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Comparative analysis of legal mechanisms to net-zero: lessons from Germany, the United States, Brazil, and China

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ABSTRACT

Amid mushrooming net-zero commitments and pledges made by states and non-state entities, a gap remains between those pledges, and the action needed in order to stay within the temperature goals of the Paris Agreement. In response, scholars and policymakers have started to examine physical, technological, economic, and policy pathways to net-zero emissions across different sectors. This article examines the existing legislation and litigation for a net-zero world in four jurisdictions: Germany, the United States, Brazil, and China. We propose a taxonomy for identifying and comparing existing legal mechanisms to reach net-zero across these jurisdictions. We identify and analyze different legislative and regulatory mechanisms that incorporate net-zero mandates and three net-zero litigation strategies in these countries. These jurisdictions provide a useful snapshot of the variety of legal mechanisms currently being used by, or imposed on, large emitting jurisdictions and entities. We then consider the critical ways in which climate law can contribute to, or hinder, emissions reductions in line with net-zero targets.

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Introduction

Achieving net-zero emissions presents significant challenges. The academic literature explores various strategies, policies, and technological advancements needed to achieve a state of net-zero greenhouse gas (GHG) emissions [1–4]. These studies emphasize the urgency and complexity of transitioning to a net-zero economy. Key themes from this body of literature include: long-term decarbonization pathways, renewable energy deployment; electrification and energy efficiency; decentralized and integrated energy systems; carbon pricing and policy instruments; technological innovations and research and development; and just transition and social considerations. The pathways towards achieving global net-zero are multifaceted and require changes to existing systems and practices, which can be difficult to achieve without strong and coordinated governance [5].

International climate agreements, like the Paris Agreement, establish a global legal framework for collective action and cooperation to address

climate change. The Paris Agreement provides a ‘bottom up’ governance structure, setting collective temperature goals and obligations of conduct for individual states. This bottom-up structure provides significant flexibility to states to determine the most nationally appropriate legal mechanisms they can use in order to meet the collective goals in the Paris Agreement and authorizes a diversity of nationally determined approaches [6,7]. Given the permissive approach of the Paris Agreement on how countries can reach the collective long-term temperature goals, countries can adopt a diversity of approaches in line with their national circumstances.

Domestically, climate legislation plays a critical role in achieving net-zero emissions. Such legislation includes legislative and regulatory mechanisms established through State-sponsored legal means that seek to address climate change [8]. Climate legislation can establish reduction targets, trajectories, and carbon pricing mechanisms. Sector-specific regulations can mandate low-carbon

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technologies and practices. Climate legislation can also prohibit deceptive practices and establish accountability mechanisms [9]. However, at the moment this diversity of approaches is not likely to meet the net-zero by 2050 goal [10]. Our article seeks to examine this diversity of approaches from the net-zero perspective.

Currently, there is not a significant amount of literature that examines legal mechanisms around net-zero [11], and we identify this as a research gap. While examining governance of carbon neutrality in net-zero commitments, Tan et al. [12] also highlight the scarce literature in this area. Hale et al. [13] analyze over 700 entities with net-zero targets and find that governance benchmarks for net-zero vary significantly, lack robustness and can result in greenwashing strategies. Existing literature assessing the governance mechanisms required to attain net-zero focuses on the effectiveness of corporate governance amid divergent models across different jurisdictions that try to regulate net-zero claims and pledges made by corporations and financial firms [14,15]. While the significance of climate legislation is recognized at both corporate and country levels, research on what these regulatory pathways might look like is mostly absent. A recently published net-zero stocktake revealed that economy-wide net-zero targets enshrined in domestic legislation have substantially increased in the past few years, while most regulations governing companies' net-zero targets were still limited to disclosure rules [16]. Maxwell et al. [17] analyze judicial pathways to assess the viability of a state or company's net-zero plan, and refer to some key cases. But a research gap remains regarding the potential contribution of legal mechanisms including both legislation and litigation towards achieving net-zero. Indeed, only one piece of literature examined the full range of legal mechanisms [11]. Further, there is no assessment of net-zero legal mechanisms used in the Global South or comparative analyses of various jurisdictions.

Our article provides a snapshot of what diverse national approaches look like in the context of net-zero pledges through discussion of a variety of legislative and regulatory mechanisms which incorporate net-zero mandates and standards in Germany, the United States, Brazil, and China. It identifies three net-zero litigation strategies and examines how these have been used in each of the countries selected.

Through comparative analysis, the article provides insights into existing legal mechanisms for

net-zero targets and highlights the need for further research to understand the effectiveness and risks associated with differing approaches in different jurisdictions. This article furthers a better understanding of the critical ways in which climate legislation and litigation can contribute to, or hinder, the delivery of emissions reductions in line with net-zero targets. The results highlight a trend toward states adopting a greater variety of legal mechanisms related to net-zero and provides a broad taxonomy for identifying and comparing them across jurisdictions.

Methodology

In response to gaps in the literature, this article develops a taxonomy to analyze domestic legal mechanisms to reach net-zero emissions, and applies this taxonomy to four countries. The taxonomy consists of a systematic framework for categorizing and comparing legislative, regulatory and litigation approaches and serves at least three important functions. First, it can help policymakers and analysts identify the key features and characteristics of different policies and assess their strengths and weaknesses in achieving net-zero emissions. Second, the taxonomy can help scholars and policymakers identify gaps and overlaps in existing policy frameworks. This knowledge enables refinement and enhancement of strategies for a more effective transition to a net-zero economy. Additionally, the taxonomy facilitates international comparisons and learning, as different countries and regions can use a common framework to analyze and compare their policy approaches. Finally, the study recognizes the importance of litigation in involuntarily imposing and enforcing net-zero goals.

In addition to directed, and state-controlled legislative and regulatory measures, state and companies are also affected by climate litigation which, in the past few years, have directly targeted state-based climate action (or inaction) as well as carbon major companies as a site of legal attention, and most recently, in some jurisdictions, as a focus of direct liability. While climate litigation can be unsuccessful in incentivizing state or non-state emissions reduction, the growing intersection between state and non-state obligations in climate change and climate litigation makes it an important part of the literature. Climate litigation can question long-held assumptions about the role of companies in climate change, and their liability for

climate-induced harms [18]. Climate litigation often falls outside of the traditional remit of state-centered regulation, but we rely on Julia Black's concept of de-centered regulation [19], which would include litigation. While a wider concept of regulation becomes untethered from the state, and its boundaries can become blurred, the benefits of a wider definition of regulation lies in the fact that it fully recognizes the dispersal of power between social actors, and between non-state actors and the state [5,6]. By developing a taxonomy to analyze different domestic legal mechanisms, policymakers, scholars, and analysts gain a valuable tool to guide the wide development of policies that can better support the transition to a net-zero economy.

This article then applies this taxonomy to comparatively analyze the legal mechanisms for achieving net-zero emissions targets in four selected jurisdictions: Germany, the United States, Brazil and China. The jurisdictions selected include countries that both have and do not have net-zero targets set in domestic law, and countries that both have or have not experienced litigation around net-zero targets (see Table 1). We selected countries that are high emitters, as well as countries where some of the largest emitting corporations have their headquarters (using the Carbon Majors 2020 Dataset) [20]. The selection aims to provide an understanding of the variety of legal mechanisms being used or imposed on large emitting jurisdictions with equal representation from countries in both the Global North and Global South.

Through conducting a comparative analysis, we identify different types of legislation and litigation currently being employed in these four jurisdictions to analyze similarities, differences and patterns across net-zero regulation and net-zero litigation of the selected jurisdictions, which helps to then identify relationships.

Legal mechanisms towards net-zero in four countries

Legislative and regulatory mechanisms

As mentioned in the introduction, we adopt an existing definition of climate legislation that

includes legislative and regulatory mechanisms established by any formal State-sponsored legal means that addresses the problem of climate change, whether focused on mitigation or adaptation, or cross-cutting [8]. The scholarship also refers to legislation and regulation in terms of primary and subsidiary legislation. Primary legislation encompasses acts of legislatures such as parliaments, whereas subsidiary legislation includes acts of regulatory agencies, for example federal agency regulations [21]. This article mainly uses the Climate Change Laws of the World (CCLW) database to identify these laws and policies [22], which defines climate laws as 'legal documents that address policy areas directly relevant to climate change mitigation, adaptation, loss and damage, or disaster risk management.'

Where states' net-zero commitments are anchored in laws, these often concern 'climate change framework laws' [23]. These laws purport to provide a comprehensive basis for climate change mitigation actions and establish targets, policies and institutions in an overarching manner [24]. Regulatory mechanisms around companies are somewhat more complex, as none of our case studies imposed legally binding obligations on businesses to reach net-zero. However, other regulatory mechanisms exist that aim to facilitate companies' net-zero transition, such as company reporting and disclosure rules, which is another instance where countries are taking a variety of approaches in the principles being applied and implemented.

In order to map and compare some of the different legislative and regulatory mechanisms in furtherance of reaching net-zero across the selected jurisdictions, we developed the following taxonomy: (1) Climate framework laws, and, as a sub-category, emissions removal legislation and (2) Company reporting and disclosure rules¹. Thus, two overarching categories of legislative and regulatory mechanisms emerge: those mandating net-zero and those facilitating net-zero.

Germany

Germany, among the four jurisdictions under examination, stands out for its highly sophisticated

Table 1. Snapshot of the location and net-zero considerations per country in this article's scope.

Country	Global South Country	Global North Country	Net-zero target in domestic law	Net-zero litigation
Germany	No	Yes	Yes	Yes
US	No	Yes	No	Yes
Brazil	Yes	No	No	No
China ⁵	Yes	No	Yes	No

regulatory mechanisms. Additionally, it serves as a notable case where regulators have proactively addressed net-zero litigation.

At the center is Germany's climate framework legislation, the Federal Climate Change Act, which provides for net-zero regulation (hereinafter 'CCA') [25]. As German climate policy is integrated in European Union (EU) climate policy [26], relevant EU rules are also touched on in this analysis where relevant. The European Climate Law [27] sets the EU's target of becoming climate-neutral by 2050, along with the intermediate target of reducing GHG emissions by 55% by 2030 which set the stage for further regulatory initiatives across the EU.

The initial (2019) version of the CCA pursued the long-term goal of reaching GHG neutrality by 2050 to limit the global temperature increase to well below 2°C and, if possible, to 1.5°C, above the pre-industrial levels (section 1). It also set the target to gradually reduce GHG emissions by at least 55% by 2030 relative to 1990 levels (section 3(1)). For post-2030, sections 4(6), (5) ordered the Federal Government to set the yearly emission reduction amounts by means of an ordinance with consent of the German parliament, the 'Bundestag.'

The legislation of emission reduction targets enabled judicial challenges of these targets [28]. In June 2021, the Bundestag amended the 2019 version of the CCA, only a few weeks after the order of the Federal Constitutional Court in *Neubauer et al. v. Germany* (2021) [29]. Arguably the amended CCA went further than the decision required. Pursuant to section 1, the net-zero GHG target was advanced to 2045, and now requires reaching negative GHG emissions after 2050. The interim target for 2030 was raised to 65% GHG emissions compared to 1990 levels. For 2040, an interim target of 88% GHG emissions reduction compared to 1990 levels was introduced (section 3(1)). Accordingly, the annual emission amounts were adjusted and updated in Annex 2.

Furthermore, the amended CCA introduced carbon dioxide removal (CDR) targets through section 3a and outlined minimum contributions exclusively for the Land Use, Land Use Change and Forestry (LULUCF) sector to climate mitigation for 2030, 2040 and 2045. The wording implies that there is no cap on a maximum CDR contribution to meet the climate targets [30]. The amended CCA does not address other negative emissions methods.

Revised in 2023, the EU's Regulation on land, land use change and forestry (LULUCF) Regulation [31] introduced a separate net carbon removal

target of 310 MtCO₂eq for the LULUCF sector by 2030. Further, the EU is looking to establish a voluntary Union Certification framework for carbon removals to quantify, monitor and verify carbon removals and address greenwashing [32].

The CCA remains silent on the use of negative emissions technologies (NETs), but the 2021 Coalition Agreement of the new government recognized the role of NETs to tackle residual emissions and the Coalition partners agreed to make further amendments to the 2021 version of the CCA [33]. One of the suggested amendments in legislation included the enhancement of the role of natural and technical sinks (such as bioenergy with carbon dioxide capture and storage (BECCS) or direct air carbon dioxide capture and storage (DACCS) to deal with residual emissions. To that end, the federal government is expected to legislate negative emissions targets for the years 2035, 2040 and 2045 [34].

While Germany's climate framework law does not impose a legally binding requirement on companies to reach net-zero, other legal mechanisms exist that may facilitate companies' net-zero transitions, such as mandatory reporting and disclosure requirements [35]. For instance, pursuant to section 5 of the CCA, the Federal Environment Agency may collect GHG emissions data from companies. Nevertheless, there exists no set of mandatory disclosure rules explicitly focused on climate. Instead, the German Commercial Code contains non-financial reporting requirements with indirect climate references [36,37]. In contrast, the EU's Corporate Sustainability Reporting Directive which entered into force at the beginning of 2023 will require in-scope companies to disclose transition plans [38].

The United States

There is no federal net-zero legislation in the United States. However, by way of submission to the UNFCCC of a Nationally Determined Contribution (NDC), President Joe Biden has set a GHG pollution reduction target of 50%–52% from 2005 levels by 2030, with a goal of reaching a carbon pollution-free electricity power sector by 2035 [39]. In addition, the Biden administration, by way of executive order, has set a general ambition of 'putting the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050 [40]. To achieve this, the Biden administration has declared that the federal government

will invest in infrastructure and new technologies to reduce emissions [40]. However, the administration has only directed federal agencies through executive order to reach these goals, with funding coming from the Bipartisan Infrastructure Investment and Jobs Act, the budget for fiscal year 2022, and the Inflation Reduction Act (IRA) [40]. In the US federal system, states are not included in such executive orders but are free to enact their own net-zero policies (i.e. New York's Climate Leadership and Community Protection Act) [41]. Executive orders are generally considered to be binding on federal agencies but typically presumed to not be judicially enforceable, and this order is unlikely to prove an exception to this general rule [42]. Moreover, such orders can be easily amended or reversed by the same or subsequent administrations.

The Inflation Reduction Act (IRA), enacted in 2022, contains certain provisions, largely tax incentives, meant to shape economic development in accordance with the net-zero commitment contained in the United States' NDC and other commitments under the Paris Agreement. These credits are available for investment, energy production, component part manufacturing, and carbon capture and sequestration. A cursory review of the numbers indicates that firms can qualify for these credits without being truly 'carbon neutral.' This is not to say that the IRA is not a welcome development as far as climate legislation is concerned. It is likely to spur on considerable investment in the clean energy space, although it is too early to tell what its impacts on the ground will be. While it is obvious more could be done, significant political and systemic barriers exist. Furthermore, many of the updates to old credits and newly created credits phase out after emissions from energy production in the U.S. have been reduced by 75% relative to the 2022 calendar year or the year 2032. As an overall assessment, this legislation is not sufficient to reach net-zero, and it should not be construed as 'implementing legislation' relative to the U.S. NDC.

The United States' federal securities regulator, the Securities and Exchange Commission (SEC), proposed a rule in March 2022 titled 'Enhancement and Standardization of Climate-Related Disclosures for Investors.' [43] The rule, projected to be finalized by the end of 2023, requires any domestic or foreign company traded on U.S. exchanges to include climate-related information in its registration statements and filings. Carbon offsets and

renewable energy credits (RECs) in transition plans are among the items which companies will have to report. The proposed disclosures are similar to those of broadly accepted disclosure frameworks, such as the Task Force on Climate-Related Financial Disclosures and the Greenhouse Gas Protocol, which many companies are starting to follow.

Brazil

Brazil adopted a framework law in 2009, but the country's regulatory approach to net-zero is currently in flux. Brazil's reduction targets were initially established in the national climate framework law [44], but only up to the year 2020. These are currently being reviewed in light of the more recent NDCs submitted by Brazil to the United Nations Framework Convention on Climate Change (UNFCCC). In its latest NDC update (March 2022) Brazil confirmed its commitment to reducing its GHG emissions by 37% by the year 2025, and by 50% by the year 2030, as compared with 2005. Brazil's commitments also include a long-term objective of achieving climate neutrality by 2050 (down from 2060 in the 2020 NDC), conditional on the receipt of financial transfers [45]. No specific policies or measures were put in place to pursue this long-term goal of reaching net-zero by 2050 [46].

There are no specific legal provisions imposing reporting obligations on companies for environmental or climate matters. There are, however, recent regulations issued by the Central Bank of Brazil and the National Monetary Council in September 2021, requiring financial institutions and corporations regulated by the Brazilian Central Bank, to disclose climate risks and information on environmental, social, and corporate governance (ESG) practices [47].

In May 2022, the administration of former President Jair Bolsonaro approved one of its few pieces of climate legislation. Federal Decree No. 11.075/2022, creates the National System for the Reduction of Greenhouse Gas Emissions (SINARE) and establishes the procedure for the elaboration of sectoral plans for mitigation of climate change [48]. The Decree initiates the path towards the development of a Brazilian carbon market, which could help set clearer action for the country to meet the long-term objective of climate neutrality from the updated NDC.

The decarbonization trajectory for net-zero emissions by 2050 in Brazil will require drastic

reduction of emissions from deforestation, reductions in the electricity sector, as well as technological innovations in all sectors [49]. Analysts hope that through the combination of new legislation, law enforcement and restoring the mandate and the resources of protection agencies, it will be possible for Brazil to be on track to achieve net-zero deforestation and long-term objectives of net-zero [50].

China

In 2021, the National People's Congress (NPC), the legislative body in China, passed the Chinese Communist Party's 14th 5-Year Plan [51]. The Plan, which is law upon passage by the NPC, contains a reaffirmation of the commitment to peaking emissions in 2030 and reaching net-zero by 2060 [51]. The only explicit target is to reduce carbon dioxide emissions per unit of gross domestic product (GDP) by 18%, and the GDP growth target is not explicitly capped [51]. While the adopted Plan indicates a commitment to reduction, without a cap on GDP that is binding, the 'percentage of GDP' figure should not be considered a legislative codification of a net-zero target; however, the commitment to net-zero by 2060 can be considered a legislative commitment to net-zero. As a part of this government-wide effort, China has begun the process of compiling a unified environmental code, which may develop additional legal mechanisms [52].

China's information disclosure regulations and rules constitute another potential regulatory mechanism that might be leveraged to reach net-zero. These regulations developed as the Chinese Communist Party (CCP) and Chinese state apparatus began to focus on a broader developmental theme of 'informatization' [53]. These regulations consist of an amalgamation of government transparency, direct democratic participation, open-source information, and also align with a growing focus on information technology and the tech sector of the economy [53]. Accordingly, a portion included rules and regulations around environmental impact information disclosure [53]. Specifically, the Ministry of Ecology and Environment published an Order in December of 2021 titled "Measures for the Management of Legal Disclosure of Enterprise Environmental Information" which mandates emission reporting [54]. These disclosure regulations combined with the cause of action contained in the most recent amendment to the Environmental

Protection Law open up a promising pathway to pursue net-zero in China [53].

Perhaps one of the more significant accomplishments for China made in furtherance of its net-zero ambitions is the implementation of a unified carbon market, the largest in the world constituting 40% of the country's national carbon emissions [55]. Since its launch in 2021, the emissions trading scheme (ETS) has gone through one compliance cycle, with the report on that cycle being published by the Ministry of Ecology and Environment [56]. The report considered the first compliance cycle a success. The market included 2,162 key compliance entities accounting for 4.5 billion tons of carbon dioxide, making China's ETS the largest in the world [56].

The regulatory mechanisms that China is using to reach net-zero, and to prevent greenwashing, are rapidly evolving. There are signs that the CCP and the government have the capability and intention of meeting or exceeding their international commitments, as well as their commitments to the Chinese people.

Litigation

There are multiple understandings of what counts as climate change litigation, and there are a wide range of cases that are categorized as climate litigation [57]. Climate litigation may extend beyond cases where climate change is at the core, to ones where climate change is one of many issues, or where addressing climate change is a clear motivation for, or consequence of, bringing a case, but may not be part of the legal arguments put to the court [57]. As such, climate litigation broadly defined includes lawsuits brought before administrative, judicial and other investigatory bodies, in domestic and international courts and organizations, that raise issues of law or fact regarding the science of climate change and climate change mitigation and adaptation efforts [58].

This article has developed a taxonomy for how to categorize litigation around net-zero that we hope can be helpful to future climate policy academics and future litigants. (1) 'Net-zero target compulsion' litigation that seeks to enforce net-zero targets or challenge the pathways for attaining them (such as over-reliance on negative emissions); (2), 'Net-zero target sufficiency' litigation that challenges the sufficiency of existing net-zero targets; and (3) 'Net-zero washing' litigation, which

challenges misleading net-zero claims (e.g. that over relies on negative emissions technologies).

Germany

In Germany, litigants have made use of a wide range of climate litigation strategies, and so the jurisdiction has experienced a lot of net-zero litigation across all categories of the taxonomy compared to other jurisdictions analyzed. Broadly, most of the net-zero litigation against national and subnational governments has scrutinized net-zero pathways, and litigation against companies, in turn, has challenged net-zero corporate pledges. The most prominent 'net-zero target compulsion' case is *Neubauer et al. v. Germany* (2021) [59]. Building on Lin's analysis we argue that the case's significance is threefold [11].

First, the Federal Constitutional Court inferred constitutional requirements for setting a climate neutrality target at the national level and considered a climate mitigation strategy without pursuing the goal of climate neutrality to be manifestly unsuitable [17].

Second, the Federal Constitutional Court set out constitutional requirements for climate neutrality pathways. It found the provisions of the initial CCA to be unconstitutional insofar as they lacked provisions on updating reduction targets post-2030 [60,61]. The Court thus made clear that 'under certain conditions, the Basic Law [the German Constitution] imposes an obligation to safeguard fundamental freedom over time and to spread the opportunities associated with freedom proportionately across generations.' Cases such as *Neubauer et al. v. Germany* illustrate how litigation can force states to set their net-zero pathways with interim targets in a timely and transparent manner and incorporate those into legislation [17].

The importance of choosing the 'right' net-zero pathway is further evident in the Court's engagement with tipping points and its efforts to evaluate climate change measures based on planetary science [61,62]. The Court considered tipping points to pose a particular risk to ecological stability and stressed their significance for the global climate as well as their potential for undergoing abrupt and often irreversible change. As a result, the Court stressed the importance of keeping global temperatures to 1.5°C. Despite the extreme dangers of crossing tipping points that the Court pointed out, it ultimately refused to demand a more ambitious

reduction path due to uncertainties regarding the remaining national carbon budget [62].

Only the reference to predictability and transparency enabled the Court to set the reduction path post-2030 earlier [62]. However, the Court's extensive engagement with tipping points suggests that they could pose a powerful benchmark against which transition plans could be assessed. Tipping points offer an opportunity to shift the focus from quantitative analysis to the preservation of both qualitative aspects of nature and society.

Third, the Court made important observations regarding states' reliance on NETs with emissions reduction targets [17]. While it acknowledged the use of NETs to meet the 1.5°C temperature goal, it explicitly stated that '*the only way* to significantly slow down human-induced climate change is by *reducing CO2 emissions*' (emphasis added). In this regard, the Court highlighted difficulties with the implementation of NETs on a larger scale connected to tipping points.

Another 'net-zero target compulsion' case strategy is evident in a case brought by Environmental Action Germany (DUH) against the German Government in November 2022 concerning the LULUCF sector [63]. This case seeks to enforce existing climate standards by highlighting the importance of terrestrial carbon sinks in reaching climate neutrality [58]. DUH demands the adoption of immediate climate measures to comply with the CDR targets for the LULUCF sector as stipulated in Section 3a para. 1 of the CCA. This case builds on conclusions from *Neubauer et al. v. Germany* (2021) and the constitutional obligation to pursue net-zero. DUH considered carbon dioxide removal to be essential in reaching climate neutrality. However, because DUH considered NETs such as direct air capturing and carbon storage to be tied to various uncertainties, DUH argued that they did not pose a reliable option for carbon dioxide removal. The significance of this case in 'net-zero litigation' lies in ensuring that existing climate measures suffice to fulfill existing carbon dioxide removal goals.

Germany also records an increasing number of climate-washing cases challenging corporate climate neutrality promises [64]. While the regional courts have employed varying standards [65], they have mostly taken a rigorous position in cracking down on these claims with outcomes favorable to climate action. The legal basis on which these cases are brought is German competition law [66].

These cases have mainly focused on product attributes; however, the scope and scale of these claims seems to be widening. DUH has initiated a series of legal proceedings against companies across various sectors, challenging the advertising of their products, their operations or the companies themselves as ‘climate neutral.’ DUH criticizes the justification of climate neutrality through carbon offsetting in general and especially in the light of insufficient compensation of various projects [67]. Going forward, climate-washing litigation in Germany may be used increasingly to tackle company-wide net-zero claims which, for instance, lack credible transition plans and/or are based on a misleading overreliance of NETs.

The United States

Few judicial cases have been brought in the United States that have challenged net-zero commitments specifically. There has been a raft of litigation at the federal level which challenge both lack of government action on climate change, as well as against corporate actors brought by states, cities and other sub-national actors for their contributions to climate change. At the moment, either these cases have been unsuccessful on standing grounds, or have not reached the merits stage yet. Corporate defendants have attempted many jurisdictional arguments to remove these cases to the federal level, where they would most likely be displaced under the *American Electric Power v Connecticut* case², but these efforts have recently been rebuffed by the Supreme Court³, so a decision on the merits, in at least some of these cases, are expected soon [68,69].

Almost all of the cases challenging net-zero specifically have recently been brought at the state level under the California Environmental Quality Act (CEQA), a statute that requires state and local agencies in California to assess the potential environmental impacts of proposed projects and to adopt mitigation measures to reduce or avoid those impacts. If a project is subject to CEQA, the agency responsible for approving the project must prepare an environmental impact report (EIR) or negative declaration, which evaluates the potential environmental impacts of the project and identifies mitigation measures to reduce or avoid those impacts [70]. We focus on these California-based cases in this section.

M-GHG-1 is a CEQA guideline referred to as the ‘Greenhouse Gas Emissions Modeling and Analysis’ guideline. It provides guidance to state and local agencies in California on how to evaluate the GHG emissions of projects subject to the California Environmental Quality Act (CEQA). The M-GHG-1 guideline provides a standardized methodology for evaluating and reporting GHG emissions from projects. It is expected that projects that are subject to CEQA will be consistent with the state’s goal of achieving net-zero GHG emissions by 2045.

In the last few years, California State Courts have upheld challenges of Climate Action Plans (CAPs), which are strategic documents that outline a community or organization’s actions and strategies to reduce GHG emissions and adapt to the impacts of climate change.

The Appellate State Court in *Golden Door Properties, LLC v. County of San Diego* emphasizes a few key points regarding the legitimacy of CAPs: 1) in order to be considered valid under CEQA, GHG offset measures set out in CAPs must comply with state standards for cap-and-trade carbon credits and be ‘real, additional, quantifiable, permanent, verifiable, and enforceable’; 2) agencies must exercise caution when allowing offsets to be acquired from outside of California and must ensure that such offsets meet state requirements; 3) agencies must be careful when deferring the details of mitigation measures and must include specific performance standards based on objective criteria; and 4) agencies are responsible for ensuring that offsets meet the aforementioned requirements and must establish criteria for evaluating offsets in mitigation measures [71].

It has yet to be seen if other states or the federal government will follow the judicial successes found in California challenging net-zero commitments. An increasing number of states are instituting net-zero targets by statutory and/or executive mandates, so more cases are likely to be brought in the near future [72].

It is important to note that there are several other types of net-zero litigation that are prevalent in the U.S. These include lawsuits that result in a net-zero plan to be included as part of a settlement [73–76]⁴, ‘anti-net-zero’ cases that seek to weaken the perceived market value of a business’ net-zero plan, claiming it is anti-competitive [77], and cases challenging existing net-zero plans as exacerbating environmental justice issues (so-called ‘just-transition’ cases) [78].

Brazil

So far there are no registered cases of litigation challenging net-zero targets in Brazil, but there is a lawsuit that has challenged a misleading NDC submitted by the national government. The lawsuit was filed by young activists, members of two NGOs (Engajamundo and Fridays for Future Brazil), against Brazil's former Minister of the Environment, former Minister for Foreign Affairs and the Federal Union. They claimed that the 2020 submission of Brazil's NDC was less ambitious than the previous one, presented in 2015, in breach of the Paris Agreement (enacted by Federal Decree 9.073/2017). Youths claimed that the reduction of Brazil's climate ambition through the use of accounting artifice constitutes 'climate pedaling' and requested an injunction until the effects of the new NDC were determined and it was updated in accordance with the progressiveness required by the Paris Agreement. The first decision by the Federal Civil Court of São Paulo rejected the injunction and the case is currently under appeal.

However, there is potential for litigation challenging corporate net-zero claims to emerge, using the established consumer protections, and potentially, the more recent regulations issued by the Brazilian Central Bank aiming at regulating ESG practices and bringing more transparency to the Brazilian market on the environmental and climate performance of financial institutions and large corporations.

Claims of 'net-zero washing' by major Brazilian companies have already started to be raised, and it is a matter of time before these are taken to the Brazilian courts. Last year, JBS, Brazil-based meat giant and the world's biggest beef business, announced that it aimed to achieve net-zero GHG emissions by 2040 [79]. The company pledged to cut its 'global Scope 1 and Scope 2 emission intensity' by at least 30% by 2030 against a base year of 2019, but according to a study JBS's emissions increased by 51% in the last five years [80,81]. In January 2023 a 'climate-washing' and fraud complaint was presented to the US Securities and Exchange Commission (SEC), calling for a full investigation into alleged misleading and fraudulent 'green bonds' issued by JBS. The complaint, filed by the NGO Mighty Earth, claims that JBS based the bond offerings on its pledge to achieve net zero emissions by 2040 – but that its emissions have in fact increased and the target excluded Scope 3 supply chain emissions that comprise 97% of JBS's climate footprint [80].

China

In China, climate litigation has remained focused primarily on more localized violations of anti-pollution laws, and historically, very few cases fit the scope of this report [82]. While recent amendments to the Environmental Protection Law have instantiated a cause of action on behalf of the environment, we have yet to see this cause of action leveraged to address 'greenwashing' in a meaningful way, or to enforce net-zero targets. Recent legal developments indicate that the judiciary will be a pathway that China seeks to use to achieve carbon neutrality.

A recent opinion released on February 17, 2023, holds promising guidance to lower courts. Included in the provisions is paragraph 3, directing courts to 'implement the most stringent system and the strictest rule of law ... [in] criminal, civil, and administrative laws ... and make the system a rigid constraint and an untouchable high-tension line.' [82] The opinion goes on to provide guidance on cases dealing with China's emissions trading system in paragraph 6 and paragraphs 17 to 21; environmental information disclosure pertaining to the financial sector in paragraph 9 and 12; and judicial reform in paragraphs 22 to 24 [82]. The Supreme People's Court also outlined 11 examples of the types of lawsuits lower Courts might expect to see, with an emphasis on the carbon trading market outlined above [82,83].

Although no net-zero cases have been initiated yet, there is significant promise in the coming decade for a wave of climate litigation in China, although there are constraints on civil society and limitations of the judiciary that must be considered.

Results

We identify a clear trend of increasing incorporation of net-zero concepts into various legal mechanisms among the selected jurisdictions and summarize the results of our findings in each jurisdiction using our taxonomy in Tables 2 and 3. Particularly given the wide variety of forms that the mechanisms can take in various legal systems, we believe the taxonomy will have utility in Of the selected countries, Germany was the only country that had a net-zero target in law, although we consider China to be a special case that does not quite fit our taxonomy, as will be outlined below. Apart from minimum contributions for the LULUCF sector, Germany does not yet have emissions removal legislation; however, NET targets are expected to

Table 2. Legislative and regulatory mechanisms.

	Net-zero target legislation	How the legislation defines net-zero	Emissions removal	Law or policy	Disclosure and reporting mechanisms
Germany	CCA (supplementing the European Climate Law (Regulation 2021/1119))	By the year 2045, greenhouse gas emissions shall be reduced to the point of net greenhouse gas neutrality. 'net greenhouse gas neutrality' shall mean an equilibrium between the anthropogenic emissions of greenhouse gasses from sources and the reduction in the volume of such gasses by means of sinks.	Silent on NETs, only minimum contributions of LULUCF sector	In law	There exists no set of State-level mandatory disclosure rules explicitly focused on climate. EU's Corporate Sustainability Reporting Directive which will be transposed into domestic laws will require in-scope companies to disclose transition plans
United States	No federal net-zero legislation Executive Order	NA	NA	Executive order - binding only on Federal agencies	(Proposed 2023) Securities and Exchange Commission "Enhancement and Standardization of Climate-Related Disclosures for Investors" - requires any domestic or foreign company traded on U.S. exchanges to include climate-related information in its registration statements and filing
Brazil	Net-zero legislation not currently in law	NA	NA	Pledge	No specific legal provisions imposing reporting obligations on companies for environmental or climate matters
China	14th 5-Year Plan (March 2021)	'Implement the 2030 Nationally Determined Contributions to Climate Change, and formulate an action plan for peak in carbon emissions by 2030' 'Anchor efforts to achieve carbon neutrality by 2060 and adopt more powerful policies and measures'	Silent on NET	Policy document enacted by legislation ⁶	The Ministry of Ecology and Environment published an Order in December of 2021 titled "Measures for the Management of Legal Disclosure of Enterprise Environmental Information" which mandates emission reporting

be introduced into the existing framework legislation. Corporate disclosure and reporting rules, in contrast, were found to be relatively weak, although recent changes at the EU level will influence these. Unsurprisingly, we found that Germany had the most litigation around net-zero, as well as the most diversity in how that litigation proceeded. The landmark case, *Neubauer et al. v. Germany*, was one of the first cases to challenge a state's net-zero pathway as being insufficient, starting a wave of 'net-zero target compulsion' cases in Germany. Additional net-zero litigation in Germany targets companies and challenges misleading climate neutrality promises. In the past, most of these cases have focused on product attributes; however, these cases have now expanded to encompass company-wide climate neutrality advertising. While these cases have mainly scrutinized the reliance on carbon offsetting, there is potential for this type of litigation to focus on a misleading overreliance of NETs.

The United States has not promulgated a federal net-zero target in law, but it has set net-zero targets by way of a presidential Executive Order as well as in its NDC pursuant to the Paris Agreement. Regardless, on a federal level there is no legally binding regulation on net-zero as these policies are usually not enforceable in court. It has been up to the states to create their own more stringent regulations. Although we limited the scope of our article to national legislation and litigation, we found it useful to open our research to state-level activity due to the unique autonomy afforded to states. California is the leading state for both setting a net-zero pathway and enacting legislation to enforce them, and similar to Germany, where there exists legislation regarding net-zero, litigation follows. Unlike Germany though, the majority of net-zero litigation in California fell under 'net-zero washing' that challenged actors' reliance on NETs to reach their net-zero goals.

Brazil has neither net-zero targets in law, nor net-zero litigation. China has set net-zero targets, but has yet to see net-zero litigation, and is considered a special case that did not quite fit our taxonomy, thus highlighting the limitations of using a Global North perspective to conduct a comparative legal analysis. Both countries' regulatory frameworks are undergoing changes which might facilitate the net-zero transition. It appears that large emitting countries in the Global South are taking on the regulatory net-zero project. In China,

Table 3. Litigation.

	'Net-zero target compulsion' litigation	'Net-zero target sufficiency' litigation	'Net-zero washing' litigation
Germany	Yes	Yes	Yes
United States	Yes	No	Yes
Brazil	No	No	No
China	No	No	No

company reporting and disclosure rules are opening up a promising pathway to reach net-zero. In Brazil, claims of 'net-zero washing' by major Brazilian companies have already started to be raised and we find potential for litigation challenging corporate net-zero claims, using already established consumer protection rules. Similarly, we find China to be at the cusp of a wave of climate litigation.

Conclusion

The concept of 'net-zero' has gained momentum only in recent years, and consequently, litigation challenging net-zero claims is just beginning to emerge. By developing our own taxonomy, we aimed to enhance understanding of the range of legal mechanisms employed by and in selected jurisdictions to achieve net-zero emissions. This article offers a snapshot of existing net-zero regulations and their intersections with litigation across four jurisdictions. Our research acknowledges the challenges inherent in analyzing a country like China due to language barriers, cultural differences, and variations in governance structures. It is important to note that our sample size was limited.

Future research endeavors may focus on examining indirect net-zero legal mechanisms facilitated by consumer protection rules. Additionally, expanding the scope to encompass all net-zero cases across jurisdictions, including provincial and local levels, and incorporating a temporal component to quantitatively study the relationship between legislation/regulation and litigation could be valuable. Furthermore, exploring cases challenging carbon offsets or reductions in general, and present promising avenues for future research.

Countries have embraced diverse legislative, regulatory and litigation pathways toward achieving net-zero emissions, aligning with the expectations set forth in the Paris Agreement. Analyzing various domestic legislative and regulatory approaches can help identify best practices and valuable lessons that can inform the development of effective policies in other countries or regions. Despite some observed similarities, our analysis revealed significant divergence in approaches among the four

jurisdictions examined. Nevertheless, certain trends emerged, such as the relative underdevelopment of climate disclosure rules. Existing literature lacks comprehensive analyses of this wide diversity of legal mechanisms, underscoring the significance of our findings.

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Data availability statement

All data are publicly available and properly cited. This article uses the Climate Change Laws of the World (CCLW) database to identify legislative and regulatory mechanisms. All documents are available at <https://climate-laws.org/>.

Notes

1. For the purpose of this paper, we are considering the scope of company reporting and disclosure as defined in the report entitled "Recommendations of the Task Force on Climate-related Financial Disclosures" published in June 2017 by the Task Force on Climate-related Financial Disclosures, available at: <https://www.fsb-tcfd.org>. The list of disclosure mentioned in various sections is not meant to be exhaustive but is more illustrative of the variety of approaches taken by different jurisdictions.
2. 564 US Sup Ct 2011, holding that the Clean Air Act displaces any federal common law claim seeking abatement of carbon dioxide emissions
3. See, for example, *Juliana v United States* No. 18-36082 (9th Cir. 2020) which failed on standing grounds. There are multiple legal actions brought by states, cities, municipalities and even

private industry such as fishing groups against a diversity of carbon major companies.

4. Another regulatory mechanism is provided by the U.S. Federal Trade Commission (FTC), an independent agency originally founded to enforce antitrust legislation which now serves as the primary federal consumer protection body. Article 5 of the FTC Act, the 1914 law that created the agency, prohibits ‘unfair or deceptive acts or practices in or affecting commerce.’ [80] The FTC can bring lawsuits against companies found to have violated the Act, such as the successful 2017 case that required Volkswagen to compensate consumers who purchased cars marketed as running on ‘clean diesel.’[81]
5. By virtue of the socialist character of the Chinese political economy, the single party system of governance, and the relative youth of the political project as a whole, fitting China into the taxonomy developed herein is necessarily challenging. However, instead of dismissing China as a known quantity, as is sometimes the tendency in Western and Global North academia, we sought to make a good faith effort to push back against implicit biases, and seek primary source policy documents and legislation to supplement our research and ensure that this article would cover a diversity of jurisdictions, not just those familiar to us.
6. The full 5-Year Plan was produced by the Chinese Communist Party and passed into law by the National People’s Congress.

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