17 June 2022

Chair Gary Gensler
Securities and Exchange Commission
100 F Street NE
Washington, DC 20549

Re: Statement Welcoming Public Input on Climate Change Disclosures (File #S7-10-22)

Dear Chair Gensler:

On behalf of the Center for Human Rights and Environment (CHRE) and the Institute for Governance & Sustainable Development (IGSD), we would like to thank you and the Securities Exchange Commission (SEC) for seeking public comments on the proposed *Rule to Enhance and Standardize Climate-Related Disclosures for Investors*. We applaud the SEC's increased emphasis and recent "all-agency" actions on environmental and climate disclosures.

The authors of this comment have an extensive background in climate mitigation and corporate accountability. Daniel Taillant, executive director of the Center for Human Rights and Environment (CHRE), has experience developing global corporate disclosure standards, guidance, and other technical materials. He was directly involved in the development of the United Nations Guiding Principles on Business and Human Rights, which include a strong focus on environmental and social governance. Durwood Zaelke, founder and President of the Institute for Governance & Sustainable Development (IGSD), works on fast mitigation strategies to protect the climate, including reducing short-lived climate pollutants. IGSD and CHRE work with partners around the world to promote fast climate mitigation to limit planetary warming enough this decade to stay within the internationally recognized 1.5 °C target for a relatively safe planet.

As elaborated in this comment, and given the urgent need to address climate change and avoid catastrophic climate tipping points, we highly encourage the SEC to further strengthen and expand climate-change-related disclosures in its integrated disclosure system. To understand and appreciate climate-related risks, investors and market participants need disclosures on emissions of climate pollutants, on companies' plans for the transition to a low- or zero-carbon economy, and on the role that publicly traded companies play in causing, adapting to, and mitigating climate change.

It is important that climate-related disclosures include a registrant's key greenhouse gas (GHG) emissions, including carbon dioxide (CO_2) and other, more powerful climate pollutants such as methane, hydrofluorocarbons (HFCs), and black carbon (soot), which is an aerosol. Disclosure on these non-CO_2 "super pollutants" (also known as SLCPs, or short-lived climate pollutants) is critical, as this is the only way to slow warming in the near-term, as even the most aggressive decarbonization efforts to cut CO_2 are not able to avoid any significant warming until mid-century, with most benefits of decarbonization starting around 2060 through end-of-century.

Registrants should also detail their plans for the energy transition, including addressing climate risks, uncertainties, and known or probable impacts of their activities, climate change's expected impacts on their activities, suppliers, and customers. Narrative reports also should disclose existing climate-related legal proceedings involving the registrant, relevant policy and management decisions, and opportunities to address climate change. Without adequate planning, registrants face larger risks related to climate mitigation and adaptation, as well as transition planning.

Specific climate-pollutant disclosures (CO_2 as well as super pollutants) are imperative given the science that limiting global warming to 1.5 °C is necessary to slow self-reinforcing feedbacks and avoid irreversible tipping points that are expected to have devastating impacts. Warming above 1.5 °C would destabilize the economy and multiply financial and operational uncertainties and disruptions.

Additionally, both global climate policies and U.S. policies recognize the existential threat posed by climate change—a threat that will require all actors to reduce emissions of climate pollutants. Such actions are accelerating as U.S. and global leaders are beginning to look to 2030 as a new target for enhanced climate action. In light of this policy priority, corporate climate disclosures are urgently needed.

Our comment is organized into three sections with direct responses to select questions attached. We first explain the science that underpins the 1.5 °C climate-change target, and discuss methods for avoiding the worst consequences on registrants and their communities. We then present our recommendations for science-based climate disclosures, followed by the justification for such disclosures. As we explain further, this comment is focused on the super pollutants that hold the greatest potential for temperature abatement leading up to 2050. We also present our recommendation to incorporate an environmental justice framework in climate disclosure requirements, as the fast mitigation strategy best addresses the immediate needs of climate-vulnerable and historically marginalized communities. Finally, we recommend that the SEC enforce funding disclosures of trade associations and other organizations concerned with climate, including organizations promoting climate denial.

1. Science Supporting a 1.5 °C Target and Mitigation Methods for Achieving it

According to the Intergovernmental Panel on Climate Change (IPCC), keeping the planet livable by limiting warming to 1.5 °C with no or limited overshoot requires reducing global human-caused methane emissions by 34% in 2030 and 44% in 2040 relative to modelled 2019 levels, in addition to cutting global CO_2 emissions in half in 2030 and by 80% in 2040, and deep cuts to other SLCPs and nitrous oxide.[1] This further confirms the conclusions of the IPCC's Special Report on Global Warming of 1.5 °C that identified the three strategies that are essential for keeping the planet livable: (i) reaching net zero CO_2 by mid-century; (ii) making deep cuts to SLCPs super pollutants in the next decades; and (iii) removing up to 1,000 billion tons of CO_2 from the atmosphere by 2100.[2] Of these three strategies, cutting SLCPs can slow warming one to two decades sooner than

CO_2-focused strategies alone, avoid two to six times more warming at 2050 than CO_2 cuts can,[3] and reduce projected warming in the Arctic by two-thirds and the rate of global warming by half.[4]

Addressing the near-term climate emergency requires selecting fast mitigation solutions[5] that provide the most avoided warming in the shortest period of time over the next decade or two; slow the self-reinforcing feedbacks and avoid tipping points;[6] and protect the most vulnerable people and ecosystems[7] from the heat, drought, flooding, and other extremes that will dramatically increase in severity and frequency with every increment of additional warming.[8] *Only a dual assault on CO_2 and SLCPs, particularly methane, would make it possible for the world to keep the 1.5 °C guardrail in sight and stay below 2 °C.*

Yet the world has already reached 1.2 °C of warming,[9] which is accelerating self-amplifying feedbacks that exacerbate warming and edge us closer to passing climate tipping points. Six tipping points are projected to occur between 1 °C and 1.5 °C, with another 11 tipping points projected between 1.5 °C and 2 °C.[10] Crossing these tipping points would trigger shifts in the Earth's climate regimes, some of which are irreversible on a human timescale and could push the climate towards a "hothouse Earth."[11]

An example of this is Arctic sea ice loss. Over the past several decades, the Arctic air temperature has been warming at four times the global average,[12] with the Barents Sea warming five to seven times the global average.[13] As a result, the extent of Arctic sea ice—a white shield reflecting incoming solar radiation safely back to space—is shrinking,[14] as is the Arctic land-based snow and ice.[15] Scientists project that the Arctic ocean could be ice-free in late summer in the next decade or two, much sooner than the IPCC originally estimated.[16] In the extreme case when all Arctic sea ice is lost for the sunlit months, climate forcing equivalent to one trillion tons of CO_2 would be added to the climate system—on top of the forcing from the 2.4 trillion tons of CO_2 added in the 270 years since the Industrial Revolution—, advancing warming by 25 years, and perhaps twice this amount if cloud cover dissipates.[17] The reduced albedo from the melting of the Arctic land-based snow and ice could double the climate impact. [18]

Decarbonizing the energy system and achieving net-zero CO_2 emissions is critical for stabilizing the climate and keeping temperatures below 1.5 °C by the end of this century, but cutting CO_2 alone is not able to achieve this target.[19] In fact, reducing the burning of fossil fuels like coal and diesel also cuts co-emitted cooling aerosols, primarily in the form of sulphates (SO_2) and nitrates. Co-emitted cooling aerosols are reflective particles that currently mask warming of about 0.5 °C.[20] While the accumulated CO_2 in the atmosphere will continue to cause warming for decades to centuries, these cooling aerosols fall out of the atmosphere in days to months, and this aerosol unmasking offsets reductions in warming from decarbonization until around 2050 and even adds warming over the first decade or more.[21] Even without accounting for the warming from reducing cooling aerosols, peaking CO_2 emissions in 2030 and reaching carbon neutrality in the 2060s would only avoid 0.1 °C of warming by 2050, although the benefits of this strategy accrue quickly starting around 2060 through the end of the century.[22]

The IPCC's *Sixth Assessment Report* (AR6) confirms that the shift from fossil fuels to clean energy is unmasking hidden warming of up to 0.5 °C that cancels out the cooling benefits of decarbonization until around 2050, underscoring the importance of cutting non-CO_2 super climate pollutants:

> "Sustained methane mitigation, wherever it occurs, stands out as an option that combines near- and long-term gains on surface temperature (*high confidence*) and leads to air quality benefits by reducing surface ozone levels globally (*high confidence*).… Additional [methane] and [black carbon] mitigation would contribute to offsetting the additional warming associated with [sulphur dioxide] reductions that would accompany decarbonization (*high confidence*)."[23]

Cutting super pollutants is the only known strategy to slow feedbacks, avoid catastrophic tipping points, and keep the 1.5 °C limit within reach.[24] Leading scientists—including the IPCC—tell us that we must cut emissions of the most polluting emissions within a very short period, i.e. before 2030.[25] In this framework, one can think of CO_2 emissions reductions as a long-term marathon, and the reduction of super pollutants—especially methane, hydrofluorocarbon (HFCs), black carbon, and tropospheric ozone—as a short-term sprint. Although super pollutants have greater warming effects than CO_2 they stay in the atmosphere for shorter periods, making them the perfect target for bending the warming curve in the next 20 years while the world transitions to a low- or zero-carbon economy.[26]

Methane is of particular concern to many regulators, investors, and executives. Methane is 86 times more potent than CO_2 over a 20-year period, but only stays in the atmosphere for around 12 years.[27] Methane is the second-most-damaging greenhouse gas after CO_2, but because of the short time it stays in the atmosphere, reducing methane this decade will result in rapid temperature abatement. The *Global Methane Assessment* from the Climate & Clean Air Coalition (CCAC) and United Nations Environment Programme (UNEP) confirms that cutting methane emissions is the fastest strategy to limit warming over the next 20 years.[28] Pursuing all methane mitigation measures this decade is the only known way to avoid nearly 0.3 °C of warming by the 2040s and slow warming by 30%.[29] AR6 confirms that "strong, rapid, and sustained methane reductions" are key to limiting warming in the near- and longer-term.[30] Further, the most recent IPCC report on climate solutions reinforces that deep and rapid cuts to methane emissions are essential to limiting warming in the near-term and shaving peak warming from overshooting 1.5 °C.[31] Limiting warming to 1.5 °C with little or no overshoot requires reducing emissions by 34% below 2019 levels in 2030 and 44% below 2019 levels in 2040.[32]

Cutting HFCs and black carbon (soot) will similarly reduce warming significantly by 2050. The CCAC estimates that widespread action to reduce methane, HFCs, and black carbon could avoid up to 0.6 °C of warming by 2050, and up to 1.2 °C by 2100,[33] which would reduce projected warming in the Arctic by two-thirds and the rate of global warming by half.[34]

Avoiding this level of warming in the near term is crucial to minimizing risks to market participants, companies, and communities.[35] Reducing super pollutants must complement the herculean efforts needed to reduce CO_2 emissions in the long term. If public and private sector actors cut these super pollutants first, we will take a significant and critical step towards the recognized target of keeping global warming to 1.5 °C. If we do not cut super pollutants significantly in the next decade, companies and communities will face greater climate-related risks and disruptions.

2. Recommendations for Science-Based Climate-Related Disclosures

The private sector is both implicated in the need to abate emissions of super pollutants and will be impacted by the worsening consequences if we crash through the 1.5 °C guardrail for a relatively safe planet. The SEC has a unique opportunity to help companies move in the right direction by guiding and requiring registrants to report on activities that have immediate impacts on climate trends, including critical emissions data and information on climate-related management and policies.

We agree with other commenters on the importance of disclosing all relevant GHG emissions, including CO_2. But, given the need to quickly limit warming, as well as the scientific global consensus regarding the importance of major climate action before 2030,[36] we specifically urge the SEC to expand disclosure requirements on the following key super pollutants and issues:

1. Quantitative reports of emissions of methane, HFCs, tropospheric ozone, and black carbon;
2. Quantitative emission reduction targets for methane, HFCs, tropospheric ozone, and black carbon;
3. Short-term (10-year) and mid-term (20-30 year) emissions reductions and energy transition plans; *and*
4. Governance systems, policies, monitoring systems, and oversight mechanisms related to climate-related risks and opportunities.

Transition plans for a low- or zero-carbon economy should incorporate information commonly framed as Environmental, Social, and Governance (ESG) disclosures. A key component of the energy transition is a workforce transition to sustainable industries.[37] Additionally, climate change and the economic damages caused by a warming planet disproportionately impact already-disadvantaged communities and developing countries.[38] Without explicitly addressing equity concerns, responses to climate change could be impaired by and exacerbate these injustices.[39]

The SEC should establish expectations, requirements and guidance on disclosures related to super pollutants, including methane, tropospheric ozone, black carbon (soot), and hydrofluorocarbons (HFCs). Such disclosures are necessary because reducing super pollutant emissions is the only way to slow near-term warming. Climate-related disclosures should also include reduction targets for super pollutants and short- and mid-term climate mitigation plans. These disclosures will inform investors about registrants' efforts to limit near-term climate-related risks by adapting to current threats while avoiding the worst consequences of climate change. Disclosures can also focus on complementary strategies such as energy efficiency, which reduce a company's need for cooling, which will reduce HFCs and CO_2 while lowering the economic costs related to energy consumption.

Additionally, registrants should report in narrative form on their corporate climate policies and plans for responding to and participating in the transition to a low- or zero-carbon economy that is underway. Disclosures should include the policies, management practices, monitoring systems and targets in place to address climate change and reduce emissions in the near-term (10 years) and medium-term (20-30 years). These plans should address the threats that impacts from climate change pose to registrants, suppliers, and their customers. Additionally, companies should be planning for "fat tail" climate risks, ie: that warming may be greater than expected, partially because of feedbacks and tipping points, and thus the consequences worse.[40] Building on currently existing requirements, this narrative report should address the registrant's actions related to the changing legal and regulatory environment.

The SEC can guide and build upon evolving corporate climate disclosure frameworks by distinguishing and setting the standard for *short-term* climate disclosures, in parallel to long-term disclosures. We specifically recommend the SEC work with the Sustainability Accounting Standards Board (SASB) and the Global Reporting Initiative (GRI) in this endeavor. A new global approach is warranted for corporate disclosures to accompany the new policy framework that is consolidating globally on the most effective strategies to contain and reverse climate change. As described in an April 2021 report by SASB and GRI, companies can use both standards for comprehensive reporting, and many already do.[41] SASB and GRI are insufficient, however, with regard to short-term planning and super-pollutant reductions. They can be strengthened by expanding required disclosures to super pollutants and short-term strategies to promote fast climate action. The SEC can help to lead this process by integrating the four disclosure requirements recommended above.

We further advise the SEC to consult regularly with key global agencies and institutions advancing climate strategies, targets, and policies on climate change to craft guidance and disclosure requirements that are based on leading science related to climate-related risks and opportunities. For a perspective on the importance of super pollutants and fast climate mitigation to 2030, the SEC should consult the UN's Climate and Clean Air Coalition (CCAC). The CCAC provides knowledge, resources, and technical support to help the private and public sector reduce methane, black carbon, HFCs, and tropospheric ozone. For example, the CCAC released the landmark *Global Methane Assessment* that shows the global reductions in methane needed to keep a 1.5 °C target within reach.[42] The U.S. is currently the co-chair of the CCAC, with Rick Duke, Senior Advisor and White House Liaison for Special Presidential Envoy for Climate John Kerry, serving in that role. The IPCC and other scientific experts can advise on the short- and mid-term risks registrants will face under different emissions scenarios.

Finally, we urge the SEC to adopt a "double materiality" disclosure regime, in which registrants would report both how their activities are affected by climate change and how their activities affect climate change. Such a requirement could be similar to the standard included in the EU's Non-Financial Reporting Directive.[43] Under this standard, information is material if it is necessary for understanding the company's "development, performance, and position" or if it is necessary for understanding the "external impacts of the company."[44] This understanding of materiality is crucial in the climate context given the extent of action needed to adequately limit warming and the impacts that such action has on companies' activities and financial stability.

Requiring transparency on these two fronts will help to ensure accountability over time and respond to near-universal calls from investors for this type of information. Companies can and should play a significant role in meeting this target, and the SEC is positioned to help companies achieve a smooth transition to a low- or zero-carbon economy. A discussion of how a registrant is either addressing or exacerbating climate change provides important information to investors and the public about the registrant's perspective. A company that has internalized the risks and urgency of the climate crisis is more likely to reduce its emissions of climate pollutants, follow through on its climate-related planning, and weather the financial storm of climate change.

3. Need for Science-Based Climate-Related Disclosure Requirements

A climate disclosure regime that includes super pollutants will help companies prepare proactively, better manage the energy transition, and avoid exacerbating the impacts of climate change on their own activities. Super pollutant emissions disproportionately impact short-term warming, and in turn, the actions a registrant must take to decrease adaptation costs and risks. Investors already understand the threat posed by super pollutants like methane.[45]

As the science summarized above demonstrates, super pollutant emissions and mitigation plans are material information for understanding a registrant's financial position, as the emissions are directly tied to increasing climate-related risks and related adaptation costs, including in the short term. Climate change is already impacting business worldwide, and climate-related consequences will continue to grow.[46] Suppliers reported being exposed to $1.21 trillion in potential financial impact related to climate change in 2020.[47] Climate change, deforestation, and water scarcity are likely to put at risk $1.26 trillion of suppliers' revenue over the next five years.[48] Swiss Re Institute estimates that meeting the "well below 2 °C" goal of the Paris Agreement would limit mid-century global GDP loss to around 4%, as opposed to the projected 11% loss at 2 °C.[49] According to IPCC AR6, "[e]xtreme events and climate hazards are adversely affecting economic activities across North America and have disrupted supply-chain infrastructure and trade (*high confidence*)."[50]

Simultaneously, the transition to low- or zero-carbon energy will introduce new opportunities to companies. How companies are responding to these evolving risks and opportunities is material information that should be disclosed. Given the call to aggressive action by 2030,[51] these plans are especially important now. The SEC can help limit the impact of this transition on the economy by guiding registrants on methods for planning and requiring that registrants disclose their plans.

Furthermore, the uptick in laws, regulations, and government action targeting reductions in GHG emissions in line with the 1.5 °C goal underscores the relevance of these disclosures to a registrant's financial situation. Congress and the federal government have taken action to curb super pollutant emissions, and companies must proactively prepare for this shifting legal and regulatory environment. In December 2020, Congress passed—and President Trump later signed into law—the American Innovation and Manufacturing (AIM) Act, which phases down HFCs in the United States. The AIM Act and related implementing regulations will reduce the production and consumption of HFCs by 85% by 2036.[52] On 16 November 2021, the White House sent the Kigali Amendment to the Senate for its advice and consent to ratification.[53]

In line with the United States' international commitments, the federal government set a target of reaching net-zero GHG emissions by no later than 2050, with an interim target of reaching 50–52% reduction from 2005 levels of greenhouse gas emissions by 2030.[54] In announcing this commitment, the White House emphasized the importance of reducing super pollutants to keep

1.5 °C within reach.[55] In November 2021, the U.S. federal government published the *U.S. Methane Emissions Reduction Plan*, a whole-of-government initiative and model for taking a sectoral approach to reducing methane emissions.[56] As part of the plan, the EPA proposed regulations under the Clean Air Act for more stringent emissions-control requirements for oil and gas operations in the form of leak and venting limits for methane emissions from new and existing oil and gas sources.[57] The EPA estimates that, if finalized, the regulations would cut 41 million tons of methane through 2035.[58] The federal government also reinstated rules to prevent waste from venting, flaring, and leaks from oil and gas development on federal lands, which were projected to reduce methane emissions by 35% against the 2014 baseline.[59] In addition, the federal government is finalizing rules to reduce leaks throughout the gas pipeline system.[60]

As of June 2022, 112 countries and the European Union have joined the *Global Methane Pledge*,[61] which establishes a collective target to achieve at least 30% methane emissions reductions below 2020 levels by 2030, representing approximately 70% of the global economy and 45% of anthropogenic methane emissions.[62] Successful implementation of the *Global Methane Pledge* would reduce warming by at least 0.2 °C by 2050[63] and would keep the planet on a pathway consistent with staying within 1.5 °C, according to the *Global Methane Assessment*.[64] Deploying all available and additional measures could lead to a 45% reduction below 2030 levels to achieve nearly 0.3 °C in avoided warming by the 2040s.[65] The *Pledge* marks the first time that heads of State have committed to fast action to cut super climate pollutants to meet the 1.5 °C temperature target of the Paris Agreement.

Methane emissions are currently estimated based on a range of existing reporting regimes and protocols, including the UNFCCC, GRI, and national reporting programs. Increasingly sophisticated systems to measure and monitor methane emissions will add transparency and accountability to global methane reduction efforts. In particular, these systems will be essential to ensuring the world is on track to securing the 30% (or greater) reductions in methane emissions necessary to slow the world's near-term warming as called for in the *Global Methane Pledge*. Monitoring systems provide critical information that the public and regulators can use to hold companies and countries accountable.[66]

Effective accountability and response mechanisms to tackle emissions sources would include several components. At the most basic level, these include: 1) inventory by emissions total, sector, and location; 2) baseline emissions level by jurisdiction; 3) reduction goal by emissions total and sector; and 4) monitoring and reporting, providing for full transparency. In addition, these components include the abilities: 1) to identify and alert organizations responsible for the emitting assets; 2) to make responsible regulatory agencies aware of the emissions; and 3) to ensure that the emissions data is available in an accessible and timely manner to civil society watchdogs, media, and affected communities.

An effective accountability and enforcement strategy should incorporate "carrot" (incentive) and "stick" (e.g., regulatory, "name and shame") mechanisms. The strategy should encompass operators of methane sources, responsible government agencies, including prosecutors, and civil society, including affected communities. Further, the strategy should also identify solutions for addressing detected emissions and connect operators to technical capacity and financial resources, as appropriate. Additional capacity building that reflects training and other proper incentives are needed for stakeholders involved in the accountability aspects of the strategy. Such stakeholders include emissions-source operators, regulatory agencies, financial risk agencies, and watchdogs.

A methane accountability strategy could have several components, including:

1) An asset map and inventory of methane sources with geospatial coordinates that allow detailed identification of sources and related contacts for operators;
2) A "phone book" of the corresponding control agents for each source point of emissions (federal, state, local, private-sector, etc.) based on location and type of asset;
3) A mechanism for accessing emissions data from monitoring systems and rapidly converting the data into usable formats for accountability actors; and
4) A coordination and communications network of civil-society actors by region, country, subnational jurisdiction where emissions are significant, in order to strengthen collective civil-society capacity to act as emissions data emerges.

In regard to super pollutants and short-term fast action climate strategies, the existing standards are insufficient. The SEC is poised to rectify this shortcoming. For example, GRI directs companies to disclose greenhouse gas emissions, ozone-depleting substances, as well as other air emissions.[67] Currently, there is no separate guidance regarding super pollutants reporting. By relying on firm global scientific consensus regarding the importance of super pollutant emissions, the SEC can improve upon existing frameworks to more accurately frame climate change risks to companies and the need to reduce super pollutant emissions in the next 10 years.

Meeting these international commitments will require action across sectors, and companies must quickly adapt and position themselves to be prepared for the challenges and opportunities that arise amid this evolving crisis. Climate-related disclosures will allow investors and other stakeholders to better understand how registrants are getting ahead of or responding to the changes in the legal and regulatory environment.

4. Need for an Environmental Justice Framework in Disclosure Requirements

Climate change impacts are unequally distributed and affect the most vulnerable frontline communities first and worst. Many communities are already experiencing the early impacts of climate change, such as extreme heatwaves, droughts, and other weather events that exacerbate already-existing health risks.[68] These frontline communities, primarily in developing countries and historically marginalized communities, have contributed the least to climate change but are bearing the worst of its impacts, and the largest adaptation gaps are among lower income communities.[69] The International Monetary Fund also recognizes that climate change is a long-term structural challenge that will make countries more prone to a severe balance of payment problems by raising the likelihood and impact of future shocks and undermining growth prospects.[70] An environmental justice-based approach to climate change solutions demands fast-acting policies, investments, and other support for climate solutions that consider the immediate needs of historically marginalized communities and addresses the climate crisis before self-reinforcing feedbacks push the planet past irreversible tipping points.

The U.S. is increasingly incorporating environmental justice concerns in their climate policies, and in parallel, corporations must also assume past responsibility for contributing to these inequities.

Corporations are in a crucial position to evaluate how their current emissions affect the most climate-vulnerable communities as well as how their current climate policies can not only contribute to tackle climate change, but also help revert past inequities of climate burdens.

The SEC can help promote disclosure and action that can tackle both climate change and address past environmental injustices. For example, the SEC draft rule is exploring the issue of zip codes to identify climate risk areas for reporting entities. This determination process for zip codes can be important indicators of climate vulnerability, linking a reporter's area of operations with climate vulnerability for stakeholders. Knowing where a corporation's GHG emissions are released and the associated vulnerability of impacted communities would allow investors to distinguish which communities tend to be exposed to the most adverse environmental impacts.

Technologies like CalEnviroScreen map out in a database the characteristics—including mean income and minority concentration—of specific communities that can assist investors and reporting entities to better understand the climate vulnerability risks of affected communities. Users can easily determine whether emissions disproportionately target certain zip codes. Protecting the wellbeing and interests is a question of ethics, and there are a growing number of investors who want to contribute to social, economic, and environmentally conscious solutions.

Without explicitly addressing environmental justice concerns, responses to climate change could be impaired by, and exacerbate, the lack of strategies to adequately address the climate emergency and persistent environmental and climate injustices.[71] By slowing near-term warming, mitigating super pollutants provide climate-vulnerable communities with more time to adapt while also decreasing communities' adaptation burdens.[72] We strongly encourage the SEC to infuse its disclosure standards to include environmental justice and human rights considerations through a focus on super pollutants and fast mitigation strategies.

5. Need to Disclose Funding of Trade Associations and All Other Organizations Concerned with Climate, Including Organizations Promoting Climate Denial and Deception

The SEC should require corporations and investors to disclose funding of trade associations and other organizations that engage in climate deception, denial or otherwise contradict sustainability claims, including funding channeled through intermediaries.

Some corporations are actively engaging in climate disinformation campaigns, as highlighted in two 2015 investigative reports that uncovered the oil and gas industry's climate deception and work in undermining climate policies in the U.S.[73] In 2021, a watchdog organization found that over 50 major corporations that claim to support climate initiatives—including Apple, Amazon, Microsoft, and Disney—were funding lobbying efforts to prevent President Biden's climate bill from passing.[74]

The SEC should ensure that corporations disclose all financial support, including through intermediaries, to trade associations and other organizations that are opposing progress on climate change or promoting climate deception or denial. In particular, the SEC should require that corporations and investors disclose trade groups' membership, funding sources, and political spending.[75] This transparency would benefit environmental investments and strengthen the capacity of the investors, other citizens, and the U.S. government to respond to the climate crisis.

These same comments will be relevant for the SEC's proposed rule on *Enhanced Disclosures by Certain Investment Advisers and Investment Companies about Environmental, Social, and Governance Investment Practices*.

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The above recommendations will help ensure that companies prepare for the impacts of climate change, minimize adaptation costs, limit the severity of climate-related risks, and provide necessary information to investors and market participants. We would be happy to continue engaging with the SEC on these important issues.

Sincerely,

Jorge Daniel Taillant
Executive Director, CHRE
[redacted]

Durwood Zaelke
President, IGSD
[redacted]

References

[1] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* Climate Change 2022: Mitigation of Climate Change, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), SPM-22 ("C.1.2 In modelled pathways that limit warming to 2°C (>67%) assuming immediate action, global net CO_2 emissions are reduced compared to modelled 2019 emissions by 27% [11–46%] in 2030 and by 52% [36-70%] in 2040; and global CH_4 emissions are reduced by 24% [9–53%] in 2030 and by 37% [20–60%] in 2040. In pathways that limit warming to 1.5°C (>50%) with no or limited overshoot global net CO_2 emissions are reduced compared to modelled 2019 emissions by 48% [36–69%] in 2030 and by 80% [61-109%] in 2040; and global CH_4 emissions are reduced by 34% [21–57%] in 2030 and 44% [31-63%] in 2040. There are similar reductions of non-CO_2 emissions by 2050 in both types of pathways: CH_4 is reduced by 45% [25–70%]; N_2O is reduced by 20% [-5 – 55%]; and F-Gases are reduced by 85% [20–90%]. [FOOTNOTE 44] Across most modelled pathways, this is the maximum technical potential for anthropogenic CH_4 reductions in the underlying models (*high confidence*). Further emissions reductions, as illustrated by the IMP-SP pathway, may be achieved through changes in activity levels and/or technological innovations beyond those represented in the majority of the pathways (*medium confidence*). Higher emissions reductions of CH_4 could further reduce peak warming. (*high confidence*) (Figure SPM.5) {3.3}").

[2] Intergovernmental Panel on Climate Change (2018) *Summary for Policymakers*, *in* Global Warming of 1.5 °C, *Special Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-15, SPM-17 ("In model pathways with no or limited overshoot of 1.5 °C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range)…. Modelled pathways that limit global warming to 1.5 °C with no or limited overshoot involve deep reductions in emissions of methane and black carbon (35% or more of both by 2050 relative to 2010)."; "C.3. All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century.").

[3] Dreyfus G. B., Xu Y., Shindell D. T., Zaelke D., & Ramanathan V. (2022) *Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming*, Proc. Nat'l. Acad. Sci. 119(22): e2123536119, 1–8, 1 ("We find that mitigation measures that target only decarbonization are essential for strong long-term cooling but can result in weak near-term warming (due to unmasking the cooling effect of co-emitted aerosols) and lead to temperatures exceeding 2°C before 2050. In contrast, pairing decarbonization with additional mitigation measures targeting short-lived climate pollutants (SLCPs) and N_2O, slows the rate of warming a decade or two earlier than decarbonization alone and avoids the 2°C threshold altogether. These non-CO_2 targeted measures when combined with decarbonization can provide net cooling by 2030, reduce the rate of warming from 2030 to 2050 by about 50%, roughly half of which comes from methane, significantly larger than decarbonization alone over this timeframe."); ("Aggressive decarbonization to achieve net-zero CO_2 emissions in the 2050s (as in the decarb-only scenario) results in weakly accelerated net warming compared to the reference case, with a positive warming up to 0.03 °C in the mid-2030s, and no net avoided warming until the mid-2040s due to the reduction in co-emitted cooling aerosols (Figure 3a). By 2050, decarbonization measures result in very limited net avoided warming (0.07°C), consistent with Shindell and Smith (43), but rise to a likely detectable 0.25°C by 2060 and a major benefit of 1.4°C by 2100 (Table S5). In contrast, pairing decarbonization with mitigation measures targeting CH_4, BC, HFC, and N_2O (not an SLCP due to its longer lifetime) independent from decarbonization are essential to slowing the rate of warming by the 2030s to under 0.3°C per decade (Table 1, Figure 3b), similar to the 0.2°C to 0.25°C per decade warming prior to 2020 (38, 53). Recent studies suggest that rate of warming rather than level of warming controls likelihood of record-shattering extreme weather events (54, 55). By 2050, the net avoided warming from the targeted non-CO_2 measures is 0.26°C, almost 4 times larger than the net benefit of decarbonization alone (0.07°C) (Table S5)."). *See also* Xu Y. & Ramanathan V. (2017) *Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes*, Proc. Nat'l. Acad. Sci. 114(39): 10315–10323, 10321 ("Constrained by CO_2 lifetime and the diffusion time of new technologies (decades), the scenarios considered here (SI Appendix, Fig. S2A) suggest that about half of the 2.6 °C CO_2 warming in the baseline-fast scenario can be mitigated by 2100 and only 0.1–0.3 °C can be mitigated by 2050… The SP [super pollutant] lever targets SLCPs. Reducing SLCP emissions thins the SP blanket within few decades, given the shorter lifetimes of SLCPs (weeks for BC to about 15 years for HFCs). The mitigation potential of the SP lever with a maximum deployment of current technologies … is about 0.6 °C by 2050 and 1.2 °C by 2100 (SI Appendix, Fig. S5B and Table S1)."); *and* Naik V., *et al.* (2021) *Chapter 6: Short-lived climate forcers*,

in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 6-6 ("Over time scales of 10 to 20 years, the global temperature response to a year's worth of current emissions of SLCFs is at least as large as that due to a year's worth of CO_2 emissions (*high confidence*).").

[4] United Nations Environment Programme & World Meteorological Organization (2011) INTEGRATED ASSESSMENT OF BLACK CARBON AND TROPOSPHERIC OZONE, 254, 262 ("Evaluating global mean temperature change, it was found that the targeted measures to reduce emissions of methane and BC could greatly reduce warming rates over the next few decades (Figure 6.1; Box 6.1). When all measures are fully implemented, warming during the 2030s relative to the present would be only half as much as in the reference scenario. In contrast, even a fairly aggressive strategy to reduce CO_2 emissions, as for the CO_2-measures scenario, does little to mitigate warming until after the next 20-30 years (Box 6.2)."; "Large impacts of the measures examined here were also seen for the Arctic despite the minimal amount of emissions currently taking place there. This occurs due to the high sensitivity of the Arctic both to pollutants that are transported there from remote sources and to radiative forcing that takes place in areas of the northern hemisphere outside the Arctic. The 16 measures examined here, including the measures on pellet stoves and coal briquettes, reduce warming in the Arctic by 0.7 ºC (range 0.2 to 1.3 ºC) at 2040. This is a large portion of the 1.1 ºC (range 0.7 to 1.7 ºC) warming projected under the reference scenario for the Arctic, and hence implementation of the measures would be virtually certain to substantially slow, but not halt, the pace of Arctic climate change."). *See also* Shindell D., *et al.* (2012) *Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security*, SCIENCE 335(6065): 183–189, 184–185 ("The global mean response to the CH_4 plus BC measures was –0.54 ± 0.05ºC in the climate model. …Roughly half the forcing is relatively evenly distributed (from the CH_4 measures). The other half is highly inhomogeneous, especially the strong BC forcing, which is greatest over bright desert and snow or ice surfaces. Those areas often exhibit the largest warming mitigation, making the regional temperature response to aerosols and ozone quite distinct from the more homogeneous response to well-mixed greenhouse gases…. BC albedo and direct forcings are large in the Himalayas, where there is an especially pronounced response in the Karakoram, and in the Arctic, where the measures reduce projected warming over the next three decades by approximately two thirds and where regional temperature response patterns correspond fairly closely to albedo forcing (for example, they are larger over the Canadian archipelago than the interior and larger over Russia than Scandinavia or the North Atlantic)."); *and* Naik V., *et al.* (2021) *Chapter 6: Short-lived climate forcers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 6-7 ("Across the SSPs, the collective reduction of CH_4, ozone precursors and HFCs can make a difference of global mean surface air temperature of 0.2 with a very likely range of [0.1–0.4] °C in 2040 and 0.8 with a very likely range of [0.5–1.3] °C at the end of the 21st century (comparing SSP3-7.0 and SSP1-1.9), which is substantial in the context of the Paris Agreement. Sustained methane mitigation, wherever it occurs, stands out as an option that combines near- and long-term gains on surface temperature (high confidence) and leads to air quality benefits by reducing surface ozone levels globally (high confidence). {6.6.3, 6.7.3, 4.4.4}").

[5] Molina M., Zaelke D., Sarma K. M., Andersen S. O., Ramanathan V., & Kaniaru D. (2009) *Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO_2 emissions*, PROC. NAT'L. ACAD. SCI. 106(49): 20616–20621, 20616 ("Current emissions of anthropogenic greenhouse gases (GHGs) have already committed the planet to an increase in average surface temperature by the end of the century that may be above the critical threshold for tipping elements of the climate system into abrupt change with potentially irreversible and unmanageable consequences. This would mean that the climate system is close to entering if not already within the zone of "dangerous anthropogenic interference" (DAI). Scientific and policy literature refers to the need for "early," "urgent," "rapid," and "fast-action" mitigation to help avoid DAI and abrupt climate changes. We define "fast-action" to include regulatory measures that can begin within 2–3 years, be substantially implemented in 5–10 years, and produce a climate response within decades. We discuss strategies for short-lived non-CO_2 GHGs and particles, where existing agreements can be used to accomplish mitigation objectives. Policy makers can amend the Montreal Protocol to phase down the production and consumption of hydrofluorocarbons (HFCs) with high global warming potential. Other fast-action strategies can reduce emissions of black carbon particles and precursor gases that lead to ozone formation in the lower atmosphere, and increase biosequestration, including through biochar. These and other fast-action strategies may reduce the risk of abrupt climate change in the next few decades by complementing cuts in CO_2 emissions."). *See also* Molina M., Ramanathan V. & Zaelke D. (2020) *Best path to net zero: Cut short-lived climate pollutants*, BULLETIN OF THE ATOMIC SCIENTISTS ("And let us be clear: By "speed," we mean

measures—including regulatory ones—that can begin within two-to-three years, be substantially implemented in five-to-10 years, and produce a climate response within the next decade or two.").

[6] Lenton T. M., Rockstrom J., Gaffney O., Rahmstorf S., Richardson K., Steffen W., & Schellnhuber H. J. (2019) *Climate tipping points—too risky to bet against*, Comment, NATURE 575(7784): 592–595, 594 ("In our view, the clearest emergency would be if we were approaching a global cascade of tipping points that led to a new, less habitable, 'hothouse' climate state11. Interactions could happen through ocean and atmospheric circulation or through feedbacks that increase greenhouse-gas levels and global temperature. Alternatively, strong cloud feedbacks could cause a global tipping point12,13.We argue that cascading effects might be common. Research last year14 analysed 30 types of regime shift spanning physical climate and ecological systems, from collapse of the West Antarctic ice sheet to a switch from rainforest to savanna. This indicated that exceeding tipping points in one system can increase the risk of crossing them in others. Such links were found for 45% of possible interactions14. In our view, examples are starting to be observed. … If damaging tipping cascades can occur and a global tipping point cannot be ruled out, then this is an existential threat to civilization. No amount of economic cost–benefit analysis is going to help us. We need to change our approach to the climate problem. … In our view, the evidence from tipping points alone suggests that we are in a state of planetary emergency: both the risk and urgency of the situation are acute…."). *See also* Steffen W., *et al*. (2018) *Trajectories of the Earth System in the Anthropocene*, PROC. NAT'L. ACAD. SCI. 115(33): 8252–8259, 8254 ("This analysis implies that, even if the Paris Accord target of a 1.5 °C to 2.0 °C rise in temperature is met, we cannot exclude the risk that a cascade of feedbacks could push the Earth System irreversibly onto a "Hothouse Earth" pathway. The challenge that humanity faces is to create a "Stabilized Earth" pathway that steers the Earth System away from its current trajectory toward the threshold beyond which is Hothouse Earth (Fig. 2). The humancreated Stabilized Earth pathway leads to a basin of attraction that is not likely to exist in the Earth System's stability landscape without human stewardship to create and maintain it. Creating such a pathway and basin of attraction requires a fundamental change in the role of humans on the planet. This stewardship role requires deliberate and sustained action to become an integral, adaptive part of Earth System dynamics, creating feedbacks that keep the system on a Stabilized Earth pathway (Alternative Stabilized Earth Pathway).").

[7] Xu Y. & Ramanathan V. (2017) *Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes*, PROC. NAT'L. ACAD. SCI. 114(39): 10319–10323, 10320 ("Box 2. Risk Categorization of Climate Change to Society. … [A] 2 °C warming would double the land area subject to deadly heat and expose 48% of the population. A 4 °C warming by 2100 would subject 47% of the land area and almost 74% of the world population to deadly heat, which could pose existential risks to humans and mammals alike unless massive adaptation measures are implemented, such as providing air conditioning to the entire population or a massive relocation of most of the population to safer climates. … This bottom 3 billion population comprises mostly subsistent farmers, whose livelihood will be severely impacted, if not destroyed, with a one- to five-year megadrought, heat waves, or heavy floods; for those among the bottom 3 billion of the world's population who are living in coastal areas, a 1- to 2-m rise in sea level (likely with a warming in excess of 3 °C) poses existential threat if they do not relocate or migrate. It has been estimated that several hundred million people would be subject to famine with warming in excess of 4 °C (54). However, there has essentially been no discussion on warming beyond 5 °C. Climate change-induced species extinction is one major concern with warming of such large magnitudes (>5 °C). The current rate of loss of species is ~1,000-fold the historical rate, due largely to habitat destruction. At this rate, about 25% of species are in danger of extinction in the coming decades (56). Global warming of 6 °C or more (accompanied by increase in ocean acidity due to increased CO_2) can act as a major force multiplier and expose as much as 90% of species to the dangers of extinction (57). The bodily harms combined with climate change-forced species destruction, biodiversity loss, and threats to water and food security, as summarized recently (58), motivated us to categorize warming beyond 5 °C as unknown??, implying the possibility of existential threats."). *See also* Xu C., Kohler T. A., Lenton T. M., Svenning J.-C., & Scheffer M. (2020) *Future of the human climate niche*, PROC. NAT'L. ACAD. SCI. 117(21): 11350–11355, 11350 ("Here, we demonstrate that for millennia, human populations have resided in the same narrow part of the climatic envelope available on the globe, characterized by a major mode around ~11 °C to 15 °C mean annual temperature (MAT). …We show that in a business-as-usual climate change scenario, the geographical position of this temperature niche is projected to shift more over the coming 50 y than it has moved since 6000 BP. … Specifically, 3.5 billion people will be exposed to MAT ≥29.0 °C, a situation found in the present climate only in 0.8% of the global land surface, mostly concentrated in the Sahara, but in 2070 projected to cover 19% of the global land (Fig. 3). … For instance, accounting for population growth projected in the SSP3 scenario, each degree of temperature rise above the current baseline roughly corresponds to one billion humans left outside the temperature niche, absent migration (*SI Appendix*, Fig. S14)."); ***and*** Watts N., *et al.* (2021) *The 2020 report of The Lancet Countdown on health*

and climate change: responding to converging crises, THE LANCET 397(10269): 129–170, 129 ("Vulnerable populations were exposed to an additional 475 million heatwave events globally in 2019, which was, in turn, reflected in excess morbidity and mortality (indicator 1.1.2). During the past 20 years, there has been a 53.7% increase in heat-related mortality in people older than 65 years, reaching a total of 296 000 deaths in 2018 (indicator 1.1.3). The high cost in terms of human lives and suffering is associated with effects on economic output, with 302 billion h of potential labour capacity lost in 2019 (indicator 1.1.4). India and Indonesia were among the worst affected countries, seeing losses of potential labour capacity equivalent to 4–6% of their annual gross domestic product (indicator 4.1.3);" *as cited in* Atwoli L., *et al.* (2021) *Call for emergency action to limit global temperature increases, restore biodiversity, and protect health*, THE LANCET 398(10304): 939–941, 939 ("Harms disproportionately affect the most vulnerable, including children, older populations, ethnic minorities, poorer communities, and those with underlying health problems.").

[8] Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-19 ("With every additional increment of global warming, changes in extremes continue to become larger. For example, every additional 0.5°C of global warming causes clearly discernible increases in the intensity and frequency of hot extremes, including heatwaves (*very likely*), and heavy precipitation (*high confidence*), as well as agricultural and ecological droughts in some regions (*high confidence*). Discernible changes in intensity and frequency of meteorological droughts, with more regions showing increases than decreases, are seen in some regions for every additional 0.5°C of global warming (*medium confidence*). Increases in frequency and intensity of hydrological droughts become larger with increasing global warming in some regions (*medium confidence*). There will be an increasing occurrence of some extreme events unprecedented in the observational record with additional global warming, even at 1.5°C of global warming. Projected percentage changes in frequency are higher for rarer events (*high confidence*)."). *See also* Fischer E. M., Sippel S., & Knutti R. (2021) *Increasing probability of record-shattering climate extremes*, NAT. CLIM. CHANGE 1–7, 1 ("Here, we show models project not only more intense extremes but also events that break previous records by much larger margins. These record-shattering extremes, nearly impossible in the absence of warming, are likely to occur in the coming decades. We demonstrate that their probability of occurrence depends on warming rate, rather than global warming level, and is thus pathway-dependent. In high-emission scenarios, week-long heat extremes that break records by three or more standard deviations are two to seven times more probable in 2021–2050 and three to 21 times more probable in 2051–2080, compared to the last three decades.").

[9] Copernicus Climate Services (10 January 2022) *Copernicus: Globally, the seven hottest years on record were the last seven; carbon dioxide and methane concentrations continue to rise* ("Globally, 2021 was the fifth warmest year on record, but only marginally warmer than 2015 and 2018; The annual average temperature was 0.3°C above the temperature of the 1991-2020 reference period, and 1.1-1.2°C above the pre-industrial level of 1850-1900; The last seven years have been the warmest years on record by a clear margin"). *See also* National Aeronautics and Space Administration (13 January 2022) *2021 Tied for 6th Warmest Year in Continued Trend, NASA Analysis Shows*; National Oceanic and Atmospheric Administration (13 January 2022) *2021 was world's 6th-warmest year on record; National Aeronautics and Space Administration* (14 January 2021) *2020 Tied for Warmest Year on Record*, NASA Analysis Shows ("Tracking global temperature trends provides a critical indicator of the impact of human activities – specifically, greenhouse gas emissions – on our planet. Earth's average temperature has risen more than 2 degrees Fahrenheit (1.2 degrees Celsius) since the late 19th century."); *and* Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-6 ("The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 [11] is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to 0.1°C, and internal variability changed it by –0.2°C to 0.2°C. It is *very likely* that well-mixed GHGs were the main driver[12] of tropospheric warming since 1979, and *extremely likely* that human-caused stratospheric ozone depletion was the main driver of cooling of the lower stratosphere between 1979 and the mid-1990s."… Footnote 11: "The period distinction with A.1.2 arises because the attribution studies consider this slightly earlier period. The observed warming to 2010–2019 is 1.06 [0.88 to 1.21] °C." Footnote 12: "Throughout this SPM, 'main driver' means responsible for more than 50% of the change.").

[10] Drijfhout S., Bathiany S., Beaulieu C., Brovkin V., Claussen M., Huntingford C., Scheffer M., Sgubin G., & Swingedouw D. (2015) *Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models*, PROC. NAT'L. ACAD. SCI. 112(43): E5777–E5786, E5777 ("Abrupt transitions of regional climate in response to the gradual rise in atmospheric greenhouse gas concentrations are notoriously difficult to foresee. However, such events could be particularly challenging in view of the capacity required for society and ecosystems to adapt to them. We present, to our knowledge, the first systematic screening of the massive climate model ensemble informing the recent Intergovernmental Panel on Climate Change report, and reveal evidence of 37 forced regional abrupt changes in the ocean, sea ice, snow cover, permafrost, and terrestrial biosphere that arise after a certain global temperature increase. Eighteen out of 37 events occur for global warming levels of less than 2°, a threshold sometimes presented as a safe limit."). *See also* Lenton T. M., Rockstrom J., Gaffney O., Rahmstorf S., Richardson K., Steffen W., & Schellnhuber H. J. (2019) *Climate tipping points—too risky to bet against*, Comment, NATURE 575(7784): 592–595, 593 ("A further key impetus to limit warming to 1.5 °C is that other tipping points could be triggered at low levels of global warming. The latest IPCC models projected a cluster of abrupt shifts between 1.5 °C and 2 °C, several of which involve sea ice. This ice is already shrinking rapidly in the Arctic…."); Arias P. A., *et al.* (2021) *Technical Summary*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), TS-71–TS-72 ("It is *likely* that under stabilization of global warming at 1.5°C, 2.0°C, or 3.0°C relative to 1850–1900, the AMOC will continue to weaken for several decades by about 15%, 20% and 30% of its strength and then recover to pre-decline values over several centuries (*medium confidence*). At sustained warming levels between 2°C and 3°C, there is limited evidence that the Greenland and West Antarctic Ice Sheets will be lost almost completely and irreversibly over multiple millennia; both the probability of their complete loss and the rate of mass loss increases with higher surface temperatures (*high confidence*). At sustained warming levels between 3°C and 5°C, near-complete loss of the Greenland Ice Sheet and complete loss of the West Antarctic Ice Sheet is projected to occur irreversibly over multiple millennia (*medium confidence*); with substantial parts or all of Wilkes Subglacial Basin in East Antarctica lost over multiple millennia (*low confidence*). Early-warning signals of accelerated sea-level-rise from Antarctica, could possibly be observed within the next few decades. For other hazards (e.g., ice sheet behaviour, glacier mass loss and global mean sea level change, coastal floods, coastal erosion, air pollution, and ocean acidification) the time and/or scenario dimensions remain critical, and a simple and robust relationship with global warming level cannot be established (*high confidence*)… The response of biogeochemical cycles to anthropogenic perturbations can be abrupt at regional scales and irreversible on decadal to century time scales (*high confidence*). The probability of crossing uncertain regional thresholds increases with climate change (*high confidence*). It is *very unlikely* that gas clathrates (mostly methane) in deeper terrestrial permafrost and subsea clathrates will lead to a detectable departure from the emissions trajectory during this century. Possible abrupt changes and tipping points in biogeochemical cycles lead to additional uncertainty in 21st century atmospheric GHG concentrations, but future anthropogenic emissions remain the dominant uncertainty (*high confidence*). There is potential for abrupt water cycle changes in some high-emission scenarios, but there is no overall consistency regarding the magnitude and timing of such changes. Positive land surface feedbacks, including vegetation, dust, and snow, can contribute to abrupt changes in aridity, but there is only low confidence that such changes will occur during the 21st century. Continued Amazon deforestation, combined with a warming climate, raises the probability that this ecosystem will cross a tipping point into a dry state during the 21st century (*low confidence*). {TS3.2.2, 5.4.3, 5.4.5, 5.4.8, 5.4.9, 8.6.2, 8.6.3, Cross-chapter Box 12.1}"); *and* Lee J. Y., *et al.* (2021) *Chapter 4: Future Global Climate: Scenario-Based Projections and Near-Term Information*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 4-96 (Table 4.1 lists 15 components of the Earth system susceptible to tipping points).

[11] Steffen W., *et al.* (2018) *Trajectories of the Earth System in the Anthropocene*, PROC. NAT'L. ACAD. SCI. 115(33): 8252–8259, 8254, 8256 ("This risk is represented in Figs. 1 and 2 by a planetary threshold (horizontal broken line in Fig. 1 on the Hothouse Earth pathway around 2 °C above preindustrial temperature). Beyond this threshold, intrinsic biogeophysical feedbacks in the Earth System (***Biogeophysical Feedbacks***) could become the dominant processes controlling the system's trajectory. Precisely where a potential planetary threshold might be is uncertain (15, 16). We suggest 2 °C because of the risk that a 2 °C warming could activate important tipping elements (12, 17), raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth System to even higher temperatures (***Tipping Cascades***). Such cascades comprise, in essence, the dynamical process that leads to thresholds in complex systems (section 4.2 in ref. 18). This analysis implies that, even if the Paris Accord target of a 1.5 °C to 2.0 °C rise in temperature is met, we cannot exclude the risk that a cascade of feedbacks could push the Earth System irreversibly onto a "Hothouse Earth" pathway. … Hothouse Earth is likely to be uncontrollable and

dangerous to many, particularly if we transition into it in only a century or two, and it poses severe risks for health, economies, political stability (**12**, **39**, **49**, **50**) (especially for the most climate vulnerable), and ultimately, the habitability of the planet for humans.").

[12] Jacobs P., Lenssen N. J. L., Schmidt G. A., & Rohde R. A. (2021) *The Arctic Is Now Warming Four Times As Fast As the Rest of the Globe*, Presentation at the American Geophysical Union Fall Meeting, A13E-02 ("We demonstrate the Arctic is likely warming over 4 times faster than the rest of the world, some 3-4 times the global average, with higher rates found both for more recent intervals as well as more accurate latitudinal boundaries. These results stand in contrast to the widely-held conventional wisdom — prevalent across scientific and lay publications alike — that the Arctic is "only" warming around twice as fast as the global mean."); *discussed in* Voosen P. (14 December 2021) *The Arctic is warming four times faster than the rest of the world*, SCIENCE.

[13] Isaksen K., *et al.* (2022) *Exceptional warming over the Barents area*, SCI. REP. 12(9371): 1–18, 11 ("The accelerated warming up to the latest decade is in agreement with the most recent assessments of instrumental observations in the Arctic7,8. Przybylak and Wyszyński8 analyzed trends from 1951 to 2015 and showed that the strongest temperature increase in the Arctic in winter was observed over Svalbard, but no stations in north-eastern areas were then available. By including newly available SAT observations from northern and eastern Svalbard and from FJL, we were able to additionally study the regional SAT developments in the NBS. Our main findings are summarised in Fig. 7 and show that the warming in western Svalbard is large, but even larger in northern and eastern Svalbard and in FJL. From 1981 to 2020, we found an annual warming rate varying between 1.0 and 1.6 °C per decade, whereas, over the two periods 1991–2020 and 2001–2020, the annual warming rates ranged from 1.1 to 2.7 °C per decade. These rates are stronger than hitherto known in this region. The increasing temperature rates for the Northern Barents Sea region are exceptional on the Arctic and global scale and correspond to 2 to 2.5 times the Arctic warming averages and 5 to 7 times the global warming averages (Fig. 7).").

[14] Druckenmiller M. L., *et al.* (2021) *The Arctic*, BULL. AM. MET. SOC. 102(8): S263–S316, S280 ("September is the month when the minimum annual sea ice extent occurs. In 2020, this average monthly ice extent was 3.92 million km^2 (Fig. 5.8b), the second lowest monthly extent in the 42-year satellite record. On 15 September, the annual minimum Arctic sea ice extent of 3.74 million km^2 was reached; this was also the second lowest on record. The September monthly extent has been decreasing at an average rate of −82,700 km^2 per year since 1979 (−13.1% per decade relative to the 1981–2010 average; Fig. 5.8c)."). *See also* Pistone K., Eisenman I., & Ramanathan V. (2014) *Observational determination of albedo decrease caused by vanishing Arctic sea ice*, PROC. NAT'L. ACAD. SCI. 111(9): 3322–3326 ("The Arctic has warmed by nearly 2 °C since the 1970s, a temperature change three times larger than the global mean (1). During this period, the Arctic sea ice cover has retreated significantly, with the summer minimum sea ice extent decreasing by 40% (2)."); *and* Jansen E., *et al.* (2020) *Past perspectives on the present era of abrupt Arctic climate change*, NAT. CLIM. CHANGE 10: 714–721, 714 ("Annual mean temperature trends over the Arctic during the past 40 years show that over this period, where satellite data are available, major portions have warmed by more than 1 °C per decade (Fig. 1a, red colours and outlined portion; a warming of 4 °C within 40 years is hereafter referred to as 1 °C per decade). … Using a criterion based on the speed of near-surface air temperature warming over the past four decades, we find that the current Arctic is experiencing rates of warming comparable to abrupt changes, or D–O events, recorded in Greenland ice cores during the last glacial period. [During the last glacial period (120,000–11,000 years ago), more than 20 abrupt periods of warming, known as Dansgaard–Oeschger (D–O) events, took place18,19.] Both past changes in the Greenland ice cores and the ongoing trends in the Arctic are directly linked to sea-ice retreat— in the Nordic Seas during glacial times and in the Eurasian Arctic at present. Abrupt changes have already been experienced and could, according to state-of-the-art climate models, occur in the Arctic during the twenty-first century, but climate models underestimate current rates of change in this region.").

[15] Wadhams P. (2017) A FAREWELL TO ICE: A REPORT FROM THE ARCTIC, Oxford University Press, 107–108 ("Warm air over an ice-free Arctic also causes the snowline to retreat. … This of the same magnitude as the sea ice negative anomaly during the same period, and the change in albedo is roughly the same between snow-covered land and snow-free tundra as it is between sea ice and open water. Nobody has yet published the calculations for tundra as Pistone and her colleagues did for sea ice, but the similarity of the magnitudes means that snowline retreat and sea ice retreat are each adding about the same amount to global warming.").

[16] Docquier D. & Koenigk T. (2021) *Observation-based selection of climate models projects Arctic ice-free summers around 2035*, COMMUN. EARTH & ENVIRON. 2: 1–8, 4, 6 ("In the high-emission scenario, five out of six selection

criteria that include ocean heat transport provide a first ice-free Arctic in September before 2040 (range of multi-model means: 2032–2039), more than 20 years before the date of ice-free Arctic for the multi-model mean without model selection (i.e. 2061)"; "This model selection reveals that sea-ice area and volume reach lower values at the end of this century compared to the multi-model mean without selection. This arises both from a more rapid reduction in these quantities through this century and from a lower present-day sea-ice area. Using such a model selection, the timing of an almost ice-free Arctic in summer is advanced by up to 29 years in the high-emission scenario, i.e. it could occur as early as around 2035."). *See also* Peng G., Matthews J. L., Wang M., Vose R., & Sun L. (2020) *What Do Global Climate Models Tell Us about Future Arctic Sea Ice Coverage Changes?*, CLIMATE 8: 15 ("Excluding the values later than 2100, the averaged projected [first ice-free Arctic summer year (FIASY)] value for RCP4.5 was 2054 with a spread of 74 years; for RCP8.5, the averaged FIASY was 2042 with a spread of 42 years. ...which put the mean FIASY at 2037. The RCP8.5 projections tended to push FIASY earlier, except for those of the MICRO-ESM and MICRO-ESM-CHEM models. Those two models also tended to project earlier Arctic ice-free dates and longer durations."); Overland J. E. & Wang M. (2013) *When will the summer Arctic be nearly sea ice free?*, GEOPHYS. RES. LETT. 40(10): 2097–2101, 2097 ("Three recent approaches to predictions in the scientific literature are as follows: (1) extrapolation of sea ice volume data, (2) assuming several more rapid loss events such as 2007 and 2012, and (3) climate model projections. Time horizons for a nearly sea ice-free summer for these three approaches are roughly 2020 or earlier, 2030 ± 10 years, and 2040 or later. Loss estimates from models are based on a subset of the most rapid ensemble members. … Observations and citations support the conclusion that most global climate model results in the CMIP5 archive are too conservative in their sea ice projections. Recent data and expert opinion should be considered in addition to model results to advance the very likely timing for future sea ice loss to the first half of the 21st century, with a possibility of major loss within a decade or two."); Guarino M.-V., *et al.* (2020) *Sea-ice-free Arctic during the Last Interglacial supports fast future loss*, NAT. CLIM. CHANGE 10: 928–932, 931 ("The predicted year of disappearance of September sea ice under high-emissions scenarios is 2086 for HadCM3 (CMIP3/5), 2048 for HadGEM2-ES (CMIP5) and 2035 for HadGEM3 (CMIP6) (Fig. 4). More broadly, multimodel CMIP3–6 mean predictions (and ranges) for a summer sea-ice-free Arctic are as follows: CMIP3, 2062 (2040–2086); CMIP5, 2048 (2020–2081); and CMIP6, 2046 (2029–2066) (Fig. 4 and Supplementary Table 3). We note that the latest year of sea-ice disappearance for CMIP6 models is 2066 and that 50% of the models predict sea-ice-free conditions between ~2030 and 2040. From this we can see that HadGEM3 is not a particular outlier, in terms of its ECS or projected ice-free year."); *and* Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), Figure SPM.8-b.

[17] Pistone K., Eisenman I., & Ramanathan V. (2019) *Radiative Heating of an Ice-Free Arctic Ocean*, GEOPHYS. RES. LETT. 46(13): 7474–7480, 7477 ("This heating of 0.71 W/m^2 is approximately equivalent to the direct radiative effect of emitting one trillion tons of CO_2 into the atmosphere (see calculation in Appendix A). As of 2016, an estimated 2.4 trillion tons of CO_2 have been emitted since the preindustrial period due to both fossil fuel combustion (1.54 trillion tons) and land use changes (0.82 trillion tons), with an additional 40 billion tons of CO_2 per year emitted from these sources during 2007–2016 (Le Quéré et al., 2018). Thus, the additional warming due to the complete loss of Arctic sea ice would be equivalent to 25 years of global CO_2 emissions at the current rate."). *See also* Institute for Governance & Sustainable Development (2019) Plain Language Summary of Pistone K., et al.

[18] Wadhams P. (2017) A FAREWELL TO ICE: A REPORT FROM THE ARCTIC, Oxford University Press: Oxford, United Kingdom, 107–108 ("Warm air over an ice-free Arctic also causes the snowline to retreat. … This of the same magnitude as the sea ice negative anomaly during the same period, and the change in albedo is roughly the same between snow-covered land and snow-free tundra as it is between sea ice and open water. Nobody has yet published the calculations for tundra as Pistone and her colleagues did for sea ice, but the similarity of the magnitudes means that snowline retreat and sea ice retreat are each adding about the same amount to global warming.").

[19] Dreyfus G. B., Xu Y., Shindell D. T., Zaelke D., & Ramanathan V. (2022) *Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming*, PROC. NAT'L. ACAD. SCI. 119(22): e2123536119, 1–8, 1 ("We find that mitigation measures that target only decarbonization are essential for strong long-term cooling but can result in weak near-term warming (due to unmasking the cooling effect of co-emitted aerosols) and lead to temperatures exceeding 2°C before 2050. In contrast, pairing decarbonization with additional mitigation measures targeting short-lived climate pollutants (SLCPs) and N_2O, slows the rate of warming a decade or two earlier than decarbonization alone and avoids the 2°C threshold altogether. These non-CO_2 targeted measures when combined with decarbonization can provide net cooling by 2030, reduce the rate of warming from 2030 to 2050

by about 50%, roughly half of which comes from methane, significantly larger than decarbonization alone over this timeframe."). *See also* Ou Y., Roney C., Alsalam J., Calvin K., Creason J., Edmonds J., Fawcett A. A., Kyle P., Narayan K., O'Rourke P., Patel P., Ragnauth S., Smith S. J., & McJeon H. (2021) *Deep mitigation of CO_2 and non-CO_2 greenhouse gases toward 1.5 °C and 2 °C futures*, NATURE COMMUN. 12: 6245, 4 ("CO_2 abatement only cannot achieve the 1.5 °C target under all modeled 1.5 °C pathways but achieves the 2 °C target if reaching net-zero CO_2 by 2030 under 2 °C pathways; CO_2-driven GHG abatement achieves the 1.5 °C target if reaching net-zero CO_2 by 2032 under 1.5 °C pathways or achieves the 2 °C target if reaching net-zero CO_2 by 2045 under 2 °C pathways; Comprehensive GHG abatement achieves the 1.5 °C target if reaching net-zero CO_2 by 2053 under 1.5 °C pathways or achieves the 2 °C target if reaching net-zero CO_2 by 2075 under 2 °C pathways.").

[20] Lelieveld J., Klingmüller K., Pozzer A., Burnett R. T., Haines A., & Ramanathan V. (2019) *Effects of fossil fuel and total anthropogenic emission removal on public health and climate*, PROC. NAT'L. ACAD. SCI. 116(15): 7192–7197, 7194 ("Finally, our model simulations show that fossil-fuel-related aerosols have masked about 0.51(±0.03) °C of the global warming from increasing greenhouse gases (Fig. 3)."). *See also* Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-2 (Figure SPM.2c shows that Sulphur dioxide (SO_2) contributes –0.49 °C (–0.10 to –0.93 °C) to observed warming in 2010–2019 relative to 1850–1900).

[21] Ramanathan V. & Feng Y. (2008) *On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead*, PROC. NAT'L. ACAD. SCI. 105(38): 14245–14250, 14248 ("Switching from coal to ''cleaner'' natural gas will reduce CO_2 emission and thus would be effective in minimizing future increases in the committed warming. However, because it also reduces air pollution and thus the ABC [Atmospheric Brown Cloud] masking effect, it may speed up the approach to the committed warming of 2.4°C (1.4–4.3°C)."). *See also* United Nations Environment Programme & World Meteorological Organization (2011) INTEGRATED ASSESSMENT OF BLACK CARBON AND TROPOSPHERIC OZONE, 254 ("Evaluating global mean temperature change, it was found that the targeted measures to reduce emissions of methane and BC could greatly reduce warming rates over the next few decades (Figure 6.1; Box 6.1). When all measures are fully implemented, warming during the 2030s relative to the present would be only half as much as in the reference scenario. In contrast, even a fairly aggressive strategy to reduce CO_2 emissions, as for the CO_2-measures scenario, does little to mitigate warming until after the next 20-30 years (Box 6.2). In fact, sulphur dioxide (SO_2) is coemitted with CO_2 in some of the most highly emitting activities, coal burning in large-scale combustion such as in power plants, for example, that are obvious targets for reduced usage under a CO_2-emissions mitigation strategy. Hence such strategies can lead to additional near-term warming (Figure 6.1), in a well-known temporary effect (e.g. Raes and Seinfeld, 2009), although most of the nearterm warming is driven by CO_2 emissions in the past. The CO_2-measures scenario clearly leads to long-term benefits however, with a dramatically lower warming rate at 2070 under that scenario than under the scenario with only CH_4 and BC measures (see Figure 6.1 and timescales in Box 6.2). Hence the near-term measures clearly cannot be substituted for measures to reduce emissions of long-lived GHGs. The near-term measures largely target different source sectors for emissions than the CO_2 measures, so that the emissions reductions of the short-lived pollutants are almost identical regardless of whether the CO_2 measures are implemented or not, as shown in Chapter 5. The near-term measures and the CO_2 measures also impact climate change over different timescales owing to the different lifetimes of these substances. In essence, the near-term CH_4 and BC measures are effectively uncoupled from CO_2 measures examined here."); Shindell D. & Smith C. J. (2019) *Climate and air-quality benefits of a realistic phase-out of fossil fuels*, NATURE 573: 408–411, 409–410, Addendum "Methods" ("These results differ greatly from the idealized picture of a near-instantaneous response to the removal of aerosol cooling followed by a slow transition to dominance by the effects of CO_2. In these more plausible cases, the temperature effects of the reduction in CO_2, SO_2 and CH_4 roughly balance one another until about 2035. After this, the cooling effects of reduced CO_2 continue to increase, whereas the warming induced by a reduction in SO_2 and the cooling induced by the reduction in CH_4 taper off, such that the cooling induced by the reduction in CO_2 dominates (Fig. 3). Examining the effects of CO_2 and SO_2 alone (Fig. 3d), the faster response of SO_2 to the changes in emissions means that the net effect of these two pollutants would indeed be a short-term warming—but a very small one, of between 0.02 °C and 0.10 °C in the ensemble mean temperature response (up to 0.30 °C for the 95th percentile across pathways). Accounting for all fossil-related emissions (Fig. 3e), any brief climate penalty decreases to no more than 0.05 °C (0.19 °C at the 95th percentile), with the smaller value largely due to the additional near-term cooling from reductions in methane. Nearly all the warming in the 2020s and 2030s (Fig. 2) is therefore attributable to the effect of the residual emissions (mainly of CO_2) during the gradual fossil phase-out, as well as the response to historical emissions."; "We note that, although this study focuses on the effects of fossil-fuel related emissions, accounting for

the effects of reductions in greenhouse gases from non-fossil sources—including fluorinated gases and both methane and nitrous oxide from agriculture—along with biofuels that are a large source of warming black carbon, could eliminate any near-term penalty entirely. In fact, given that the net effect of the fossil-fuel phase-out on temperature is minimal during the first 20 years (Fig. 3), reducing those other emissions is the only plausible way in which to decrease warming during that period."); Hansen J. E. & Sato M. (2021) *July Temperature Update: Faustian Payment Comes Due* ("It follows that the global warming acceleration is due to the one huge climate forcing that we have chosen not to measure: the forcing caused by imposed changes of atmospheric aerosols… We should expect the global warming rate for the quarter of a century 2015-2040 to be about double the 0.18°C/decade rate during 1970-2015 (see Fig. 2), unless appropriate countermeasures are taken."); *as discussed in* Berwyn B. (15 September 2021) *The Rate of Global Warming During Next 25 Years Could Be Double What it Was in the Previous 50, a Renowned Climate Scientist Warns*, INSIDE CLIMATE NEWS; *and* Feijoo F., Mignone B. K., Kheshgi H. S., Hartin C., McJeon H., & Edmonds J. (2019) *Climate and carbon budget implications of linked future changes in CO_2 and non-CO_2 forcing*, ENVIRON. RES. LETT. 14(4): 04407, 1–11.

[22] Dreyfus G. B., Xu Y., Shindell D. T., Zaelke D., & Ramanathan V. (2022) *Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming*, PROC. NAT'L. ACAD. SCI. 119(22): e2123536119, 1–8, 5 ("Aggressive decarbonization to achieve net-zero CO_2 emissions in the 2050s (as in the decarb-only scenario) results in weakly accelerated net warming compared to the reference case, with a positive warming up to 0.03 °C in the mid-2030s, and no net avoided warming until the mid-2040s due to the reduction in co-emitted cooling aerosols (Figure 3a). By 2050, decarbonization measures result in very limited net avoided warming (0.07°C), consistent with Shindell and Smith (43), but rise to a likely detectable 0.25°C by 2060 and a major benefit of 1.4°C by 2100 (Table S5). In contrast, pairing decarbonization with mitigation measures targeting CH_4, BC, HFC, and N_2O (not an SLCP due to its longer lifetime) independent from decarbonization are essential to slowing the rate of warming by the 2030s to under 0.3°C per decade (Table 1, Figure 3b), similar to the 0.2°C to 0.25°C per decade warming prior to 2020 (38, 53). Recent studies suggest that rate of warming rather than level of warming controls likelihood of record-shattering extreme weather events (54, 55). By 2050, the net avoided warming from the targeted non-CO_2 measures is 0.26°C, almost 4 times larger than the net benefit of decarbonization alone (0.07°C) (Table S5).").

[23] Naik V., *et al.* (2021) *Chapter 6: Short-lived climate forcers*, in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 6-7, 6-8 ("Across the SSPs, the collective reduction of CH_4, ozone precursors and HFCs can make a difference of global mean surface air temperature of 0.2 with a very likely range of [0.1–0.4] °C in 2040 and 0.8 with a very likely range of [0.5–1.3] °C at the end of the 21st century (comparing SSP3-7.0 and SSP1-1.9), which is substantial in the context of the Paris Agreement. Sustained methane mitigation, wherever it occurs, stands out as an option that combines near- and long-term gains on surface temperature (*high confidence*) and leads to air quality benefits by reducing surface ozone levels globally (*high confidence*). {6.6.3, 6.7.3, 4.4.4}"; "Additional CH_4 and BC mitigation would contribute to offsetting the additional warming associated with SO_2 reductions that would accompany decarbonization (*high confidence*)."). *See also* Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-36 ("Strong, rapid and sustained reductions in CH_4 emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality.").

[24] Dreyfus G. B., Xu Y., Shindell D. T., Zaelke D., & Ramanathan V. (2022) *Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming*, PROC. NAT'L. ACAD. SCI. 119(22): e2123536119, 1–8, 1 ("We find that mitigation measures that target only decarbonization are essential for strong long-term cooling but can result in weak near-term warming (due to unmasking the cooling effect of co-emitted aerosols) and lead to temperatures exceeding 2°C before 2050. In contrast, pairing decarbonization with additional mitigation measures targeting short-lived climate pollutants (SLCPs) and N_2O, slows the rate of warming a decade or two earlier than decarbonization alone and avoids the 2°C threshold altogether. These non-CO_2 targeted measures when combined with decarbonization can provide net cooling by 2030, reduce the rate of warming from 2030 to 2050 by about 50%, roughly half of which comes from methane, significantly larger than decarbonization alone over this timeframe.").

[25] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), SPM-30–SPM-31 ("Deep GHG emissions reductions by 2030 and 2040, particularly reductions of methane emissions, lower peak warming, reduce the likelihood of overshooting warming limits and lead to less reliance on net negative CO_2 emissions that reverse warming in the latter half of the century… Future non-CO_2 warming depends on reductions in non-CO_2 GHG, aerosol and their precursor, and ozone precursor emissions. In modelled global low emission pathways, the projected reduction of cooling and warming aerosol emissions over time leads to net warming in the near- to mid-term. In these mitigation pathways, the projected reductions of cooling aerosols are mostly due to reduced fossil fuel combustion that was not equipped with effective air pollution controls. Non-CO_2 GHG emissions at the time of net zero CO_2 are projected to be of similar magnitude in modelled pathways that limit warming to 2°C (>67%) or lower. These non-CO_2 GHG emissions are about 8 [5–11] $GtCO_2$-eq per year, with the largest fraction from CH_4 (60% [55–80%]), followed by N_2O (30% [20–35%]) and F-gases (3% [2–20%]). [FOOTNOTE 52] Due to the short lifetime of CH_4 in the atmosphere, projected deep reduction of CH_4 emissions up until the time of net zero CO_2 in modelled mitigation pathways effectively reduces peak global warming. (*high confidence*) {3.3, AR6 WG I SPM D1.7}").

[26] United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 21 ("Methane mitigation offer a way of rapidly reducing the rate of near-term warming. Also, mitigation of methane, along with non- fossil greenhouse gases including some hydroflurocarbons (HFCs) and black carbon-rich sources of particulate matter (PM), is the only plausible way of decreasing warming relative to a reference case with minimal changes in current policies over the next 20 years. This is because a realistically paced phase-out of fossil fuels, or even a rapid one under aggressive decarbonization, is likely to have minimal net impacts on near-term temperatures due to the removal of co-emitted aerosols (Shindell and Smith 2019). As methane is the most powerful driver of climate change among the short-lived substances (Myhre *et al*. 2013), mitigation of methane emissions is very likely to be the most powerful lever in reducing near-term warming. This is consistent with other assessments; for example, the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) showed that methane controls implemented between 2010 and 2030 would lead to a larger reduction in 2040 warming than the difference between RCPs 2.6, 4.5 and 6.0 scenarios. (The noted IPCC AR5-era scenarios are called representative concentration pathways (RCPs, with the numerical value indicating the target radiative forcing in 2100 (Kirtman *et al*. 2013)).").

[27] Climate & Clean Air Coalition, *Methane* (*last visited* 14 June 2022) ("Methane is a short-lived climate pollutant with an atmospheric lifetime of around 12 years. While its lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), it is much more efficient at trapping radiation. Per unit of mass, the impact of methane on climate change over 20 years is 86 times greater than CO_2; over a 100-year period it is 28 times greater.").

[28] United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 17 ("Mitigation of methane is very likely the strategy with the greatest potential to decrease warming over the next 20 years.").

[29] United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 21 ("This is because a realistically paced phase-out of fossil fuels, or even a rapid one under aggressive decarbonization, is likely to have minimal net impacts on near-term temperatures due to the removal of co-emitted aerosols (Shindell and Smith 2019). As methane is the most powerful driver of climate change among the short-lived substances (Myhre et al. 2013), mitigation of methane emissions is very likely to be the most powerful lever in reducing near-term warming. This is consistent with other assessments; for example, the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) showed that methane controls implemented between 2010 and 2030 would lead to a larger reduction in 2040 warming than the difference between RCPs 2.6, 4.5 and 6.0 scenarios. (The noted IPCC AR5-era scenarios are called representative concentration pathways (RCPs, with the numerical value indicating the target radiative forcing in 2100 (Kirtman et al. 2013))."). *See also* Ocko I. B., Sun T., Shindell D., Oppenheimer M., Hristov A. N., Pacala S.W., Mauzerall D. L., Xu Y., & Hamburg S. P. (2021) *Acting rapidly to deploy readily available methane mitigation measures by sector can immediately slow global warming*, ENVIRON. RES. LETT. 16(5): 054042 ("Pursuing all mitigation measures now could slow the global-mean rate of near-term decadal warming by around 30%, avoid a quarter of a degree centigrade of additional global-mean warming by midcentury, and set ourselves on a path to avoid more than half a degree centigrade by end of century. On the other hand, slow implementation of these measures may result in an additional

tenth of a degree of global-mean warming by midcentury and 5% faster warming rate (relative to fast action), and waiting to pursue these measures until midcentury may result in an additional two tenths of a degree centigrade by midcentury and 15% faster warming rate (relative to fast action)."); *and* Shindell D. & Smith C. J. (2019) *Climate and air-quality benefits of a realistic phase-out of fossil fuels*, NATURE 573: 408–411, Addendum "Methods" ("We note that, although this study focuses on the effects of fossil-fuel related emissions, accounting for the effects of reductions in greenhouse gases from non-fossil sources—including fluorinated gases and both methane and nitrous oxide from agriculture—along with biofuels that are a large source of warming black carbon, could eliminate any near-term penalty entirely. In fact, given that the net effect of the fossil-fuel phase-out on temperature is minimal during the first 20 years (Fig. 3), reducing those other emissions is the only plausible way in which to decrease warming during that period.").

[30] Intergovernmental Panel on Climate Change (2021) *Summary for Policymakers*, *in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), SPM-36 ("Strong, rapid and sustained reductions in CH_4 emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality."). *See also* Naik V., *et al.* (2021) *Chapter 6: Short-lived climate forcers*, in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 6-7 ("Sustained methane mitigation, wherever it occurs, stands out as an option that combines near- and long-term gains on surface temperature (*high confidence*) and leads to air quality benefits by reducing surface ozone levels globally (*high confidence*). {6.6.3, 6.7.3, 4.4.4}").

[31] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), SPM-30–SPM-31 ("Deep GHG emissions reductions by 2030 and 2040, particularly reductions of methane emissions, lower peak warming, reduce the likelihood of overshooting warming limits and lead to less reliance on net negative CO2 emissions that reverse warming in the latter half of the century. Reaching and sustaining global net zero GHG emissions results in a gradual decline in warming. (high confidence) (Table SPM.1) {3.3, 3.5, Box 3.4, Cross-Chapter Box 3 in Chapter 3, AR6 WG I SPM D1.8}").

[32] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), SPM-22 ("C.1.2 In modelled pathways that limit warming to 2°C (>67%) assuming immediate action, global net CO2 emissions are reduced compared to modelled 2019 emissions by 27% [11–46%] in 2030 and by 52% [36-70%] in 2040; and global CH4 emissions are reduced by 24% [9–53%] in 2030 and by 37% [20–60%] in 2040. In pathways that limit warming to 1.5°C (>50%) with no or limited overshoot global net CO2 emissions are reduced compared to modelled 2019 emissions by 48% [36–69%] in 2030 and by 80% [61-109%] in 2040; and global CH4 emissions are reduced by 34% [21–57%] in 2030 and 44% [31-63%] in 2040. There are similar reductions of non-CO2 emissions by 2050 in both types of pathways: CH4 is reduced by 45% [25–70%]; N2O is reduced by 20% [-5 – 55%]; and F-Gases are reduced by 85% [20–90%]. [FOOTNOTE 44] Across most modelled pathways, this is the maximum technical potential for anthropogenic CH4 reductions in the underlying models (high confidence). Further emissions reductions, as illustrated by the IMP-SP pathway, may be achieved through changes in activity levels and/or technological innovations beyond those represented in the majority of the pathways (medium confidence). Higher emissions reductions of CH4 could further reduce peak warming. (high confidence) (Figure SPM.5) {3.3}").

[33] Xu Y. & Ramanathan V. (2017) *Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes*, PROC. NAT'L. ACAD. SCI. 114(39): 10315–10323, 10321 ("The SP [super pollutant] lever targets SLCPs. Reducing SLCP emissions thins the SP blanket within few decades, given the shorter lifetimes of SLCPs (weeks for BC to about 15 years for HFCs). The mitigation potential of the SP lever with a maximum deployment of current technologies … is about 0.6 °C by 2050 and 1.2 °C by 2100 (SI Appendix, Fig. S5B and Table S1)."). *See also* Naik V., *et al.* (2021) *Chapter 6: Short-lived climate forcers*, in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte V., *et al.* (eds.), 6-7 ("Across the SSPs, the collective reduction of CH_4, ozone precursors and HFCs can make a difference of global mean surface air temperature of 0.2 with a very likely range of [0.1–0.4] °C in 2040 and 0.8 with a very likely range of [0.5–1.3] °C at the end of the 21st century (comparing SSP3-7.0 and SSP1-

1.9), which is substantial in the context of the Paris Agreement. Sustained methane mitigation, wherever it occurs, stands out as an option that combines near- and long-term gains on surface temperature (*high confidence*) and leads to air quality benefits by reducing surface ozone levels globally (*high confidence*). {6.6.3, 6.7.3, 4.4.4}").

[34] Shindell D., *et al.* (2012) *Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security*, SCIENCE 335(6065): 183–189, 183–185 ("The global mean response to the CH_4 plus BC measures was –0.54 ± 0.05ºC in the climate model. …Roughly half the forcing is relatively evenly distributed (from the CH_4 measures). The other half is highly inhomogeneous, especially the strong BC forcing, which is greatest over bright desert and snow or ice surfaces. Those areas often exhibit the largest warming mitigation, making the regional temperature response to aerosols and ozone quite distinct from the more homogeneous response to well-mixed greenhouse gases… . BC albedo and direct forcings are large in the Himalayas, where there is an especially pronounced response in the Karakoram, and in the Arctic, where the measures reduce projected warming over the next three decades by approximately two thirds and where regional temperature response patterns correspond fairly closely to albedo forcing (for example, they are larger over the Canadian archipelago than the interior and larger over Russia than Scandinavia or the North Atlantic)."). *See also* United Nations Environment Programme & World Meteorological Organization (2011) INTEGRATED ASSESSMENT OF BLACK CARBON AND TROPOSPHERIC OZONE, 254, 262 ("Evaluating global mean temperature change, it was found that the targeted measures to reduce emissions of methane and BC could greatly reduce warming rates over the next few decades (Figure 6.1; Box 6.1). When all measures are fully implemented, warming during the 2030s relative to the present would be only half as much as in the reference scenario. In contrast, even a fairly aggressive strategy to reduce CO_2 emissions, as for the CO_2-measures scenario, does little to mitigate warming until after the next 20-30 years (Box 6.2)."; "Large impacts of the measures examined here were also seen for the Arctic despite the minimal amount of emissions currently taking place there. This occurs due to the high sensitivity of the Arctic both to pollutants that are transported there from remote sources and to radiative forcing that takes place in areas of the northern hemisphere outside the Arctic. The 16 measures examined here, including the measures on pellet stoves and coal briquettes, reduce warming in the Arctic by 0.7 ºC (range 0.2 to 1.3 ºC) at 2040. This is a large portion of the 1.1 ºC (range 0.7 to 1.7 ºC) warming projected under the reference scenario for the Arctic, and hence implementation of the measures would be virtually certain to substantially slow, but not halt, the pace of Arctic climate change.").

[35] Swiss Re Institute (2021) *The economics of climate change: no action not an option* ("Recent scientific research indicates that current likely temperature-rise trajectories, supported by implementation of mitigation pledges, would entail 2.0–2.6°C global warming by mid-century. We use this as the baseline to simulate the impact of rising temperatures over time, while also modelling for the uncertainties around most severe possible physical outcomes. The result is that global GDP would be 11–14% less than in a world without climate change (ie, 0°C change). Under the same no climate change comparative, the Paris target too result in negative GDP impact, but less much so (–4.2%). We also consider a severe scenario in which temperatures rise by 3.2°C by mid-century, with society doing nothing to combat climate change. In this scenario, the global economy would be 18% smaller than in a world without warming, reinforcing the imperative of, if anything, more action on climate change.").

[36] *See e.g.* G7 (21 May 2021) *G7 Climate and Environment Ministers' Meeting Communiqué* ("We highlight with deep concern the findings from the IPCC Special Report 2018, and recognise the need to reduce the global level of annual GHG emissions to 25-30 Gt of carbon dioxide equivalent or lower by 2030 to put the world on track to limit global warming to 1.5°C above pre-industrial levels, in order to reduce the risk of catastrophic consequences of climate change. We commit to submitting long-term strategies (LTSs) that set out concrete pathways to net zero GHG emissions by 2050 as soon as possible, making utmost efforts to do so by COP26. We commit to updating them regularly, including to reflect on the latest science, as well as technological and market developments. We also note with concern the initial version of the NDC Synthesis Report prepared by the UNFCCC Secretariat which highlights that many parties are yet to submit new and updated NDCs. NDCs communicated by 2020 collectively fall far short of the ranges found in pathways identified by the IPCC, which limit global warming to 1.5°C or well below 2°C. We welcome the significantly enhanced ambition reflected in 2030 targets announced by all G7 members, which put us on clear and credible pathways towards our respective 2050 net zero GHG emission reduction targets. We note the important contribution these commitments make towards keeping 1.5°C within reach and in providing an unequivocal direction of travel for business, investors and society at large. Those of us who have not already done so commit to submitting our enhanced NDCs to the UNFCCC as soon as possible ahead of COP26."). *See also* Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on*

Climate Change, Shukla P. R., *et al.* (eds.), SPM-30–SPM-31 ("Deep GHG emissions reductions by 2030 and 2040, particularly reductions of methane emissions, lower peak warming, reduce the likelihood of overshooting warming limits and lead to less reliance on net negative CO_2 emissions that reverse warming in the latter half of the century… Future non-CO_2 warming depends on reductions in non-CO_2 GHG, aerosol and their precursor, and ozone precursor emissions. In modelled global low emission pathways, the projected reduction of cooling and warming aerosol emissions over time leads to net warming in the near- to mid-term. In these mitigation pathways, the projected reductions of cooling aerosols are mostly due to reduced fossil fuel combustion that was not equipped with effective air pollution controls. Non-CO_2 GHG emissions at the time of net zero CO_2 are projected to be of similar magnitude in modelled pathways that limit warming to 2°C (>67%) or lower. These non-CO_2 GHG emissions are about 8 [5–11] $GtCO_2$-eq per year, with the largest fraction from CH_4 (60% [55–80%]), followed by N_2O (30% [20–35%]) and F-gases (3% [2–20%]). [FOOTNOTE 52] Due to the short lifetime of CH_4 in the atmosphere, projected deep reduction of CH_4 emissions up until the time of net zero CO_2 in modelled mitigation pathways effectively reduces peak global warming. (*high confidence*) {3.3, AR6 WG I SPM D1.7}").

[37] United Nations Framework Convention on Climate Change (2016) *Just Transition of the Workforce, and the Creation of Decent Work and Quality Jobs*, 17 ("Most studies that have investigated the net impact on employment of environmental policy measures suggest it is positive. A review of 30 studies (covering individual countries and economic regions) has found that meaningful employment gains either have been achieved or are possible through the pursuit of climate policies (ILO and IILS, 2012). Most of the studies indicated net employment gains of 0.5–2 per cent, or 15–60 million additional jobs globally. […] The likelihood that the overall net employment outcome will be positive should not obscure the reality that far-reaching mitigation policies will change global, regional and national economies in potentially profound ways and severely disrupt the lives of affected workers and their communities. Regions which lack diversification (with a high degree of dependence on a single industry), which have a limited capacity for innovation, or whose economic mainstay is vulnerable to decisions made elsewhere will face the greatest challenge, as will workers with skills that are in less demand or who are unable to acquire new skills. The situation is also more challenging if the shift in demand of occupation is in a sector that offers a big share of employment for the region (e.g. agriculture). Such concerns are particularly strong for (but not limited to) developing countries."). *See also* Pathak M., *et al.* (2022) *Technical Summary*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), TS-142 ("The landscape of transitions to sustainable development is changing rapidly, with multiple transitions already underway. This creates the room to manage these transitions in ways that prioritise the needs of workers in vulnerable sectors (e.g., land, energy) to secure their jobs and maintain secure and healthy lifestyles (medium evidence, high agreement). {17.3.2}"… Accelerating the transition to sustainability will be enabled by explicit consideration being given to the principles of justice, equality and fairness (high confidence). {5.2, 5.4, 5.6, 13.2, 13.6, 13.8, 17 13.9,17.4}).

[38] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: IMPACTS, ADAPTATION, AND VULNERABILITY, *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Pörtner H.-O., *et al.* (eds.), SPM-15 ("**SPM.B.4.6** Projected estimates of global aggregate net economic damages generally increase non-linearly with global warming levels (high confidence).35 The wide range of global estimates, and the lack of comparability between methodologies, does not allow for identification of a robust range of estimates (high confidence). The existence of higher estimates than assessed in AR5 indicates that global aggregate economic impacts could be higher than previous estimates (low confidence).36 Significant regional variation in aggregate economic damages from climate change is projected (high confidence) with estimated economic damages per capita for developing countries often higher as a fraction of income (high confidence). Economic damages, including both those represented and those not represented in economic markets, are projected to be lower at 1.5°C than at 3°C or higher global warming levels (high confidence). {4.4, 9.11, 11.5, 13.10, Box 14.6, 16.5, CWGB ECONOMICS}").

[39] World Economic Forum (2022) GLOBAL RISKS REPORT 2022, 18 ("The economic overhang of the COVID-19 crisis and weakened social cohesion—in advanced and developing economies alike—may further limit the financial and political capital available for stronger climate action. The European Union, the United Kingdom and the United States, for example, were reluctant to commit to a formal climate finance target to respond to worsening climate change impacts in developing country Parties.[35] China and India lobbied to change the Pact's wording from "phase out" to "phase down" of "unabated coal power and inefficient fossil fuel subsidies".[36] The economic crisis created by the COVID-19 pandemic risks delaying efforts to tackle climate change by encouraging countries to prioritize short-term

measures to restore economic growth, regardless of their impact on the climate, over pursuing green transitions.… Climate change continues to be perceived as the gravest threat to humanity. GRPS respondents rate "climate action failure" as the risk with potential to inflict the most damage at a global scale over the next decade (see Figure 1.3).").

[40] Weitzman, M. L. (2010) *Revisiting Fat-Tailed Uncertainty in the Economics of Climate Change*, REV. ENVIRON. ECON. POLICY 5: 275–292, 275 ("I believe that the most striking feature of the economics of climate change is that its extreme downside is nonnegligible. Deep structural uncertainty about the unknown unknowns of what might go very wrong is coupled with essentially unlimited downside liability on possible planetary damages. This is a recipe for producing what are called ''fat tails'' in the extremes of critical probability distributions. There is a race being run in the extreme tail between how rapidly probabilities are declining and how rapidly damages are increasing. Who wins this race, and by how much, depends on how fat (with probability mass) the extreme tails are. It is difficult to judge how fat the tail of catastrophic climate change might be because it represents events that are very far outside the realm of ordinary experience."). *See also* Molina M., Ramanathan V., & Zaelke D. (9 October 2018) *Climate report understates threat*, BULLETIN OF THE ATOMIC SCIENTISTS ("The UN's Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5 degrees Celsius, released on Monday, is a major advance over previous efforts to alert world leaders and citizens to the growing climate risk. But the report, dire as it is, misses a key point: Self-reinforcing feedbacks and tipping points—the wildcards of the climate system—could cause the climate to destabilize even further. The report also fails to discuss the five percent risk that even existing levels of climate pollution, if continued unchecked, could lead to runaway warming—the so-called "fat tail" risk. These omissions may mislead world leaders into thinking they have more time to address the climate crisis, when in fact immediate actions are needed. To put it bluntly, there is a significant risk of self-reinforcing climate feedback loops pushing the planet into chaos beyond human control."); *and* Zaelke D. (21 May 2021) *We have a chance to halt climate change if we stop destroying carbon sinks and cut methane*, THE HILL ("Climate change, we are beginning to realize, presents the ultimate fat tail risk. This includes risks to the stability of the world financial system and economy — through, for example, losing $1 trillion to $4 trillion of fossil fuel assets made unviable by stricter climate regulations and cheaper renewable energy. But the real stinger in the tail is the risk that self-reinforcing feedbacks could cause the Earth to warm itself beyond our control, pushing the climate past a series of deadly tipping points into Hothouse Earth.").

[41] Sustainability Accounting Standards Board & Global Reporting Initiative (2021) *A Practical Guide to Sustainability Reporting Using GRI and SASB Standards*, 5 ("Transparency is the best currency for creating trust among organizations and their stakeholders, including investors. That is why companies and other organizations focus on disclosing the information each stakeholder group requires. GRI and SASB provide compatible standards for such disclosures. Their standards are mutually supportive and designed to fulfill different purposes.").

[42] United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 9 ("Currently available measures could reduce emissions from these major sectors by approximately 180 Mt/yr, or as much as 45 per cent, by 2030. This is a cost-effective step required to achieve the United Nations Framework Convention on Climate Change (UNFCCC) 1.5° C target. According to scenarios analysed by the Intergovernmental Panel on Climate Change (IPCC), global methane emissions must be reduced by between 40–45 per cent by 2030 to achieve least cost-pathways that limit global warming to 1.5° C this century, alongside substantial simultaneous reductions of all climate forcers including carbon dioxide and short-lived climate pollutants. (Section 4.1)").

[43] Directive 2014/95/EU (22 October 2014).

[44] European Commission (2019) *Guidelines on reporting climate-related information*, 6 ("As indicated in the Commission's 2017 Non-Binding Guidelines on Non-Financial Reporting, the reference to the "impact of [the company's] activities" introduced a new element to be taken into account when assessing the materiality of non-financial information. In effect, the Non-Financial Reporting Directive has a double materiality perspective: - The reference to the company's "development, performance [and] position" indicates financial materiality, in the broad sense of affecting the value of the company. Climate-related information should be reported if it is necessary for an understanding of the development, performance and position of the company. This perspective is typically of most interest to investors. - The reference to "impact of [the company's] activities" indicates environmental and social materiality. Climate-related information should be reported if it is necessary for an understanding of the external impacts of the company. This perspective is typically of most interest to citizens, consumers, employees, business partners, communities and civil society organisations. However, an increasing number of investors also need to know

about the climate impacts of investee companies in order to better understand and measure the climate impacts of their investment portfolios.").

[45] Ceres (12 May 2021) *Major investors demand ambitious methane*, Press Release ("As the Biden administration prepares to revise federal methane regulations, 147 oil and gas industry investors representing $5.35 trillion in assets under management signed on to a statement calling for comprehensive regulations to curb dangerous GHG emissions — and more stringent enforcement mechanisms to back them up. As "prudent fiduciaries", the statement says, the signatories believe that virtually eliminating methane emissions supports the financial goals of companies and investors. "By taking action on methane emissions, government can achieve valuable greenhouse gas reductions while helping American industry become cleaner and more competitive," it continues. In 2019, U.S. oil and gas operations emitted 16 million metric tons of methane emissions, with a near-term climate impact greater than all U.S. coal-fired power plants."). *See also* Watson D. (28 February 2022) *Round one of EPA methane comment period draws record engagement; Here's how companies and investors can step up in round two*, ENVIRONMENTAL DEFENSE FUND ("**Record number of investors speak up.** From major global investors including Legal & General, PIMCO, Allianz and Wellington to U.S.-based oil and gas private equity firms such as Quantum and EIG, a record $9 trillion in assets under management came out in support of ambitious federal methane policy. That's great news. But these firms are still a fraction of the $130 trillion in capital publicly committed to net-zero. The largest U.S. money managers including Blackrock, Vanguard, State Street, Fidelity and JP Morgan, failed to submit comments.").

[46] Swiss Re Institute (2021) *The economics of climate change: no action not an option* ("Recent scientific research indicates that current likely temperature-rise trajectories, supported by implementation of mitigation pledges, would entail 2.0–2.6°C global warming by mid-century. We use this as the baseline to simulate the impact of rising temperatures over time, while also modelling for the uncertainties around most severe possible physical outcomes. The result is that global GDP would be 11–14% less than in a world without climate change (ie, 0°C change). Under the same no climate change comparative, the Paris target too result in negative GDP impact, but less much so (–4.2%). We also consider a severe scenario in which temperatures rise by 3.2°C by mid-century, with society doing nothing to combat climate change. In this scenario, the global economy would be 18% smaller than in a world without warming, reinforcing the imperative of, if anything, more action on climate change."). *See also* World Economic Forum (2022) GLOBAL RISKS REPORT 2022, 35 ("The consequences and repercussions of the transition will necessarily reflect the speed at which it takes place; the efforts that go into it; and whether it is slow or aggressive, concerted or entrenched, and focused more on mitigation or adaptation. The goal of 1.5°C is so fundamental that societies need to be prepared to assume negative consequences of policies taken by governments today to avoid the worst consequences tomorrow. This includes job losses, increased costs and geopolitical insecurity associated with a disorderly transition. Only a socially just transition will make the consequences bearable for large parts of societies with governments needing to create policies and social-protection systems that help reduce the impacts for those affected. A rapid decarbonization would increase economic and societal disruption in the short term, while a slower pace with fewer short-term impacts would entail much larger costs and greater disorderliness in the long-term. GRPS respondents drew attention to the societal consequences of environmental degradation at a global scale. They identify "climate action failure" and "extreme weather" as strong aggravators of "involuntary migration", "livelihood crises" and "social cohesion erosion". In contrast, respondents to the Executive Opinion Survey (EOS) see the impacts from "climate action failure" as top risks in the short-term at a country level: "human environmental damage" and "extreme weather" are considered top-10 risks in 90 economies and 60 countries, respectively. All countries ranking these risks highly are particularly prone to wildfires, droughts, floods, deforestation and pollution.."); *and* Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: IMPACTS, ADAPTATION, AND VULNERABILITY, *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Pörtner H.-O., *et al.* (eds.), SPM-15 ("**SPM.B.4.6** Projected estimates of global aggregate net economic damages generally increase non-linearly with global warming levels (high confidence).35 The wide range of global estimates, and the lack of comparability between methodologies, does not allow for identification of a robust range of estimates (high confidence). The existence of higher estimates than assessed in AR5 indicates that global aggregate economic impacts could be higher than previous estimates (low confidence).36 Significant regional variation in aggregate economic damages from climate change is projected (high confidence) with estimated economic damages per capita for developing countries often higher as a fraction of income (high confidence). Economic damages, including both those represented and those not represented in economic markets, are projected to be lower at 1.5°C than at 3°C or higher global warming levels (high confidence). {4.4, 9.11, 11.5, 13.10, Box 14.6, 16.5, CWGB ECONOMICS}").

[47] CDP (2021) TRANSPARENCY TO TRANSFORMATION: A CHAIN REACTION, CDP Global Supply Chain Report 2020, 13 ("This is easily justified by the scale of the problem. In 2020, suppliers reported that they were exposed to some US$1.21 trillion in potential financial impact related to climate change.").

[48] CDP (2021) TRANSPARENCY TO TRANSFORMATION: A CHAIN REACTION, CDP Global Supply Chain Report 2020, 9 ("In 2020, over 8,000 suppliers disclosing through CDP reported that US$1.26 trillion of revenue is likely to be at risk over the next five years due to climate change, deforestation and water insecurity. The anticipated financial risk covers potential loss of revenue due to changing consumer preferences, loss of access to capital, and increased operational costs. The increased costs alone amount to as much as US$120 billion, and are caused by physical environmental impacts as well as addressing regulation and market changes.").

[49] Swiss Re Institute (2021) *The economics of climate change: no action not an option* ("Recent scientific research indicates that current likely temperature-rise trajectories, supported by implementation of mitigation pledges, would entail 2.0–2.6°C global warming by mid-century. We use this as the baseline to simulate the impact of rising temperatures over time, while also modelling for the uncertainties around most severe possible physical outcomes. The result is that global GDP would be 11–14% less than in a world without climate change (ie, 0°C change). Under the same no climate change comparative, the Paris target too result in negative GDP impact, but less much so (–4.2%). We also consider a severe scenario in which temperatures rise by 3.2°C by mid-century, with society doing nothing to combat climate change. In this scenario, the global economy would be 18% smaller than in a world without warming, reinforcing the imperative of, if anything, more action on climate change.").

[50] Hicke J. A., *et al.* (2022) *Chapter 14: North America, in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), 14-4 ("**Extreme events and climate hazards are adversely affecting economic activities across North America 16 and have disrupted supply-chain infrastructure and trade (*high confidence*).** Larger losses and 17 adaptation costs are observed for sectors with high climate exposures, including tourism, fisheries, and 18 agriculture (high confidence) and outdoor labor (medium confidence). Disaster planning and spending, 19 insurance, markets, and individual and household level adaptation have acted to moderate effects to 20 date (medium confidence). Entrenched socioeconomic vulnerabilities have amplified climate impacts for 21 marginalized groups, including Indigenous Peoples due to the impact of colonialism and discrimination 22 (medium confidence). {14.5.4, 14.5.5, 14.5.6, 14.5.7, 14.5.9, Box 14.1, Box 14.5, Box 14.6}").

[51] *See e.g.* G7 (21 May 2021) *G7 Climate and Environment Ministers' Meeting Communiqué* ("We highlight with deep concern the findings from the IPCC Special Report 2018, and recognise the need to reduce the global level of annual GHG emissions to 25-30 Gt of carbon dioxide equivalent or lower by 2030 to put the world on track to limit global warming to 1.5°C above pre-industrial levels, in order to reduce the risk of catastrophic consequences of climate change. We commit to submitting long-term strategies (LTSs) that set out concrete pathways to net zero GHG emissions by 2050 as soon as possible, making utmost efforts to do so by COP26. We commit to updating them regularly, including to reflect on the latest science, as well as technological and market developments. We also note with concern the initial version of the NDC Synthesis Report prepared by the UNFCCC Secretariat which highlights that many parties are yet to submit new and updated NDCs. NDCs communicated by 2020 collectively fall far short of the ranges found in pathways identified by the IPCC, which limit global warming to 1.5°C or well below 2°C. We welcome the significantly enhanced ambition reflected in 2030 targets announced by all G7 members, which put us on clear and credible pathways towards our respective 2050 net zero GHG emission reduction targets. We note the important contribution these commitments make towards keeping 1.5°C within reach and in providing an unequivocal direction of travel for business, investors and society at large. Those of us who have not already done so commit to submitting our enhanced NDCs to the UNFCCC as soon as possible ahead of COP26."). *See also* Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE, *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Shukla P. R., *et al.* (eds.), SPM-30–SPM-31 ("Deep GHG emissions reductions by 2030 and 2040, particularly reductions of methane emissions, lower peak warming, reduce the likelihood of overshooting warming limits and lead to less reliance on net negative CO_2 emissions that reverse warming in the latter half of the century… Future non-CO_2 warming depends on reductions in non-CO_2 GHG, aerosol and their precursor, and ozone precursor emissions. In modelled global low emission pathways, the projected reduction of cooling and warming aerosol emissions over time leads to net warming in the near- to mid-term. In these mitigation pathways, the projected reductions of cooling aerosols are mostly due to reduced fossil fuel combustion that was not equipped with effective

air pollution controls. Non-CO_2 GHG emissions at the time of net zero CO_2 are projected to be of similar magnitude in modelled pathways that limit warming to 2°C (>67%) or lower. These non-CO_2 GHG emissions are about 8 [5–11] $GtCO_2$-eq per year, with the largest fraction from CH_4 (60% [55–80%]), followed by N_2O (30% [20–35%]) and F-gases (3% [2–20%]). [FOOTNOTE 52] Due to the short lifetime of CH_4 in the atmosphere, projected deep reduction of CH_4 emissions up until the time of net zero CO_2 in modelled mitigation pathways effectively reduces peak global warming. (*high confidence*) {3.3, AR6 WG I SPM D1.7}").

[52] American Innovation and Manufacturing Act, Pub. L. No. 116-260, §103(h)(1) (codified at 42 U.S.C. § 7675 (h)(1)). *See also* U.S. Environmental Protection Agency, *AIM Act* (*last visited* 14 June 2022) ("On December 27, 2020, the American Innovation and Manufacturing (AIM) Act of 2020 was enacted as section 103 in Division S, Innovation for the Environment, of the Consolidated Appropriations Act, 2021 (H.R. 133 (116th): Consolidated Appropriations Act, 2021 [Including Coronavirus Stimulus & Relief]). The AIM Act directs EPA to address HFCs by providing new authorities in three main areas: to phase down the production and consumption of listed HFCs, manage these HFCs and their substitutes, and facilitate the transition to next-generation technologies.").

[53] White House (16 November 2021) *A Message to the Senate on the Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer* ("TO THE SENATE OF THE UNITED STATES: With a view to receiving the advice and consent of the Senate to ratification, I transmit herewith the Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (the "Montreal Protocol"), adopted at Kigali on October 15, 2016, by the Twenty-Eighth Meeting of the Parties to the Montreal Protocol (the "Kigali Amendment"). The report of the Department of State is also enclosed for the information of the Senate. The principal features of the Kigali Amendment provide for a gradual phasedown in the production and consumption of hydrofluorocarbons (HFCs), which are alternatives to ozone-depleting substances being phased out under the Montreal Protocol, as well as related provisions concerning reporting, licensing, control of trade with non-Parties, and control of certain byproduct emissions."); *discussed in* Mason J. (16 November 2021) *White House sends Kigali amendment on climate-warming gases to Senate*, REUTERS.

[54] The White House (22 April 2021) *FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies* ("Today, President Biden will announce a new target for the United States to achieve a 50-52 percent reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030 – building on progress to-date and by positioning American workers and industry to tackle the climate crisis. […] The target is consistent with the President's goal of achieving net-zero greenhouse gas emissions by no later than 2050 and of limiting global warming to 1.5 degrees Celsius, as the science demands.").

[56] White House Office of Domestic Climate Policy (2021) *U.S. Methane Emissions Reduction Action Plan*. *See also* The White House (2 November 2021) *FACT SHEET: President Biden Tackles Methane Emissions, Spurs Innovations, and Supports Sustainable Agriculture to Build a Clean Energy Economy and Create Jobs*.

[57] United States Environmental Protection Agency (2 November 2021) *EPA Proposes New Source Performance Standards Updates, Emissions Guidelines to Reduce Methane and Other Harmful Pollution from the Oil and Natural Gas Industry* ("EPA is taking a significant step in fighting the climate crisis and protecting public health through a proposed rule that would sharply reduce methane and other harmful air pollution from both new and existing sources in the oil and natural gas industry. The proposal would expand and strengthen emissions reduction requirements that are currently on the books for new, modified and reconstructed oil and natural gas sources, and would require states to reduce methane emissions from hundreds of thousands of existing sources nationwide for the first time.").

[58] United States Environmental Protection Agency (2021) *EPA's Proposal to Reduce Climate- and Health-Harming Pollution from the Oil and Natural Gas Industry: Overview*, 2 ("Reduce methane emissions by approximately 41 million tons through 2035, the equivalent of 920 million metric tons of carbon dioxide – more than the amount of carbon dioxide emitted in 2019 from all U.S. passenger cars and commercial aircraft combined. In 2030 alone, the proposed rule would reduce methane emissions from covered sources by an estimated 74 percent compared to emissions from those sources in 2005.").

[59] Waste Prevention, Production Subject to Royalties, and Resource Conservation, 81 Fed. Reg. 83008, 83014 (18 November 2016) (Codified at 43 C.F.R. Parts 3100, 3160, and 3170) ("The BLM estimates that this rule would result

in monetized benefits of $209–403 million per year (calculating the monetized emissions reductions using model averages of the social cost of methane with a 3 percent discount rate).162 We estimate that the rule would reduce methane emissions by 175,000– 180,000 tpy, which we estimate to be worth $189–247 million per year (this social benefit is included in the monetized benefit above). We estimate that the rule would reduce VOC emissions by 250,000–267,000 (this benefit is not monetized in our calculations).163 Overall, we predict the rule will reduce methane emissions by 35% from the 2014 estimates and reduce the flaring of associated gas by 49%, when the capture requirements are fully phased in.164").

[60] White House Office of Domestic Climate Policy (2021) *U.S. Methane Emissions Reduction Action Plan*, 7 ("As part of implementing the bipartisan PIPES Act, PHMSA is advancing a commonsense regulatory agenda that has the potential to provide annual methane reductions of as much as 20 MMT of CO2e in methane emissions per year—a spur for new jobs for pipeline workers, welders, electricians, and other trades. The reductions will be achieved by reducing leaks throughout the gas pipeline system and by reducing the frequency and scope of ruptures. In addition to being a major safety hazard, ruptures are a particularly large source of pipeline methane emissions. More than 1,000 metric tons of methane are lost, on average, with each pipeline rupture. A single rupture from a large, high-pressure gas pipeline can release more than 1,300 metric tons of methane emissions.").

[61] For a list of Global Methane Pledge participants, *see* https://www.globalmethanepledge.org/#pledges.

[62] U.S. Department of State (2 November 2021) *United States, European Union, and Partners Formally Launch Global Methane Pledge to Keep 1.5°C Within Reach*, Press Release ("Today, the United States, the European Union, and partners formally launched the Global Methane Pledge, an initiative to reduce global methane emissions to keep the goal of limiting warming to 1.5 degrees Celsius within reach. A total of over 100 countries representing 70% of the global economy and nearly half of anthropogenic methane emissions have now signed onto the pledge."). *See also* International Energy Agency (2022) GLOBAL METHANE TRACKER 2022, 19 ("Led by the United States and the European Union, the Pledge now has 111 country participants who together are responsible for 45% of global human-caused methane emissions.").

[63] U.S. Department of State (11 October 2021) *Joint U.S.-EU Statement on the Global Methane Pledge,* Press Release ("Countries joining the Global Methane Pledge commit to a collective goal of reducing global methane emissions by at least 30 percent from 2020 levels by 2030 and moving towards using highest tier IPCC good practice inventory methodologies to quantify methane emissions, with a particular focus on high emission sources. Successful implementation of the Pledge would reduce warming by at least 0.2 degrees Celsius by 2050.").

[64] United Nations Environment Programme & Climate & Clean Air Coalition (2021) *Briefing on the Global Methane Pledge* ("The Global Methane Pledge is a strong first step as the first-ever Heads-of State global commitment to cut methane emissions at a level consistent with a 1.5 C pathway."). *See also* United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 9 ("Currently available measures could reduce emissions from these major sectors by approximately 180 Mt/yr, or as much as 45 per cent, by 2030. This is a cost-effective step required to achieve the United Nations Framework Convention on Climate Change (UNFCCC) 1.5° C target. According to scenarios analysed by the Intergovernmental Panel on Climate Change (IPCC), global methane emissions must be reduced by between 40–45 per cent by 2030 to achieve least cost-pathways that limit global warming to 1.5° C this century, alongside substantial simultaneous reductions of all climate forcers including carbon dioxide and short-lived climate pollutants. (Section 4.1).").

[65] United Nations Environment Programme & Climate & Clean Air Coalition (2021) GLOBAL METHANE ASSESSMENT: BENEFITS AND COSTS OF MITIGATING METHANE EMISSIONS, 8 ("Available targeted methane measures, together with additional measures that contribute to priority development goals, can simultaneously reduce human-caused methane emissions by as much as 45 per cent, or 180 million tonnes a year (Mt/yr) by 2030. This will avoid nearly 0.3°C of global warming by the 2040s and complement all long-term climate change mitigation efforts.").

[66] See a recently-published guide for journalists on covering methane and investigating specific sources: McIntosh T. (6 February 2022) *GIJN's Guide to Investigating Methane — A Key to Fighting Climate Change*, GLOBAL INVESTIGATIVE JOURNALISM NETWORK.

[67] Global Reporting Initiative (2016) *GRI 305: Emissions*, 4 ("*GRI 305* addresses emissions into air, which are the discharge of substances from a source into the atmosphere. Types of emissions include: greenhouse gas (GHG), ozone-depleting substances (ODS), and nitrogen oxides (NOX) and sulfur oxides (SOX), among other significant air emissions.").

[68] Romanello M., *et al.* (2021) *The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future*, THE LANCET 398(10311): 1619–1662, 1619–1620 ("The 44 indicators of this report expose an unabated rise in the health impacts of climate change and the current health consequences of the delayed and inconsistent response of countries around the globe—providing a clear imperative for accelerated action that puts the health of people and planet above all else…. Through these effects, rising average temperatures, and altered rainfall patterns, climate change is beginning to reverse years of progress in tackling the food and water insecurity that still affects the most underserved populations around the world, denying them an essential aspect of good health.").

[69] Intergovernmental Panel on Climate Change (2022) *Summary for Policymakers*, *in* CLIMATE CHANGE 2022: IMPACTS, ADAPTATION, AND VULNERABILITY, *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Pörtner H.-O., *et al.* (eds.), SPM-21 ("**SPM.C.1.2** Despite progress, adaptation gaps exist between current levels of adaptation and levels needed to respond to impacts and reduce climate risks (high confidence). Most observed adaptation is fragmented, small in scale, incremental, sector-specific, designed to respond to current impacts or near-term risks, and focused more on planning rather than implementation (high confidence). Observed adaptation is unequally distributed across regions (high confidence), and gaps are partially driven by widening disparities between the estimated costs of adaptation and documented finance allocated to adaptation (high confidence). The largest adaptation gaps exist among lower income population groups (high confidence). At current rates of adaptation planning and implementation the adaptation gap will continue to grow (high confidence). As adaptation options often have long implementation times, long-term planning and accelerated implementation, particularly in the next decade, is important to close adaptation gaps, recognising that constraints remain for some regions (high confidence). {1.1, 1.4, 5.6, 6.3, Figure 6.4, 7.4, 8.3, 10.4, 11.3, 11.7, 15.2, Box 13.1, 13.11, 15.5, Box16.1, Figure 16.4, Figure 16.5, 16.3, 16.5, 17.4, 18.2, CCP2.4, CCP5.4, CCB FINANCE, CCB SLR}").

[70] International Monetary Fund (11 April 2022) *Proposal to Establish a Resilience and Sustainability Trust*, 11–12 ("**The RST adds to the lending toolkit by helping members address risks to prospective BoP stability stemming from select macro-critical longer-term structural challenges.** While not necessarily posing imminent BoP problems, longer-term challenges such as climate change make countries more prone to severe BoP problems in the longer run by raising the likelihood and impact of future shocks and undermining growth prospects. Policy inaction—including on account of scarce financing—to address these challenges could increase these risks and jeopardize *prospective BoP stability,* as defined in ¶9. Helping member countries to address such risks through policy support and financing is consistent with the Fund's mandate to support members' BoP stability.") (Emphasis in original).

[71] World Economic Forum (2022) GLOBAL RISKS REPORT 2022, 16 (""Social cohesion erosion" is the risk that has worsened the most globally since the start of the COVID-19 crisis, according to the GRPS. It is perceived as a critical threat to the world across all time spans—short, medium and long term—and is seen as among the most potentially damaging for the next 10 years. In 31 out of the 124 countries surveyed in the EOS—including Argentina, France, Germany, Mexico and South Africa among the G20—"social cohesion erosion" was seen as a top-10 short-term threat to their countries. Inequality—economic, political, technological and intergenerational—was already challenging societies even before income disparities increased through the pandemic.23 These disparities are now expected to widen further: research by the World Bank estimates that the richest 20% of the world's population will have recovered half their losses in 2021, while the poorest 20% will have lost 5% more of their income.24 By 2030, 51 million more people are projected to live in extreme poverty compared to the pre-pandemic trend.25 Income disparities exacerbated by an uneven economic recovery risk increasing polarization and resentment within societies..").

[72] Zaelke D., Picolotti R., & Dreyfus G. (14 November 2021) *Glasgow climate summit: A glass half full*, THE HILL ("The new architecture also includes cutting not just carbon dioxide but also non-carbon dioxide climate emissions, with a specific focus on methane, a super climate pollutant responsible for 0.5 degrees Celsius of today's observed warming of 1.1 degrees Celsius. Cutting methane presents the single biggest and fastest mitigation action the world can take to keep warming from breaching the 1.5 degrees Celsius guardrail. This makes fast reductions of methane essential for adaptation as well."). *See also* Intergovernmental Panel on Climate Change (2022) *Summary for*

Policymakers, *in* CLIMATE CHANGE 2022: IMPACTS, ADAPTATION, AND VULNERABILITY, *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Pörtner H.-O., *et al.* (eds.), SPM-13 ("Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (*very high confidence*).").

[73] For a history of Exxon's climate disinformation campaign, see two independent investigations by Inside Climate News and the Columbia Journalism School: Banerjee N., Cushman J. H., Hasemyer D., & Song L. (2015) *Exxon: The Road Not Taken*, INSIDE CLIMATE NEWS; *and* Columbia Journalism School (2015) *Two-Year Long Investigation: What Exxon Knew About Climate Change*. For proof of the oil industry's knowledge of the risks of climate change from as early as 1968, see their report unearthed by the Center for International Environmental law: Robinson E. & Robbins R. C. (1968) *Sources, abundance, and fate of gaseous atmospheric pollutants: Final report and supplement*, Stanford Research Institute. For a description of Big Oil's disinformation campaign and political influence modeled after the tobacco industry's strategies, *see* Center for Climate Integrity (2019) DOCUMENTARY EVIDENCE OF OIL AND GAS COMPANIES' KNOWLEDGE OF THEIR PRODUCTS' ROLE IN CAUSING CLIMATE CHANGE AND THEIR SUBSEQUENT DECEPTION CAMPAIGN; Franta B. (2021) *Weaponizing economics: Big Oil, economic consultants, and climate policy delay*, ENV. POL. 31(4): 555–575; *and* Oreskes N. & Conway E. (2010) MERCHANTS OF DOUBT: *HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING*, Bloomsbury Publishing.

[74] Accountable.US (2021) *Over 50 Major Corporations That Claim To Be Concerned About Climate Issues Help Lead The Very Trade Groups Fighting The "Biggest Climate Change Bill Ever" – The Reconciliation Package In Congress*, 1 ("As Congress considers "its biggest climate change bill ever"—the $3.5 trillion budget reconciliation package—a "torrent of political groups" representing the nation's biggest industries prepared a "lobbying blitz" against the budget's proposals, undermining the nation's best shot at reaching 100% clean energy sources by 2035 and combating the "existential threat" of climate change. But an Accountable.US review has found that while these industry groups have been undermining unprecedented climate legislation, their leading corporate members have been claiming commitments to sustainability, carbon emissions cuts, and concern about climate change: • The U.S. Chamber of Commerce vowed to do "everything we can" to block the $3.5 trillion package. Its Board Of Directors includes executives from corporations that have touted climate action, including: o Nasdaq, Intuit, Honeywell, United Airlines, Tenet, Emerson Electric, Anthem, Amway, Enterprise Holdings, Microsoft, U.S. Bank, Deloitte, Delta Air Lines, and Emergent Biosolutions. • The Business Roundtable called the $3.5 trillion package "troubling" as it prepared "'a significant, multifaceted campaign'" against its tax increases. Its Exclusive Membership is stocked with CEOs from purportedly green-friendly corporations, including: o Dupont De Nemours, 3M, Abbott Labs, Abbvie, Accenture, Adobe, Aflac, Alliant, American Airlines, Amazon, Alphabet Inc., Apple, Bank of America, BP, and Comcast. • PhRMA has run ads against the $3.5 trillion package and has spent more than $15 million on lobbying this year. Its corporate members that have publicly shown concern about climate include: o Amgen, Astellas, AstraZeneca, Bayer, Bristol-Myers Squibb, Daiichi-Sankyo, Eli Lily, Gilead, And Johnson & Johnson.") (hyperlinks omitted); *discussed in* Accountable.US (1 October 2021) *Major Corporations Hypocritically Undermine Climate Action by Backing Anti-BBB Coalitions*, Press Release; *and* Milman O. (1 October 2021) *Apple and Disney among companies backing groups against US climate bill*, THE GUARDIAN.

[75] Mulvey K. (10 September 2020) *Trade Groups Must Be Challenged for Their Harmful Climate Deception,* UNION OF CONCERNED SCIENTISTS ("Public officials at all levels of government, corporate leaders, and public interest organizations all have power—and responsibility—to strengthen business groups' climate accountability. Here are my top five recommendations for holding trade groups accountable for climate deception—inspired by a recent United States Senate report; lawsuits filed by the state of Minnesota and the city of Hoboken, New Jersey; and analysis by nonpartisan research organizations. **1) Reveal trade groups' membership, funding sources, and political spending** The chapter on so-called "Dark Money" in "The Case for Climate Action: Building a Clean Economy for the American People," released last month by the Senate Democrats' Special Committee on the Climate Crisis… describes the problem in stark terms: "Giant fossil fuel corporations have spent billions—much of it anonymized through scores of front groups—during a decades-long campaign to attack climate science and obstruct climate action." Peer-reviewed studies have documented more than 100 fossil fuel front groups, including the Heartland Institute and the Competitive Enterprise Institute, many of which have also lobbied for the tobacco industry. Fossil fuel companies also depend on trade associations to advocate for or against public policies, fund political candidates, challenge regulations in agencies and courts, and sponsor public relations campaigns. Some, like the API, focus all of their lobbying and public relations spending on oil and gas industry interests. Others, like the US Chamber, have broader memberships

that imply they are speaking for the business community—but in reality, the US Chamber does the bidding of the fossil fuel industry when it comes to climate policy. One key solution put forth in "The Case for Climate Action" is exposure: Congress should investigate who funds fossil fuel front groups and require trade group witnesses at Congressional hearings to disclose the funding and financial interests at stake. **2) Reform laws and regulations to strengthen transparency** Congress and federal agencies such as the Securities and Exchange Commission (SEC) have the authority to enact laws and regulations to mandate disclosure by corporations and trade groups. They should require transparency in political and election spending and enforce existing laws designed to prevent political corruption. Improved transparency by corporations and the groups that represent them is a precondition for passing comprehensive and effective federal climate legislation. Adoption of the DISCLOSE Act and SEC rules requiring corporate disclosure of political spending would be important steps toward fixing our campaign finance system. **3) Renounce trade groups that spread disinformation and oppose climate action** Corporate executives have considerable power—and responsibility—within trade groups.… Misalignment between a company's stated positions and values and the actions of its trade and lobby groups can pose significant reputational risks. Under pressure from UCS and dozens of other organizations, since 2011 more than 100 companies with a total of $7 trillion in market capitalization have quit the climate-denying American Legislative Exchange Council (ALEC)—with a recent exodus over the group's advocacy for racist and white supremacist policies…. But if reputational risk doesn't get their attention, perhaps legal risk will. As the "Dark Money" chapter notes, member companies may even face liability for due diligence failures to monitor egregious misbehavior by trade associations. **4) Resist fossil fuel industry manipulation** Public interest organizations can and should also stand up to industry groups. The April 2019 NAACP report "Fossil-Fueled Foolery" documented how the fossil fuel industry manipulates communities, policy makers, and academia in ways that harm communities and pollute the environment. The report warns that "Some, but not all, fossil fuel companies and most, but not all, fossil fuel trade associations, engage in these tactics!" **5) Recover costs of trade groups' climate deception** Local and state decisionmakers have their own role to play in holding trade groups accountable. Since 2017, more than a dozen US cities, counties, and states have sued the fossil fuel industry accountable over its outsize role in climate change. This summer, for the first time, a trade group—API—was named as a defendant in lawsuits filed by the state of Minnesota and the city of Hoboken, New Jersey. Although API members were warned of the dangers their products posed to the global climate more than 50 years ago, the group has a long history of spreading climate science disinformation—exemplified by a notorious 1998 internal memo by an API task force laying out a plan to deliberately cast doubt on the public's understanding of climate science.").