	Sub-total (%-of total)	165	14	179 (74%)
SBTi EU branches	Total	217	25	243
Coverage	SBTi with ESR	146 (67%)	*NA (NA)*	146 (60%)
	SBTi with ETS	72 (33%)	25 (100%)	97 (40%)

implementation on a pathway to keep global temperature below 2 °C goal based on seven models. However, only looking at cost-effective implementation has been contested by studies that investigated emission allowances of countries under different equity principles[39–41]. Therefore, our findings indicate that the 2020 SBTi company targets in total are at best in line or only modestly more ambitious than a cost-effective pathway to keep temperature below 2 °C.

One element is important for contextualising the results. The estimated additional reductions of SBTi company targets depend on the reference level used. The reference scenario (PS) used to assess potential additional reductions is the EEA WEM scenario that assumes both the ETS and ESR targets are not achieved by 2030, indicating policies in the pipeline need to be implemented or additional policies are needed. In line with Kuramochi et al.[9], this analysis uses the policy scenario with implemented policies, identifying opportunities to go beyond their impact. However, other existing reference scenarios could be chosen if they distinguish between ETS and ESR policy instruments. In literature, sometimes the Nationally Determined Contributions are used, but no scenarios (to our knowledge) exist that distinguish between these two instruments. The EEA 'Trends and projections in Europe 2020'[21] present two variants to the WEM scenario; the with additional measures (WAM) scenario that also includes policies in the pipeline to be implemented, and another scenario that is based on the set ETS caps and ESR targets. If we would use these

Table 2. Additional emissions reductions from the implementation of SBTi targets to ETS and ESR reductions by 2030 categorised into those that overlap with ETS and ESR.

Scenario/GHG emissions ($MtCO_2eq$)		2019 (history)	2030 total scope 1 + 2 emissions (2020 policies)	2030 total scope 1 + 2 emissions (2020 policies + SBTi scenario)	2030 total scope 1 + 2 emissions (2020 policies + SBTi scenario + flanking measures)	Additional reduction to PS by 2030 (2020 policies + SBTi scenario)	Additional reductions to PS by 2030 (2020 policies + SBTi scenario + flanking measures)
SBTi companies without ETS installations	ESR	52 (52 + 0)	47 (47 + 0)	59 (59 + 0)	59 (59 + 0)	−12	−12
(electricity)	ETS	12 (0 + 12)	11 (0 + 11)	11 (0 + 11)	9 (0 + 9)	0	+1
SBTi companies with ETS installations	ESR	93 (93 + 0)	86 (86 + 0)	65 (65 + 0)	65 (65 + 0)	+21	+21
	ETS	86 (72 + 14)	78 (65 + 12)	78 (65 + 12)	56 (48 + 7)	0	+22
Total		243 (217 + 25)	221 (198 + 23)	212 (189 + 23)	189 (172 + 17)	+8	+31

Additional reductions are calculated by comparing emissions in the 2020 policies scenario (PS) encompassing ETS and ESR regulation and the 2020 policies + SBTi approved targets scenario (PS + SBTi) that also includes SBTi company targets until 2030. The PS + SBTi+ scenarios include flanking measures to ensure the realisation of additional ETS reductions. Due to rounding errors, total emissions do not always sum to the parts.

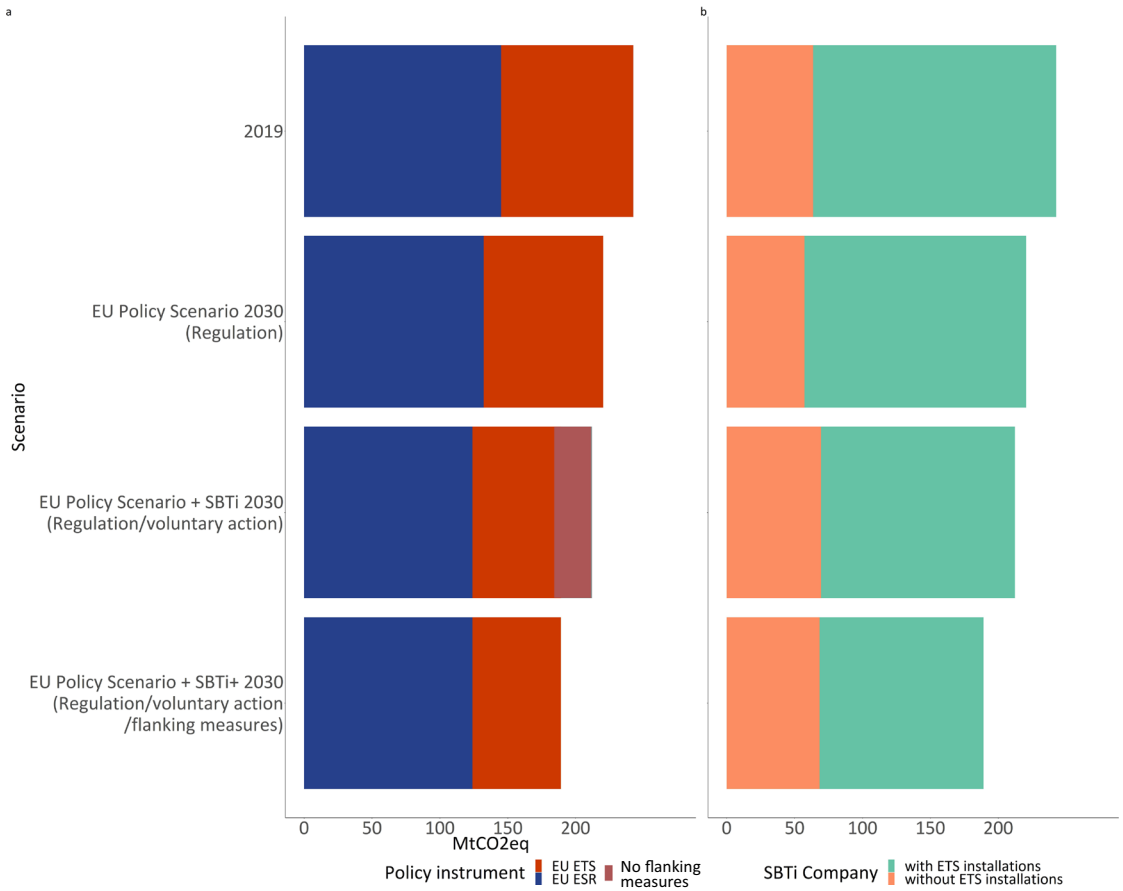

Fig. 2 Projections by 2030 of GHG impact from EU companies within Science Based Targets Initiative in the context of EU polices. Total GHG emissions in 2019 and 2030 represent historical emissions, projected emissions in the EU 2020 policies scenario, the EU 2020 policies and SBTi scenario, and the EU 2020 policies and SBTi+ scenario. The first represents the projected impact on GHG emissions by 2030 from EU regulation implemented before or in the year 2020, the second scenario additionally includes voluntary SBTi company emissions, while the third one also includes flanking measures to compensate for the ETS waterbed effect by diminishing the availability of allowances in the market. Panels show the results categorised **a** per policy instrument and **b** per type of company.

scenarios as reference levels the results even more clearly show that total company targets would only result in additional reduction if flanking ETS measures would be implemented (see the Supplementary Discussion for details). Without these measures, they are projected to lead to higher emissions levels compared to the reference scenario. In addition, the lower performance of companies without ETS installations is even more significant.

DISCUSSION

This study took into consideration more country- and policy/sector-specific contexts compared to existing studies, and therefore provided new insights into the potential additional emissions reductions of company climate actions in the context of EU policies. These insights were attained through an assessment of the potential GHG emission reductions from companies resulting from the implementation of their voluntary targets approved by the SBTi.

This assessment is forward-looking and does not evaluate historical achievements. The emissions pathways we present are based on the reported inventory 2019 emission levels of the EU as a whole and for individual SBTi companies. To begin with, the realised 2019 EU emissions levels for both ETS and ESR were reduced beyond the established cap for that year[42]. In addition, several individual companies have also made considerable progress. If emissions were to be interpolated on a linear pathway between the target base year and the target year (extrapolated to 2030 if the target year is before), SBTi companies would need to achieve an annual reduction of 6.9% annually between 2019 and 2030 to achieve their targets. However, given that they have made more (reported) progress (on average) than could be expected assuming a linear pathway, the required annual targeted reductions have decreased to 5.2%. As we use inventory emissions, the additional historical reductions are incorporated in our results, and therefore historically high-performing companies are not credited for this action. Currently, there is ongoing discussion regarding the extent to which the self-reported progress of individual companies correlates with high ambition. Giesekam et al.[7] have raised questions about whether significant progress has genuinely led to additional actions, while Bolay et al.[43] have found that progress since the announcement of the target can be indicative of weak ambition. Hence, we proceed with the assumption that targeted reductions since the most recent reporting year (2019) reflect the current ambition of companies. Furthermore, this highlights the significance of monitoring, reporting and verification (MRV) concerning company GHG inventories and the establishment of targets, which remain focal points of discussion (see discussion).

It is important to realise that while we compare emission reduction targets resulting from government policies with those from voluntary company targets, the governance of these measures differs significantly. EU reductions are legally mandated and monitored and verified by designated EU institutions. However, the number of voluntary actions is much larger, and compliance is monitored and verified by non-party stakeholders such as academia or NGOs, without enforcement authority. Nevertheless, companies have a better understanding of their reduction potential compared to governments, and stakeholder demand could encourage increased ambition.

At the same time, guidelines for non-state action at the international level, including companies, are continually evolving, parallel to ongoing developments in domestic climate policies. An increasing number of countries and companies are adopting net-zero emissions reduction targets, and the UN High-Level Champions for Climate Action have proposed guidance on advancing such targets[44]. The current ETS cap, designed to ensure a 43% reduction relative to 2005 levels, was established in 2018 and has recently been adjusted to align with the Fit-for-55 package[45] and the updated EU Nationally Determined Contribution (NDC) target aiming for a 55% reduction relative to 1990 by 2030[46]. Furthermore, the transport and building sectors will be included within the ETS framework by 2027. In addition, improved insights from the Corporate Sustainability Directive[47] could enhance transparency and data availability for European companies. It is equally important to assess the progress companies make towards achieving their goals, which varies significantly among them[7]. This highlights that once the new EU policies have been implemented, and companies have adjusted their voluntary targets accordingly, a new assessment is needed to verify whether SBTi company targets are in line with long-term net-zero and 1.5 °C pathways, or even exhibit additional reductions to these goals.

Despite the challenges in securing reductions from higher voluntary ambitions regulated by ETS, the establishment of a fund that holds ETS allowances and prevents their re-entry into the market could increase potential reductions. This necessitates robust governance, including an independent fund manager and clear rules. In addition, a strict buy-and-hold approach is needed to ensure the effectiveness of this strategy[48]. However, further research is required to develop and guide the implementation of effective flanking measures and to uncover the factors contributing to the observed higher ambition among SBTi-affiliated companies operating under ETS regulation.

Three main areas for improvement are identified, all of which are currently constrained by data limitations. First, the emissions from SBTi companies are influenced by sector-specific characteristics and other EU policies, such as building codes or CO_2 performance standards for vehicles. Unfortunately, detailed sector breakdowns are unavailable in the current CDP dataset, which could differentiate reduction estimates from the ESR regulation. The transport and buildings sectors are the two largest sectors in ESR, representing 54% and 34% of emissions by 2030 (EEA, 2021). As for the ETS projections, it might be useful to distinguish projected emissions between electricity companies and other heavy industries, given that these industries receive free allocations. Second, insights into how SBTi companies implement their targets, especially in different countries and scopes, are lacking. Therefore, it is unclear if they diversify climate actions between countries and scopes or if they simply do not report them. We assume the applicability of the scope $1+2$ targets to the EU branches based on our assessment. Third, there is uncertainty about whether companies strictly adhere to the CDP guidance on reporting emission reduction targets, and whether the use of offsets could impact estimated emissions reductions[49].

In conclusion, the comprehensive policy and sector analysis employed in this study has provided significant insights into the interaction between regulation and voluntary commitments. In a general sense, if there is an overlap between regulations and voluntary commitments, especially if the former includes a fixed emissions cap and the trading of emissions allowances or credits, flanking measures are needed to ensure the realisation of additional reductions. If a conservative estimate is needed, it is prudent to assume no additional reductions unless the policy instrument allows exemptions. This principle holds true for all regions. How this plays out for cities is an interesting topic for future research.

METHODS

Data collection

The datasets used for this assessment were all released in 2020, and therefore 2019 was the last year for which historical data was collected. Both historical emissions and projections for ETS and ESR on the EU and Member State levels were retrieved from EEA[21,42,50,51], while emissions from companies regulated by ETS were available at EUETS.INFO[23], see Supplementary Methodology for details. The data in the EUETS.INFO dataset (referred to as EUTL dataset hereafter) is retrieved from the European transaction log (EUTL), which is the official registry that keeps track of allowances, transfers, and verified emissions for EU installations and account holders[28]. In 2020, this EUTL dataset totalled more than 5861 account holders and 12,646 installations (see Supplementary Methodology). The total GHG emissions covered by the ETS for the

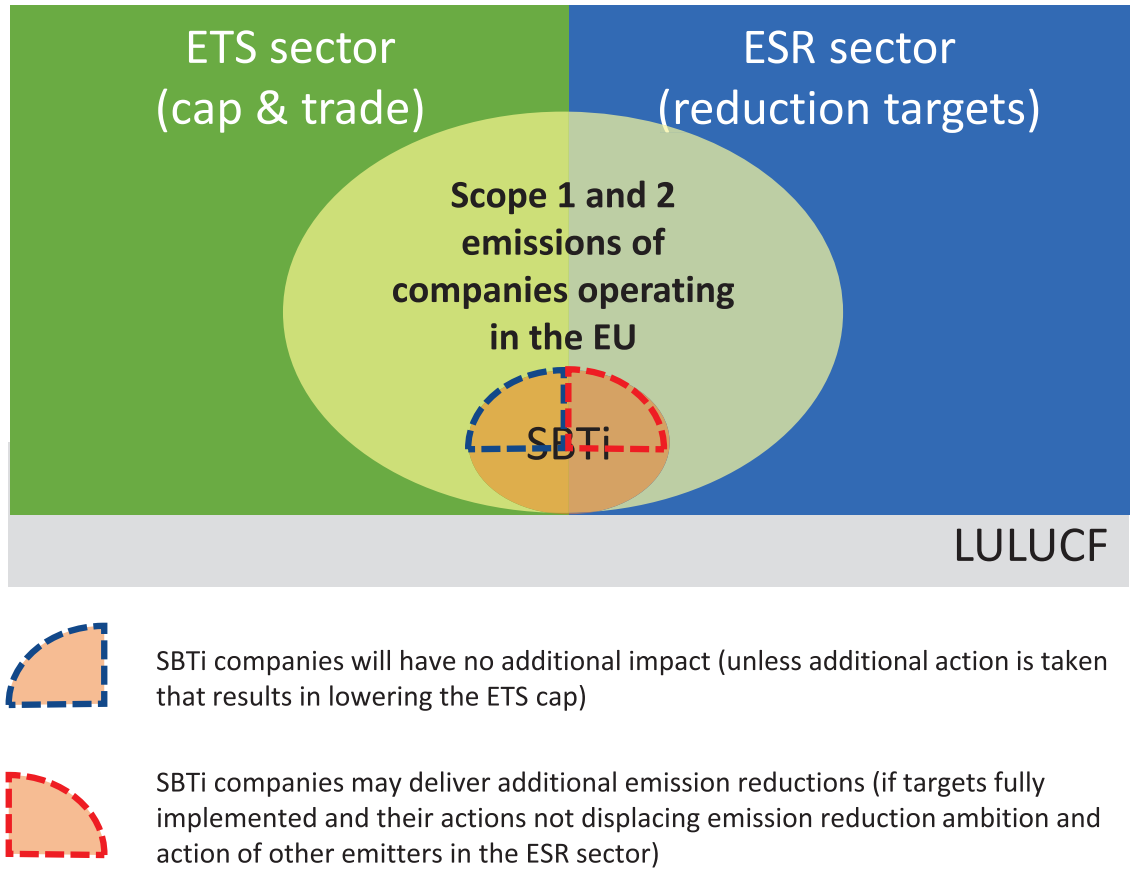

Fig. 3 EU companies' scope 1 and 2 emissions in the context of total EU emissions. The emissions scopes of EU companies can be covered by emissions from the (green) Emissions Trading System (ETS), (blue) Effort Sharing Regulation (ESR) or (grey) Land-Use, Land-Use Change and Forestry (LULUCF).

EU, Norway and Iceland were 1555 $MtCO_2eq$ in 2019, and the total ESR emissions were 2231 $MtCO_2eq$ by 2019[51].

The CDP dataset comprises responses from companies to the 2020 questionnaire[22,52,53]. CDP requires companies to report emission reduction targets that exclude offsets[52], although the extent to which this has consistently been followed remains uncertain[54]. The CDP data from 2020 does not explicitly differentiate between SBTi targets aligned with 2 or 1.5 °C trajectories.

Our selection processes included only companies for which quantifiable absolute emissions reductions could be determined, based on the scope, base year, most recent reporting year and targeted reduction information. When a company had multiple targets, we prioritised selecting the targets based on the ranking scope 1 + 2, scope 1 or scope 2. Subsequently, we chose the two targets closest to 2030. Our analysis identified 335 companies with SBTi-approved targets, accounting for 670 $MtCO_2eq$ emissions in 2019, of which 243 $MtCO_2eq$ were emitted by 200 companies across 1,067 branches situated within the EU (see Supplementary Methodology).

Coverage of policy instruments and additionality of targets

Prior to discussing the scenario development, it is essential to establish clear definitions for the terms 'additional impact of climate actions' and 'coverage of policy instruments', as these are key to this assessment.

Quantifying the impact of non-state climate actions, including those of companies, on greenhouse gas (GHG) emissions, both ex-ante and ex-post, remains at a relatively early stage compared to the assessment of policies from national governments at the country level. SBTi company commitments are potentially additional to EU policies if a company sets more ambitious targets that overlap with sectors and emissions linked to the EU policies[3]. Therefore, to determine the impact of SBTi targets relative to individual EU policies, first the coverage of SBTi emissions by the ETS and ESR instruments needs to be determined. Subsequently, additional reductions by 2030 are calculated in relation to the emissions levels companies would realise if they would follow EU ETS and ESR trends, encompassing all EU sectors except for LULUCF (see Fig. 3).

In this assessment, it is assumed that the voluntary company targets are fully achieved. The estimation of future additional impact involves determining the percentage of SBTi-associated emissions reductions that exceed the estimated emission reductions from national policy instruments, assuming corporate climate actions do not replace action elsewhere. This assumption is currently considered valid due to limited coordination in climate target-setting between national governments and companies[55]. If coordination at the national level increases, companies might adjust their strategic behaviour, potentially resulting in reduced efforts to mitigate emissions in other sectors or geographic areas. This phenomenon could be compared to carbon leakage observed between countries[11].

ETS and ESR coverage of company emissions

To determine the potential additionality of voluntary company targets to EU policies by 2030, the first step is identifying the EU policy instruments and emissions under which the SBTi company

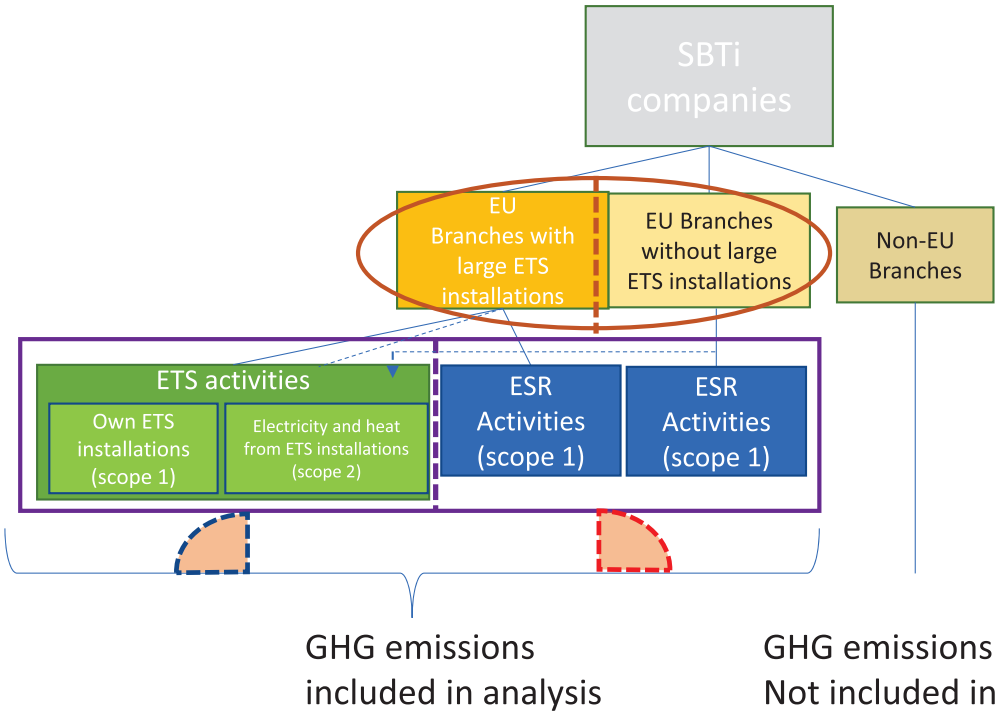

Fig. 4 Classification of emissions from companies with SBTi-approved targets operating in multiple EU branches. SBTi company activities resulting in GHG emissions are categorised into their coverage by EU policy instrument (ETS (green)/ESR(blue)). In addition, these companies are subdivided based on whether they own ETS installations (also representing industrial activities and aviation) (orange) or not (yellow), and the scope of the emissions: (direct) scope 1 emission (solid line), or scope 2 (purchased) electricity and heat emissions (dashed line).

emissions are regulated in 2020. These emissions from companies operating within the EU may stem from various branches located across distinct EU Member States. Company branches outside the EU, Norway and Iceland are not considered in this analysis (see Fig. 4).

GHG emissions targeted by SBTi companies can be categorised into those regulated by ETS or ESR, depending on whether the emissions are listed in the ETS directive[56–58] and the scope of the emissions. For each company, EU ETS emissions are calculated as the sum of the Member State, Norway and Iceland emissions. Scope 1 emissions encompass direct emissions resulting from company operations, whereas scope 2 emissions result from purchased electricity and heat[59]. Within the EU, Scope 1 emissions are regulated by either ETS or ESR (see solid line in Fig. 4), while indirect scope 2 emissions are always subject to ETS regulation, given that they are emitted by electricity companies operating large installations (dashed lines in Fig. 4).

To further differentiate between ETS and ESR coverage for scope 1 emissions, we must consider the company's classification:

1. Heavy industries owing ETS installations (including aviation), conducting other industrial activities, or operating in the domestic aviation sector are obligated to participate in ETS (referred to hereafter as 'companies with ETS installations').
2. Light industries, which do not meet the criteria for heavy industry (referred to hereafter as 'companies without ETS installations').

The Scope 1 emissions originating from the companies operating in the light industry are fully covered by ESR. On the other hand, within the heavy industry sector, scope 1 emissions are subject to the potential regulation of both ETS and ESR. If these emissions originate from activities such as electricity/heat production, energy-intensity industrial processes, or aviation they are regulated by ETS, while if they arise from activities not covered by ETS, such as heating of buildings or freight transport, they fall under ESR.

The classification discussed above is used to allocate the scope 1 and 2 emissions from the CDP dataset for the end of 2019 to either the emissions regulated by ETS or ESR. Instead of emissions, we also classify companies into those with and without ETS installations. We use the term ETS installations in this article for all companies that fall under ETS, including aviation companies. Both the CDP and the EUTL datasets are utilised for this classification (see Methods section on Data collection):

1. SBTi companies without ETS installations (light industry)
   a. SBTi companies present in the CDP dataset but absent from the EUTL dataset are not obligated to participate in ETS. Consequently, their scope 1 emissions are covered by ESR.
   b. All Scope 2 emissions within the CDP dataset from SBTi companies are covered by ETS, given they are generated by large installations from electricity companies.
2. SBTi companies with ETS installations (heavy industry)
   a. Scope 1 emissions from companies present in both the CDP and EUTL datasets are presumed to be covered by ETS. In cases where the scope 1 SBTi emissions exceed the EUTL-verified ETS emissions, the surplus emissions are assumed to fall under ESR.
   b. The Scope 2 emissions are handled in the same manner as those of SBTi companies without ETS installations, consequently falling under ETS.

To identify SBTi companies in the CDP dataset that are obliged to participate in ETS, we needed to match the company names with those from the EUTL dataset. As these names are not always

identical between the two datasets, we applied a fuzzy logic name-matching algorithm from Nijhuis[60] using the company names (see "Methodology" in Supplementary Methodology). It should be noted that ETS account holders with divergent names from those in the CDP dataset are especially difficult to identify and match.

For the companies with ETS installations, it is interesting to calculate the percentage of EU SBTi emissions covered by the ETS. This is defined as the total (scope 1 + 2) emissions from SBTi EU companies regulated by ETS, divided by total SBTi EU emissions. Subsequently, the percentage of EU SBTi emissions covered by ESR for these companies is 100 minus this percentage.

In addition to the ETS and ESR coverage, it is interesting to calculate the emissions coverage of the two different company types: with and without ETS installations. This coverage is calculated by dividing the sum of GHG emissions of companies that have both SBTi-approved targets and ETS installations by the sum of GHG emissions of all companies with SBTi-approved targets.

Flanking measures to materialise additional ETS reductions

Additional emissions reductions in the ETS sector will not yield additional reductions due to the waterbed effect[61]. This phenomenon arises because incorporating additional measures solely impacts which company emits, rather than altering the total reduced emissions as the ETS cap remains the same. This is analogous to the distribution of water in a waterbed that does not affect the volume[62]. Nevertheless, companies could introduce specific flanking measures to diminish the number of ETS allowances, thereby tightening the emissions gap in response to lower-than-anticipated emission levels under ETS. For instance, initiatives like the SBTi, or similar programs, could encourage or even oblige companies to cancel excess allowances as is done in voluntary schemes[63]. To achieve this, the allowances need to be taken out of the market and cancelled by holding them in a distinct mutual fund. It is imperative that these allowances remain unavailable for future market entry, as any later availability could potentially undermine the achieved emissions[48]. Nonetheless, even with the existence of the waterbed effect, insights on the reduction potential of companies could already give policymakers important information for the next round of ETS or economy-wide target setting. Within the ESR sectors, SBTi companies may deliver additional GHG impact if they do not replace emission reduction efforts elsewhere.

Scenario analysis

To calculate the potential additional emissions reductions achievable through SBTi targets in relation to EU policies, we have developed scenarios outlining alternative futures[64]. These scenarios are normative in nature describing possible situations in which specific policy targets are achieved, offering potential developments in the realm of climate policy and actions[65,66]. This scenario approach facilitates the comparison of different emissions levels from the group of SBTi companies by the year 2030, enabling the calculation of potential additional reductions attributed to corporate climate actions. Three scenarios were defined with distinct pathways that encompass the policies and targets that apply to SBTi companies up to 2020:

1. The EU 2020 policies scenario (PS).
2. The EU 2020 policies + SBTi scenario (PS+SBTi).
3. The EU 2020 policies + SBTi scenario + flanking measures (PS + SBTi+).

The starting point for all scenarios is the GHG emissions data for SBTi companies at the close of 2019 (see Supplementary Methodology) and the emissions trends for ETS and ESR between 2019 and 2030. The EU 2020 policies scenario (PS) acts as a reference, with emissions adhering to ETS and ESR emissions trends in accordance with the official EU ETS and ESR "With existing measures" (WEM) projections from the European Environment Agency[21]. The EEA WEM scenario is based on information submitted by EU Member States including the latest GHG inventories and projections up until 2035[21]. Each Member State assesses whether they are on track to meet the ESR targets and their anticipated emissions under ETS and for land use. The EEA quality checks these projections and aggregates them to the EU level. Both the resulting EU emissions projections for ETS and ESR in this scenario are projected to miss the stated policy targets, indicating more efforts are needed. We have chosen this policy scenario as a reference (and not the stated caps and targets) as this scenario starts from the 2020 inventory emissions. In addition, we are interested in what extent climate actions by companies could help the EU and its Member States in addition to current efforts. Note that it is assumed that the ETS and ESR trends from this scenario are applicable to each individual company.

The EU GHG emissions between 2019 and 2030 from the PS scenario (official WEM scenario) on average decline annually by 0.9% for ETS, while this is 0.8% for ESR[21,51]. Notably, these projected annual reductions fall below those implied by the ETS and ESR caps. The ETS projections do not meet the stated targets of a 43% reduction relative to 2005 as several Member States expect increasing emissions due to nuclear phase-out or increase in carbon-intensive industries and processes[67]. The ESR projections do not meet the stated targets of a 30% reduction relative to 2005 as 10 Member States reported increasing emissions until 2030, where especially reductions in the transport sector are relatively low[68]. In this scenario, the ESR projections differ across Member States due to the effort-sharing rule that establishes targets based on the gross domestic product (GDP). We assume that the estimated ESR reductions are achieved through policy implementation at the Member State level, coupled with overlapping EU policy instruments such as CO_2 performance standards for cars. The total EU GHG emission reductions excluding LULUCF in the WEM scenario were 8.8% relative to 2019 levels, 39.4% relative to 1990 levels, and 34.7% relative to 1990 including LULUCF[21,42].

In addition to the PS reference scenario, we have defined two scenarios that include both EU regulation and SBTi targets. The second of these two scenarios include flanking measures to materialise the potential high ambition relative to ETS. These scenarios start from the emissions in 2019 based on the allocation of the "Methods" section on ETS and ESR coverage.

The *EU 2020 policies + SBTi scenario (PS + SBTi)* starts from the 2020 PS scenario. In addition, this scenario presents potential additional reductions resulting from the implementation of SBTi-approved targets in comparison to EU policies by 2030. These reductions may also be negative, indicating an increase in emissions relative to PS. Due to the waterbed effect, additional reductions from SBTi targets are set to zero. Note that the assumption that emission reductions do not replace reductions elsewhere does not hold in this case. Unlike the situation for ETS, this scenario does anticipate additional reductions from SBTi emissions covered by ESR to lead to additional reductions (see the "Methods" section). SBTi targets with a target year set prior to 2030 are extrapolated to 2030 using the ETS or ESR annual reduction rates contingent on their coverage. Meanwhile, SBTi targets with target years after 2030 are linearly interpolated between 2019 and the target year.

In the *EU Current policies + SBTi + flanking measures scenario (PS + SBTi+)*, it is assumed that supplementary measures are undertaken such as the establishment of a distinct mutual fund to absorb surplus allowances and tighten the ETS cap. This step is taken to ensure locking in the additional SBTi emission reductions from companies that surpass the ambition implied by ETS. The assumptions for emissions covered by ESR are the same as for the PS+SBTi scenario.

Reporting summary

Further information on research design is available in the Nature Research Reporting Summary linked to this article.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, but restrictions apply to the availability of these data, which were used under license for the current study and are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of CDP. The results of the name matching of SBTi and EU ETS company names are available in the Supplementary Methodology. Data for Figs. 1 and 2 and publicly available data used in the analysis is available as Roelfsema, Mark (2023), "Supplementary data to 'Comparing ambition of EU companies with science-based targets to EU regulation-imposed reductions'", Utrecht University, V2, https://doi.org/10.17632/28c94dbhb9.2.

CODE AVAILABILITY

Due to restrictions on CDP data, the Excel code can not be provided. However, the aggregated results, list of included companies, and EU ETS (EU and company level) and ESR GHG emissions are available at https://doi.org/10.17632/28c94dbhb9.2.

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REFERENCES

1. Data-Driven EnviroLab & Utrecht University. *Global Climate Action. Progress and Ambition of Cities, Regions, and Companies*. https://www.uu.nl/sites/default/files/Global Climate Action_Cities%2CRegions%2CCompanies_Final.pdf (2022).
2. UNFCCC. *Global Climate Action (NAZCA)*. Actor tracking https://climateaction.unfccc.int/Actors (UNFCCC, 2023).
3. Hsu, A. et al. A research roadmap for quantifying non-state and subnational climate mitigation action. *Nat. Clim. Change* **9**, 11–17 (2019).
4. Sullivan, R. An assessment of the climate change policies and performance of large European companies. *Clim. Policy* **10**, 38–50 (2010).
5. Latapí Agudelo, M. A., Jóhannsdóttir, L. & Davídsdóttir, B. A literature review of the history and evolution of corporate social responsibility. *Int. J. Corp. Soc. Responsib.* **4**, 1 (2019).
6. Bjørn, A. et al. Increased transparency is needed for corporate science-based targets to be effective. *Nat. Clim. Chang.* **13**, 1–4 (2023).
7. Giesekam, J., Norman, J., Garvey, A. & Betts-Davies, S. Science-based targets: on target? *Sustainability* **13**, 1657 (2021).
8. Hultman, N. E. et al. Fusing subnational with national climate action is central to decarbonization: the case of the United States. *Nat. Commun.* **51**, 5255 (2020).
9. Kuramochi, T. et al. Beyond national climate action: the impact of region, city, and business commitments on global greenhouse gas emissions. *Clim. Policy* **20**, 275–291 (2020).
10. Lui, S. et al. Correcting course: the emission reduction potential of international cooperative initiatives. *Clim. Policy* **21**, 232–250 (2021).
11. Roelfsema, M., Harmsen, M., Olivier, J. G., Hof, A. F. & van Vuuren, D. P. Integrated assessment of international climate mitigation commitments outside the UNFCCC. *Global Environ. Change* **48**, 67–75 (2018).
12. Hale, T. et al. Sub- and non-state climate action: a framework to assess progress, implementation and impact. *Clim. Policy* **0**, 1–15 (2020).
13. EC. *A Policy Framework for Climate and Energy in the Period from 2020 to 2030*. (EC, 2014).
14. Geden, O. & Schenuit, F. *Climate Neutrality as Long-term Strategy: the EU's Net Zero Target and its Consequences for Member States* Vol. 33/2019 (Stiftung Wissenschaft und Politik -SWP- Deutsches Institut für Internationale Politik und Sicherheit, 2019).
15. Schoenefeld, J. J., Jordan, A. J., Schulze, K. & Hildén, M. Policy monitoring in the EU: the impact of institutions, implementation, and quality. *Polit. Vierteljahresschr.* **60**, 719–741 (2019) https://doi.org/10.1007/s11615-019-00209-2.
16. EC. *A Roadmap for Moving to a Competitive Low Carbon Economy in 2050* https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112 (EC, 2011).
17. EC. *Regulation on the Inclusion of Greenhouse Gas Emissions and Removals from Land Use, Land Use Change and Forestry in the 2030 Climate and Energy Framework* (EC, 2018).
18. Science Based Targets initiative. *From Ambition to Impact: How Companies are Reducing Emissions at Scale with Science-Based Targets*. Science Based Targets initiative Annual Progress Report, 2020 (Science Based Targets initiative, 2021).
19. CDP. CDP *Climate Change 2020 Questionnaire* https://guidance.cdp.net/en/guidance?cid=13&ctype=theme&idtype=ThemeID&incchild=1&microsite=0&otype=Questionnaire&tags=TAG-13071%2CTAG-605%2CTAG-599 (CDP, 2020).
20. CDP. Search and view past CDP responses, CDP https://www.cdp.net/en/responses (CDP, 2022).
21. EEA. *Trends and Projections in Europe 2020* (EEA, 2020).
22. CDP. *Explore CDP Data* https://www.cdp.net/en/data (CDP, 2020).
23. EUETS.INFO. Track Carbon Trade in Europe. (2022).
24. EC. *Impact Assessment Accompanying the Document—Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions—A Policy Framework for Climate and Energy in the Period* (EC, 2014).
25. EC. *Commission Decision (EU) 2020/1722 of 16 November 2020 on the Union-wide Quantity of Allowances to be Issued Under the EU Emissions Trading System for 2021* (EC, 2020).
26. EC. *Commission Decision of 22 October 2010 Adjusting the Union-wide Quantity of Allowances to be Issued Under the Union Scheme for 2013 and Repealing Decision 2010/384/EU* (EC, 2010).
27. EEA. *Notice on the Union-wide Quantity of Allowances for 2021 and the Market Stability Reserve under the EU Emissions Trading System* (EEA, 2020).
28. EC. *European Union Transaction Log, version 13.1.2EUTLP23-04-2021* (EC, 2021).
29. EC. *Effort sharing: Member States' Emission Targets* (EC, 2021).
30. EU, 2020a. COMMISSION IMPLEMENTING DECISION (EU) 2020/2126.
31. EU, 2018. REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.
32. EC. *The European Union, Iceland and Norway Agree to Deepen their Cooperation in Climate Action* (EC, 2019).
33. CDP. *Doubling Down. Europe's Low-carbon Investment Opportunity* https://cdn.cdp.net/cdp-production/cms/reports/documents/000/004/958/original/Doubling_down_Europe's_low_carbon_investment_opportunity.pdf?1586852291 (CDP, 2020).
34. Bai, X. et al. How to stop cities and companies causing planetary harm. *Nature* **609**, 463–466 (2022).
35. SBTi. *SBTI Corporate Net-Zero Standard* https://sciencebasedtargets.org/resources/files/Net-Zero-Standard.pdf (SBTi, 2021).
36. Hale, T. *Governing Net Zero: the Conveyor belt* https://www.bsg.ox.ac.uk/sites/default/files/2021-11/2021-11%20Hale%20Net%20Zero%20Policy%20Memo.pdf (2022).
37. United Nations Global Compact, We Mean Business, & World Resources Institute. *The Ambition Loop* https://static1.squarespace.com/static/5bbe243651f4d40801af46d5/t/5c00266c0e2e728a28cee091/1543513751309/The-Ambition-Loop.pdf (United Nations Global Compact, We Mean Business, & World Resources Institute, 2018).
38. van Soest, H. L. et al. Low-emission pathways in 11 major economies: comparison of cost-optimal pathways and Paris climate proposals. *Clim. Change* **142**, 491–504 (2017).`
39. Climate Analytiscs, NewClimate Institute, Country factsheet EU, https://climateactiontracker.org/countries/eu/ (Climate Analytics, NewClimate Institute, 2022).
40. Pan, X., Elzen, M., den, Höhne, N., Teng, F. & Wang, L. Exploring fair and ambitious mitigation contributions under the Paris Agreement goals. *Environ. Sci. Policy* **74**, 49–56 (2017).
41. Robiou du Pont, Y. et al. Equitable mitigation to achieve the Paris Agreement goals. *Nat. Clim. Change* **7**, 38–43 (2017).
42. EEA. *EU-27 Effort Sharing, ETS, LULUCF and Aviation Emission Trends and Member States' MMR Projections in the EU* (EEA, 2020).
43. Bolay, A.-F., Bjørn, A., Weber, O. & Margni, M. Prospective sectoral GHG benchmarks based on corporate climate mitigation targets. *J. Clean. Prod.* **376**, 134220 (2022).
44. UN HLEG. *Integrity Matters: Net Zero Commitments by Bussiness, Financial Institutions, and Regions* https://www.un.org/sites/un2.un.org/files/high-levelexpertgroupupdate7.pdf (UN HLEG, 2022).
45. EC. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'Fit for 55': delivering the EU's 2030 Climate Target on the Way to Climate Neutrality. COM/2021/550 fi* (EC, 2021).
46. EC. NDC Submission by Croatia and the European Commission on behalf of the European Union and its Member States. http://www4.unfccc.int/submissions/INDC/PublishedDocuments/Latvia/1/LV-03-06-EUINDC.pdf (European Commission, 2020).
47. EC. *Amending Regulation and Directive, as Regards Corporate Sustainability Reporting* (EC, 2022).
48. Doda, B., La Hoz Theuer, S., Cames, M., Healy, S. & Schneider, L. *Voluntary Offsetting: Credits and Allowances* https://www.carbon-mechanisms.de/fileadmin/media/dokumente/Publikationen/Bericht/2021_01_11_cc_04-2020_voluntary_offsetting_credits_and_allowances_1.pdf (2021).

49. Haya, B. et al. Managing uncertainty in carbon offsets: insights from California's standardized approach. *Clim. Policy* **20**, 1112–1126 (2020).
50. EEA. *Member States' Greenhouse Gas (GHG) Emission Projections 2020* (EEA, 2020).
51. EEA. *2020 GHG Projections, Reported and Quality Checked in 2019 and 2020* (EEA, 2020).
52. CDP. *CDP Climate Change 2020 Reporting Guidance*. https://guidance.cdp.net/en/guidance?cid=13&ctype=theme&idtype=ThemeID&incchild=1&microsite=0&otype=Guidance&page=1&tags=TAG-646%2CTAG-604%2CTAG-60A (CDP, 2020).
53. CDP. *CDP Full GHG Emissions Dataset. 2019 Summary* (CDP, 2020).
54. NewClimate Institute. *Corporate Sustainability Monitor 2023* https://newclimate.org/sites/default/files/2023-04/NewClimate_CorporateClimateResponsibilityMonitor2023_Feb23.pdf (NewClimate Institute, 2023).
55. Hsu, A. & Rauber, R. Diverse climate actors show limited coordination in a large-scale text analysis of strategy documents. *Commun. Earth Environ.* **2**, 30 (2021).
56. EC. *Establishing a System for Greenhouse Gas Emission Allowance Trading Within the Union and amending Council Directive 96/61/EC* (EC, 2018).
57. EC. *Include Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading Within the Community (amending Directive 2003/87/EC)* (EC, 2008).
58. EC. *Establishing a System for Greenhouse Gas Emission Allowance Trading Within the Union and Amending Council Directive 96/61/EC* (EC, 2003).
59. Greenhouse Gas Protocol. Greenhouse Gas Protocol—A Corporate Accounting and Reporting Standard. Revised Edition. (2004).
60. Nijhuis, M. *Company Name Matching* (DNB, 2022).
61. Verde, S. F., Galdi, G., Alloisio, I. & Borghesi, S. The EU ETS and its companion policies: any insight for China's ETS? *Environ. Dev. Econ.* **26**, 302–320 (2021).
62. Perino, G. New EU ETS Phase 4 rules temporarily puncture waterbed. *Nat. Clim. Change* **8**, 262–264 (2018).
63. Broekhoff, D., Gillenwater, M., Colbert-Sangree, T. & Cage, P. *Securing Climate Benefit: A Guide to Using Carbon Offsets* (2019).
64. Duinker, P. N. & Greig, L. A. Scenario analysis in environmental impact assessment: Improving explorations of the future. *Environ. Impact Assess. Rev.* **27**, 206–219 (2007).
65. Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T. & Finnveden, G. Scenario types and techniques: towards a user's guide. *Futures* **38**, 723–739 (2006).
66. Fauré, E., Arushanyan, Y., Ekener, E., Miliutenko, S. & Finnveden, G. Methods for assessing future scenarios from a sustainability perspective. *Eur. J. Futur. Res.* **5**, 17 (2017).
67. EEA. *The EU Emissions Trading System in 2020: Trends and Projections* https://www.eea.europa.eu/themes/climate/the-eu-emissions-trading-system/the-eu-emissions-trading-system (EEA, 2020).
68. EEA. *ETC/CME Report 8/2020: Trends and Projections Under the Effort Sharing Legislation. Overview on Developments and Drivers* https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-8-2020 (EEA, 2020).

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AUTHOR CONTRIBUTIONS

M.R. executed the data collection and analysis. Both M.R. and T.K. wrote the main text of the article. M.d.E. supported with literature, ideas and helped in all reviews from the report draft to the final version of the article.

COMPETING INTERESTS

The authors declare no competing interests.

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