June 16, 2022

BEFORE THE ENVIRONMENTAL PROTECTION AGENCY

Petition to Phase Out Greenhouse Gas (GHG) Pollution to Restore a Stable and Healthy Climate

TO

Michael S Regan, Administrator
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Submitted on Behalf of Petitioners

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John Birks,

Richard Heede,

Lise Van Susteren,

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Climate Protection and Restoration Initiative (CPR Initiative) a non-profit organization,

Filed June 16, 2022
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Table of Contents—Part I

I. EXECUTIVE SUMMARY

Petitioners seek to phase out the anthropogenic manufacture, processing, distribution, use, and disposal of greenhouse gas (GHG) emissions, fossil fuels, and fossil fuel emissions (hereafter "subject chemical substances and mixtures").

Petitioners specifically seek a determination by the federal Environmental Protection Agency ("EPA" or "the Agency") that the continuing manufacture, processing, distribution, use and disposal of the subject chemicals and mixtures presents *an unreasonable risk of injury to health and the environment*. That determination will authorize and compel the Agency to undertake a rulemaking to impose one or more requirements as necessary, until the point that the unreasonable risk is eliminated.

EPA's obligations to render that determination, and subsequently to commence determined action, stems from the Toxic Substances Control Act[1] (TSCA, or "the Act") and other US law. Timely and effective Agency action under the Act also would partly uphold the nation's relevant obligation under international law. Thus, pursuant to the United Nations Framework Convention on Climate Change (UNFCCC) nations retain "common but differentiated responsibilities" to "protect the climate system for the benefit of present and future generations of humankind.[2]

Consistent with the Paris Agreement, the Biden Administration's recent filing with the UNFCCC Secretariat committed the nation to a wide ranging decarbonization effort. Specifically, by that submission, the US committed to reduce net GHG emissions by 50-52 percent below 2005 levels by 2030; to achieve "100 percent carbon pollution-free electricity" by 2035; and "**to exceed** [] a straight-line path to achieve net-zero emissions, economy-wide, by no later than 2050." (Emphasis added.)[3]

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1 15 U.S.C.A. §§ 2601 to 2697, as amended by 130 Stat. 448 (June 22, 2016) (the "Frank R. Lautenberg Chemical Safety for the 21st Century Act").

2 UNFCCC, Article 3.1. *See also* the 1972 Rio Declaration on Environment and Development, Principle 7 ("States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command") at https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf.

3 The United States of America Nationally Determined Contribution: Reducing Greenhouse Gases in the United States: A 2030 Emissions Target, submitted pursuant to Article 4 of the Paris Agreement to the United Nations Framework Convention on Climate Change, April 21, 2021, at pages 3 and 6. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

Relevant here, Petitioners hold that it is in only by "exceeding" a pathway to net-zero by 2050 – that is, it is only by ensuring that emissions within the reach of US law are "net negative" before then – that our nation can acquit its fundamental international obligation. In particular, as shown in Part II of this Petition, the US is responsible for an outsized share of worldwide historical GHG emissions. One implication of this is that the US clearly bears a disproportionately greater burden to reverse the increasing endangerment of low-lying island and coastal nations to climate-induced sea level rise and superstorms.

Petitioners agree with President Biden that present and anticipated impacts from global warming and ocean acidification impose an "existential threat" to the United States and other States.[4] But actual US practice under federal law is grossly insufficient. We have scarcely begun to decarbonize, even as the climate and pollution toll imposed on the nation and others grows and grows. Accordingly, Petitioners here demand that the Agency render the specific determination, pursuant to TSCA §6, namely that the subject chemical substances and mixtures "present an *unreasonable risk of injury to health or the environment*." 15 USC §2605. Indeed, the evidence outlined in the Petition, along with material that is otherwise reasonably available to the Agency, establishes that the subject chemicals and mixtures *present an imminent and unreasonable* risk *of serious or widespread injury to health and the environment.* TSCA §7, 15 USC 2606.

The aforementioned "unreasonable risk of injury to health or the environment" determination is a prerequisite for EPA to commence rulemaking under TSCA, while the "imminent and unreasonable risk of serious or widespread injury to health or the environment" is a prerequisite for the Agency to take legal action.

One central factual predicate and two legal suppositions undergird the Petition.

As to the first, Petitioners aver that the atmospheric concentrations of key greenhouse gases, including carbon dioxide (CO_2) and methane (CH_4), are already well into the danger zone and must be dialed back to eliminate their unlawful imposition on humanity and nature.

As to the second, under TSCA the Agency is authorized, upon its relevant determination, and within the jurisdiction of the United States, to impose requirements upon appropriate parties (a) to restrict or phase-out the manufacture (including production and importation) and, as warranted, the processing, distribution, use, or disposal, of the subject chemicals and mixtures, and (b) to compel industry to remove and, as necessary, to securely sequeseter legacy GHG emissions.

4 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, The White House, April 22, 2021. Available at https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/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/.

II. PETITIONERS

Petitioners are Dr. James E. Hansen; Dr. Donn J. Viviani; Dr. John Birks; Richard Heede; Dr. Lise Van Susteren; Climate Science, Awareness and Solutions, Inc. (CSAS); and Climate Protection and Restoration Initiative (CPR Initiative).

Donn J. Viviani, PhD, is a retired U.S. Environmental Protection Agency scientist. He was the Director of EPA's Climate Policy Assessment Division in the Office of Policy, Economics and Innovation; served as Chairman of the Great Lakes Water Quality Board's Toxic Substances Committee; and served as a member of the Science Coordinating Committee for the International Joint Commission for the Great Lakes.

Dr. Viviani serves as Board President of the Climate Protection and Restoration Initiative.

John Birks, PhD, is the Chief Scientist at 2B Technologies, a company he co-founded in 1998 that develops and manufactures new products for air quality measurements. He is Professor Emeritus of the University of Colorado where he and his graduate students carried out research in atmospheric chemistry for 25 years. He is best known for his work in quantifying the rates of chemical reactions that cause the Antarctic Ozone Hole, his co-development of the "nuclear winter" theory with Paul Crutzen in 1982, and development of miniaturized instruments for air pollution measurements. His current research is focused on the use of low-cost sensors for mobile monitoring of air pollutants in cities, an outgrowth of the AQTreks educational outreach programs his company implemented in several hundred schools around the US.

Dr. Birks also serves on the CPR Initiative Board of Directors.

Richard Heede is a petitioner here in his personal capacity. Mr. Heede leads the Climate Accountability Institute and serves as the principal investigator for its widely-cited "Carbon Majors" project, which traces historical CO_2 emissions to oil, natural gas, and coal companies. He has authored/co-authored several papers on the climate responsibilities of fossil fuel producers.[5] Mr. Heede co-founded CAI in 2011 to provide the scientific basis for leveraging climate stewardship by carbon producers. Mr. Heede published his thesis *A Geography of Carbon* with the National Center for Atmospheric Research in 1984. He worked on energy and climate solutions with the Rocky Mountain Institute 1984-2002, and founded Climate Mitigation Services in 2003.

Mr. Heede also serves on the CPR Initiative Board of Advisors.

Lise Van Susteren is a practicing general and forensic psychiatrist in Washington, DC, and an expert on the physical and mental health effects of climate disruption. Dr. Susteren is a co-founder of the Climate Psychiatry Alliance and has served on the Advisory Board of the Center for Health and the Global Environment at the Harvard T. H. Chan School of Public Health. In 2006, Dr. Susteren sought the Democratic nomination for the US Senate from Maryland. She is currently on the board of Physicians for Social Responsibility and Earth Day Network. In 2011, Dr Susteren co-authored *The Psychological Effects of Climate Warming on the U.S.: And Why the US Mental Health System Is Not Prepared.* Her book, *Emotional Inflammation Discover your Triggers and Reclaim Your Equilibrium During Anxious Times*, co-authored with science writer Stacy Colino, was released in April 2020.

5 *See* https://climateaccountability.org/publications.html.

Dr. Susteren also serves on the CPR Initiative Board of Directors.

James E. Hansen, PhD, is the former Director of the NASA Goddard Institute of Space Studies and current Director of Climate Science, Awareness and Solutions. CSAS is a program of the Earth Institute at Columbia University in New York City. Dr. Hansen is the author of the books *Storms of My Grandchildren* and the forthcoming *Sophie's Planet*, and the principal author or co-author of numerous papers on the subject of climate change and Earth's energy imbalance. He is best known for his testimony on climate change to congressional committees in the 1980s that helped raise broad awareness of the global warming issue. Dr. Hansen's recent research establishes that fossil fuel GHG emissions have already raised Earth's temperature well beyond the Holocene range, potentially imposing an increasingly untenable burden on young people to undertake or pay for exceedingly expensive CO_2 extraction to limit climate change and its consequences. His research also raises the prospect that continued high fossil fuel emissions will melt the planet's major ice sheets at a non-linear rate. On the other hand, in his work Dr. Hansen has helped specify the magnitude and rate of decarbonization required to preserve a habitable climate, and he has highlighted the potential utility of select methods and policies for deep decarbonization and large-scale CO_2 removal with lasting co-benefits.

Dr. Hansen also serves on the CPR Initiative Board of Advisors.

Climate Science, Awareness and Solutions (CSAS), is a public interest non-profit organization with headquarters in New York, NY. csas.earth.columbia.edu.

Climate Protection and Restoration Initiative (CPR Initiative) is a public interest non-profit organization with headquarters in Eugene, Oregon. CPRclimate.org.

Conflict of Interest Statement

Petitioners retain no conflict to disclose except, potentially, one: Petitioner Birks retains an interest in the success of air quality sensors manufactured by 2B Technologies wherein that interest may be affected by federal rulemaking, compliance with which may require wider use of such sensors to detect and eliminate GHG and other source emissions.

Representative

Petitioners are represented by attorney Daniel M. Galpern, to whom any questions or requests for further information should be addressed: General Counsel, CPR Initiative, 2495 Hilyard Street, Ste. A, Eugene Oregon 97405. (541) 968-7164. dan.galpern@cprclimate.org.

III. ACTION REQUESTED

At issue herein is the unreasonable risk imposed on humanity, future generations, and nature as we have come to know it from non deminimis[6] anthropogenic greenhouse gas (GHG) emissions[7] and the manufacture, processing, distribution, use and disposal of fossil fuels.[8] Together, the GHG emissions from all anthropogenic sources, the fossil fuels, and those emissions associated with fossil fuels (GHGs and otherwise) are referred to as "subject chemical substances and mixtures."

This Petition is brought pursuant to the United States Constitution, including its Preamble wherein the Framers declared their determination "to secure the blessings of liberty to ourselves and our posterity," and its First Amendment, recognizing the right of citizens to petition for "a redress of grievances."

As well, the Petition is brought pursuant to the Administrative Procedure Act (5 U.S.C. §553(e)) (establishing that "every interested person" may petition an agency to issue a rule), and Section 21 of the Toxic Substances Control Act (TSCA), 15 USC §§2620 and 2605 (entitling "any person" to petition the Environmental Protection Agency for its issuance of a rule.)

Specifically, the undersigned here expressly request that EPA render a determination that "the manufacture, processing, distribution in commerce, use, or disposal" of the subject chemical substances and mixtures *present an unreasonable risk of injury to health or the environment.* 15 USC §2605.

Further, because the manufacture, processing, distribution in commerce, use, or disposal of the subject chemical substances and mixtures **already** present *an imminent and unreasonable risk of serious or widespread injury to health or the environment,* Petitioners call upon the Agency to undertake immediate legal action to commence a serious effort to contain that risk. 15 USC §2606.

Petitioners note, as well, that the unreasonable risk determination sought by Petitioners herein will compel EPA to undertake a rulemaking under TSCA §6 (regulatory restrictions) and also, potentially, to take action under TSCA §9 (Utilization of Other Law) in order, at minimum, to compel responsible parties to:

(i) **phaseout** their production and importation and, as warranted, their processing, distribution, use or atmospheric disposal of the subject chemical substances and mixtures, as required to secure the elimination of associated emissions and legacy GHG emissions, on a

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6 We leave for the agency to determine a workable definition of "non deminimis" with respect to the quantum of acceptable release or emission of each greenhouse gas, acknowledging that declining curves may be required to reflect a shrinking carbon budget.

7 The greenhouse gases (GHGs) at issue in this Petition include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the Halocarbons -- chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons (HFCs)) from all sources. Quantities of GHGs at issue in this Petition include not only those being emitted currently and in the foreseeable future, but also so-called "legacy GHG emissions." Petitioners here deem such legacy GHGs to be the quantity of such GHGs already released or emitted by or because of human activity that retain a present effect on ambient global or regional temperatures, or on ocean pH. This is critical, in light of the long-lived nature of CO2 (among other GHGs) once released into the environment. *See infra*, nte 82 (work by Archer).

8 Petitioners include within the phrase "emissions associated with the manufacture, processing, distribution, use and disposal of fossil fuels" both (1) GHGs released or emitted during those activities, and (2) other pollutants released or emitted during those activities, including particulate matter and sulfur and nitrogen dioxides.

timetable that is consistent with both the overarching need to protect and restore a habitable climate system and with the demands of national and international security,[9]

(ii) **remove** and securely sequester from the environment excess atmospheric greenhouse gases including, at minimum, surfeit atmospheric carbon dioxide (CO_2) and methane (CH_4) **or, in the alternative, to pay into an Atmospheric Carbon Abatement Fund** that EPA will establish for the purpose of removing such subject chemicals and mixtures in an amount and pursuant to a timetable consistent with protection and restoration of a habitable climate system.

The Petition establishes that the continuing production and use of the subject chemicals and mixtures, as well as the release of their associated emissions (accounting also for legacy GHG emissions) present both an "unreasonable risk of injury to health and the environment," and "an imminent and unreasonable risk of serious or widespread injury to health or the environment." TSCA §6, 15 USC §2605, and §7, 15 USC §2607, respectively. There are viable alternatives to the continued heavy reliance on fossil fuels, and potential alternatives to the sources of the other subject chemical substances and mixtures. As well, options are increasingly available to contain from the environment or remove from the atmosphere certain species of legacy emissions.

Accordingly, Petitioners aver herein that the continuing production, importation, distribution, use, release and disposal of the subject chemical substances and mixtures presents a decidedly imminent risk to health and the environment that is manifestly unreasonable, serious, and widespread. At minimum, EPA must render the requested determination, and then commence the requested rulemaking. In addition, the Agency should pursue immediate legal action in federal court to address the imminent, serious and widespread risk.

9 Petitioners acknowledge that the Russian Federation's illegal war against Ukraine may extend into the period of deep decarbonization contemplated by the Petition. Accordingly, some heightened demand for US oil and gas production and distribution may persist – in order to backfill prior Russian supply – until efficiency and decarbonization efforts, within Europe as well as in the US, more than offset any needed additional production, processing and delivery. A reasonable transition period therefore will be required, but that already is provided for by law. TSCA §6(d)(1)(E), 15 USC 2606(d)(1)(E). Moreover, notwithstanding NATO's newfound determination to combat climate change, continuing supply requirements by US and allied armed forces may at some point justify a partial, if temporary, waiver, so as to ensure continued, if sharply reduced, supply. A long-standing TSCA provision also already provides for such a national security waiver. 15 USC §2621. The statute is sufficiently flexible, in our judgment.

IV. AUTHORITY

In the 1992 United Nations Framework Convention on Climate Change ("UNFCCC" or "the Convention") the United States, along with, eventually, 196 other parties,[10] committed itself "to achieve. . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[11] The clear aim was to prevent "additional warming of the Earth's surface and atmosphere" and thus stem a process that threatened to "adversely affect natural ecosystems and humankind."

In particular, by its signing of the Convention, the United States assumed the obligation to take "precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects,"[12] particularly "threats of serious or irreversible damage," including by "limiting its anthropogenic emissions of greenhouse gases."[13] Consistent with the injunction contained in the Preamble to the United States Constitution, the UNFCCC emphasized that "the Parties should protect the climate system for the benefit of present and future generations of humankind. . . ."

To secure the Convention's fundamental objectives, the US in 2015, along with most other nations, signed onto the Paris Agreement to the UNFCCC. The US thereby committed itself to action that would hold "the increase in the global average temperature *to well below* 2°C above pre-industrial levels" and to "efforts to limit the temperature increase to 1.5°C above pre-industrial levels."[14] Consistent with that commitment, and in recognition that national commitments to date had come up short,[15] President Biden's 2021 Nationally Determined Contribution, filed pursuant to the Paris Agreement,[16] obliges the US to achieve an "economy-wide target" for net greenhouse gas emissions of "50-52 percent below 2005 levels in 2030." The 2021 filing also established US goals "to reach 100 percent carbon pollution-free electricity by

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10 In total there are 197 signatories, comprised of 196 nations and one regional economic integration organization (the European Union). See https://treaties.un.org/Pages/ViewDetailsIII.aspx?src=IND&mtdsg_no=XXVII-7&chapter=27&Temp=mtdsg3&clang=_en.

11 UNFCCC Article 2. The full text is available, in English and five other languages, at https://unfccc.int/process-and-meetings/the-convention/status-of-ratification/status-of-ratification-of-the-convention.

12 UNFCCC Article 3.3.

13 UNFCCC Article 4.2. Moreover, in light of its status as a "developed country Party," the US agreed to "take the lead in combating climate change and the adverse effects thereof." Id. at Article 3.

14 Paris Agreement Article 2(1)(a). The full text of the Agreement is available, in English and five other languages, at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. In Article 4.1 of the Agreement, nations must reach global peak GHG emissions "as soon as possible," and "undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century."

15 The United Nations Environment Program reported late last year that "new national climate pledges combined with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century," which is "well above the goals of the Paris climate agreement and would lead to catastrophic changes in the Earth's climate. To keep global warming below 1.5°C this century, the aspirational goal of the Paris Agreement, the world needs to halve annual greenhouse gas emissions in the next eight years." UNEP, Emissions Gap Report 2021, available at https://www.unep.org/resources/emissions-gap-report-2021.

16 The United States of America Nationally Determined Contribution Reducing Greenhouse Gases in the United States: A 2030 Emissions Target (filed April 20, 2021), available at https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

2035"[17] and to "exceed [] a straight-line path to achieve net-zero emissions, economy-wide, by no later than 2050."[18]

In 1976, Congress enacted the Toxic Substances Control Act (TSCA) in recognition that certain chemical substances and mixtures impose serious risks to health or the environment, but are not "single media" problems and so require a holistic approach to mitigation and control.[19] In particular, Congress aimed to ensure that the federal Environmental Protection Agency retained "adequate authority to regulate chemical substances and mixtures which present an unreasonable risk of injury to health or the environment." TSCA §2; 15 USC §2601(b)(2).

TSCA conveys express authority to the Agency to pursue restrictions by rule where it determines that "the manufacture, processing, distribution in commerce, use or disposal of a chemical substance or mixture, *or any combination of such activities*, present "an unreasonable risk of injury to health or the environment." TSCA §6, 15 USC§2605 (emphasis added). Further, where such substances and mixtures present an "imminent and unreasonable risk of serious or widespread injury to health or the environment," the Agency may and, in the view of Petitioners, should take legal action to contain and eliminate the risk. TSCA §7, 15 USC§2606. Fossil fuel GHG emissions manifestly present just such an imminent, unreasonable, serious and widespread risk.

As Petitioners also discuss *infra*, 2016 amendments to TSCA "radically transformed" the statute, "with clear requirements and a mandate to . . . put in place strong and timely protections against any unreasonable risks."[20] For instance, prior to 2016 EPA was authorized to impose requirements only "to the extent necessary to protect adequately against such risk using the least burdensome requirements." 15 USC §2605 (2015). These and other limitations created a "legal threshold that [] proved difficult for EPA [to meet]."[21] Indeed, courts interpreted TSCA pre-2016 to require the Agency, "[i]n evaluating what is 'unreasonable' . . . to consider the costs of any proposed actions" as well as "the environmental, economic, and social impact of any action."[22] In sharp contrast, under the 2016 amendments, EPA must render its unreasonable risk

17 *See also,* https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/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/.

18 The United States of America Nationally Determined Contribution: Reducing Greenhouse Gases in the United States: A 2030 Emissions Target, submitted pursuant to Article 4 of the Paris Agreement to the United Nations Framework Convention on Climate Change, April 21, 2021, at pages 3 and 6. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

19 David Markell, An Overview of TSCA, Its History and Key Underlying Assumptions, and Its Place in Environmental Regulation, 32 WASH. U. J. L. & POL'Y333 (2010), at https://openscholarship.wustl.edu/law_journal_law_policy/vol32/iss1/11/.

20 EPA Office of Chemical Safety and Pollution Prevention, Chemical Update: EPA Proposes to Ban Ongoing Uses of Asbestos, Taking Historic Step to Protect People from Cancer Risk, April 5, 2022, at https://www.epa.gov/newsreleases/epa-proposes-ban-ongoing-uses-asbestos-taking-historic-step-protect-people-cancer-risk (visited April 6).

21 David Markell, An Overview of TSCA, its History and Key Underlying Assumptions, and its Place in Environmental Regulation, Journal of Law & Policy (Vol. 32:333, 2010) at 367, citing to U.S. Gov't Accountability Office, Chemical Regulation: Options For Enhancing The Effectiveness Of The Toxic Substances Control Act (2009) at 9.

22 Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1222 (5th Cir. 1991) (quoting prior version of 15 U.S.C. §2605(c)(1)).

determination "without consideration of costs or other nonrisk factors." 15 USC 2605(a) and 2605(b)(4)(A).

Pursuant to TSCA §21, 15 USC §2620, "[a]ny person may petition the [EPA] to initiate a proceeding for the issuance, amendment, or repeal of a rule" under several substantive sections of the statute, including TSCA §6, 15 USC §2605.[23] Petitioners are obliged only to "set forth the facts which it is claimed establish that it is necessary to issue, amend, or repeal a rule." TSCA §21(b)(1), 15 USC §2020(b)(1). The Agency then has 90 days to either grant or deny the petition, TSCA §21, 15 USC §2620(b)(3), on the basis of whether the petition's asserted facts establish that the rule advocated is necessary. 15 USC §2620(b)(1).

Congress did not define the term "necessary," as it employed the term, so Petitioners read the term, as used in TSCA §21, in its ordinary sense -- as in "needed," or "warranted under the circumstances,"[24] and not in an absolute sense, as in "logically necessary," or "impossible without").[25, 26]

Upon EPA's grant of a petition, the Agency is to "promptly commence an appropriate proceeding in accordance with," the relevant substantive TSCA section. 15 USC §2020(b)(3). Where the subject chemical substances and mixtures present an unreasonable risk of injury to health or the environment, then TSCA §6, 15 USC §2605 provides that the Agency must aim in that proceeding to fashion a rule controlling, to the point of prohibition, the "manufacture, processing, distribution in commerce, use, or disposal" of such chemical substances or mixtures, in order to ensure that "the chemical substance[s] or mixture[s] no longer present[] such risk."[27]

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23 Moreover, pursuant to the Administrative Procedure Act, "any interested person" retains the right to petition any Agency for the issuance, amendment, or repeal of a rule.

24 Indeed, an even more inclusive sense of the term is often intended. The term "[n]ecessary . . . must be considered in the connection in which it is used, as it is a word susceptible of various meanings. It may import absolute physical necessity or inevitability, or may import that which is only convenient, useful, appropriate, suitable, proper, or conducive to the end sought. It is an adjective expressing degrees, and may express mere convenience or that which is indispensable or an absolute physical necessity. It may mean something which in the accomplishment of a given object cannot be dispensed with, or it may mean something reasonably useful and proper, and of greater or lesser benefit nr convenience, and its force and meaning must be determined with relation to the particular object sought." Black's Law Dictionary, Revised Fourth Edition (1968) at 1181-82.

Thus, "the word "necessary" does not always import an absolute physical necessity, so strong that one thing, to which another may be termed "necessary," cannot exist without that other. It frequently imports no more than that one thing is convenient or useful or essential to another. To employ the means necessary to an end is generally understood as employing any means calculated to produce the end, and not as being confined to those single means without which the end would be entirely unattainable." Black's Law Dictionary, Current Version (2022) at https://thelawdictionary.org/necessary/

25 Octane Fitness, LLC v. ICON Health & Fitness, Inc., 572 U.S. 545, 553 (2014) ("[] Patent Act does not define "exceptional," so it is construed in accordance with its ordinary meaning.").

26 Thus, while it is logically possible that, on their own accord, major fossil fuel companies will rapidly transition to clean energy and remove their legacy GHG emissions, there is no evidence that will be done and Petitioners deem that to be exceedingly improbable.

27 The Agency, accordingly, needs pursue two proceedings. In the first, it must determine whether the subject chemical substances or mixtures present an unreasonable risk of injury. In the section, it needs to craft the set of requirements requisite to eliminating the unreasonable risk.

Congress defined the term "manufacture" expansively, to include "to produce," as well "to import into the customs territory of the United States." 15 USC § 2602(9).[28] Accordingly, the full set of activities to be considered in the Agency's unreasonable risk evaluation, pursuant to TSCA §5, includes the production, importation, processing, distribution in commerce, use and disposal of the subject chemical substances and mixtures, and *any combination of such activities.*

As for the term "unreasonable," in "unreasonable risk," it too is not expressly defined in TSCA. Still, its meaning in the statute is rendered clear by recent statutory history. Thus, whereas for its first 40 years the statute compelled EPA, for its unreasonable risk determination, to balance, albeit not necessarily in a formal way,[29] the costs of the proposed regulation with the benefits of the substance or mixture to be banned or restricted, by its 2016 amendments Congress ended that balancing and directed EPA to make the unreasonable risk determination on the basis of a risk evaluation that it must conduct "without consideration of cost or other nonrisk factors."[30] In that context, then, a risk does not become reasonable, in the sense of "warranted,"[31] by a showing that the running of it will result in lowered financial cost. Rather, in considering a significant risk of injury to health or the environment from a chemical substance or mixture, that risk must be deemed "unreasonable" unless the running of it is necessary to the avoidance of a greater injury to health or the environment.

The evidence herein establishes that the "manufacture, processing, distribution in commerce, use or disposal," TSCA §6, of the subject chemical substances and mixtures induce and exacerbate climate change – "[t]he existential threat to human existence as we know it,"[32] among other injuries to health and the environment. Accordingly, the continued imposition and exacerbation of that risk must be deemed unreasonable – unless it is unavoidable.

Further, upon its determination, that "the manufacture,[33] processing, distribution in commerce, use, or disposal of a chemical substance . . . presents an unreasonable risk of injury to health or the environment," EPA "*shall* by rule," *Id.* (emphasis added) impose requirements, as necessary, so that the chemical substance "no longer presents such risk." *Id.* Accordingly, in the second proceeding, that is, the relief stage, EPA must consider whether it should impose one

28 *See also*, TSCA §13, 15 USC 2612 (requiring the Secretary of the Treasure to bar entry to the US of "any chemical substance, mixture, or article containing a chemical substance or mixtures" that "fails to comply with any rule in effect" under TSCA").

29 House Report 94-1341 on TSCA (July 14, 1976) at 14.

30 Frank R. Lautenberg Chemical Safety for the 21st Century Act, 114 P.L. 182, 130 Stat. 448, 2016 (enacting H.R. 2576 adding current TSCA §6(b)(4)(A), 15 USC §2605(b)(4)(A).

31 Webster's provides, among synonyms for "unreasonable," the term "unwarranted."

32 Kate Sullivan, Biden says the climate crisis is "the existential threat to human existence as we know it," CNN, Nov. 2, 2021, https://www.cnn.com/world/live-news/cop26-climate-summit-intl-11-01-21/h_51ac65e9640565572a1707e2fef6cb50.

33 As employed in the statute, and so in this Petition, the term "manufacture" includes within its meaning "import" and "produce." 15 USC § 2602(9). As also employed there and herein, the statutory term "environment" includes "water, air, and land and the interrelationship which exists among water, air, and land and all living things." 15 USC § 2602(6). For completeness, here, we note as well that the term "commerce" includes within its meaning "trade, traffic, transportation." 15 USC § 2602(3).

or more out of a set of seven Congressionally specified requirements to address and eliminate the unreasonable risk.[34]

V. PROCEDURAL HISTORY: TWO PETITIONS UNDER TWO TSCAS

Petitioners here address the TSCA Section 21 requirements, 15 USC §2621, in part by discussing the Agency's 2015 treatment[35] of an earlier petition filed by present Petitioner Viviani and the Center on Biological Diversity (CBD). That 2015 Petition sought an unreasonable risk finding specifically with respect to CO_2.[36]

Though similar in some ways, the 2015 Petition requested that EPA render a TSCA §6 unreasonable risk finding principally with respect to injury to the oceans, i.e., ocean acidification and warming caused by CO_2 emissions. The present Petition seeks the Agency's determination with respect not only to CO_2, but the full gamut fossil fuels and their associated emissions (including GHG emissions), as well as other GHG sources. And the case for the present Petition cites to their impact the public health and all significant realms of the environment. Petitioners emphasize, however, that impacts to the ocean environment remain important in the present Petition; indeed, injury to the ocean has mounted since EPA's rejection of the 2015 Petition. But the unreasonable risk determination requested by Petitioners here requires the Agency to consider the imposition not only to the oceans, nor even to water in general, but *also* with respect to impacts to the air, to the land, and to "the interrelationship which exists among and between water, air, and land and all living things." TSCA §5(a) and §2(7), 15 USC §2605(a) and §2602(7).

EPA offered several arguments for its earlier refusal to issue an "unreasonable risk" finding.

First, and most important here, the Agency had argued that it could not make the requested unreasonable risk finding because the earlier petition failed to provide sufficient data for the Agency to adequately analyze *the costs* of a requested rule, and because the earlier petition had not delineated a sufficient yet "least burdensome" requirement. Second, EPA maintained that TSCA §6(a)(7)(C), providing the Agency with authority to impose a "replace or repurchase" requirement on manufacturers, did not authorize it to compel removal of legacy fossil fuel emissions – in part because CO_2 is a mere by-product of industrial activity that does not move in the stream of commerce.[37]

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34 Congress also specified, however, that where a specific risk to health or the environment "could be eliminated or reduced to a sufficient extent by actions taken under . . . other Federal law[]" also administered by the Agency, then that should be used – unless in the Agency's discretion it is "in the public interest to protect against such risk" by taking action under TSCA. TSCA §9(b)(1), 15 USC 2608(b)(1). Accordingly, even if another statute were available to resolve an aspect of the fossil fueled climate crisis, Congress expressly reserved to EPA the option of proceeding under TSCA.

35 EPA, Reasons for Agency Response; TSCA Section 21 Petitions: Carbon Dioxide Emissions and Ocean Acidification, Oct. 6, 2015, at https://www.regulations.gov/document/EPA-HQ-OPPT-2015-0487-0001. *See also*, https://www.epa.gov/assessing-and-managing-chemicals-under-tsca.

36 *See* https://www.epa.gov/sites/default/files/2015-09/documents/petition_oa_tsca_2014_final_2.pdf

37 We note, for completeness, that EPA also maintained that the earlier petitioners failed to adequately specify the rule they sought, and that they retained no right under TSCA to request EPA consider use of legal authority other than TSCA to address the relevant risks.

A. Unreasonable Risk

Petitioners emphasize here, most importantly, that several of the Agency's earlier arguments no longer obtain, and thus simply cannot tell against the instant Petition. The reason? Because, on June 22, 2016, Congress substantially amended TSCA.[38] As EPA itself observes, TSCA now compels the Agency to evaluate chemicals "against a new risk-based safety standard to determine whether a chemical use poses an 'unreasonable risk'." In particular, the Agency notes that such a risk evaluation now must *exclude* consideration of costs or non-risk factors.[39] That was a critical and long-overdue change that the Agency itself describes as having "radically transformed" the statute.[40]

Accordingly, under the revised statute, EPA's unreasonable risk determination now must be "in accordance" with a risk evaluation that the Agency must conduct "*without consideration of costs or other nonrisk factors. . . .*" TSCA §§6(a), 15 USC 2605(a) and §§6(b)(4)(A), 15 USC 2605(b)(4)(A) (emphasis added). Questions as to the cost of a proposed requirement, or whether a method of constraining fossil fuel GHG emissions is the 'least burdensome,' simply no longer may be entertained by the Agency in determining unreasonable risk for the subject chemical substances and mixtures.[41]

Petitioners note here that EPA in the past has considered certain risks from chemicals to be unreasonable, thus compelling it to regulate under TSCA §6(a) – including those from mixed mono and diamides of an organic acid,[42] triethanolamine salt of a substituted organic acid,[43] triethanolamine salt of tricarboxylic acid,[44] and hexavalent chromium-based water treatment chemicals in cooling systems.[45] But the imposed risk of injury to health and the environment (as well as *actual* injury) stemming from fossil fuels and other GHG sources is orders of magnitude greater than the above-referenced risks. Accordingly, Petitioners hold that EPA should proceed in no less an expedited fashion to address the unreasonable risk from the subject chemical substances and mixtures.

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38 See https://www.congress.gov/114/plaws/publ182/PLAW-114publ182.pdf.

39 EPA, Highlights of Key Provisions in the Frank R. Lautenberg Chemical Safety for the 21st Century Act, available at https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/highlights-key-provisions-frank-r-lautenberg-chemical. TSCA §§6(a), 15 USC 2605(a) and §§6(b)(4)(A), 15 USC 2605(b)(4)(A). [Emphasis added.]

40 Press release, EPA Proposes to Ban Ongoing Uses of Asbestos, Taking Historic Step to Protect People from Cancer Risk, April 5, 2022, available at https://www.epa.gov/newsreleases/epa-proposes-ban-ongoing-uses-asbestos-taking-historic-step-protect-people-cancer-risk.

41 Indeed, even prior to the recent strengthening amendments, EPA had responded favorably, in part, to a TSCA §21 petition that it nonetheless deemed to lack sufficient facts to assess a "least burdensome" requirement. However, instead of commencing an immediate rulemaking docket, EPA opened "a proceeding to investigate whether and what type of regulatory or other action might be appropriate to protect against risks posed by formaldehyde emitted from pressed wood products. EPA, Formaldehyde Emissions from Composite Wood Products; Disposition of TSCA Section 21 Petition (June 26, 2008) available at https://www.regulations.gov/document/EPA-HQ-OPPT-2008-0267-0032. On July 27, 2016, EPA finalized a rule to reduce exposure to formaldehyde vapors from certain wood products produced domestically or imported into the United States. *See* https://www.epa.gov/formaldehyde/formaldehyde-emission-standards-composite-wood-products.

42 CFR 747.115

43 40 CFR 747.195

44 40 CFR 747.20

45 40 CFR 749.68

Importantly, here, Petitioners emphasize that the instant Petition seeks only EPA's unreasonable risk determination. That will require EPA to initiate a rulemaking process, but it is not Petitioners' burden *here* to propose in detail requirements that EPA should propose following its determination. Rather, Petitioners are obliged here only to provide risk factors that would support the unreasonable risk determination. Upon this petition's submittal, then, EPA is at an early stage in its process,[46] so that, again, EPA here must decide only the question whether it should grant the petition. Much less information, at this stage, is required than that which is needed to assess the range of alternatives required for final policy choices. Again, here, Petitioners seek Agency action in two phases: (1) the risk determination, and then (2) commencement of a rulemaking proceeding.[47, 48]

B. Stream of Commerce

EPA also rejected the 2015 Petition's suggestion "that EPA [] use its authority under TSCA §6(a)(7)(C) to require emitters to take steps to mitigate or sequester past CO_2 emissions," on the ground that the provision "is intended to address chemical substances and mixtures that move in the stream of commerce, not air pollution that is a byproduct of industrial and other activity on a global scale."[49]

In relevant part, TSCA §6(a)(7) enables EPA, upon its determination that a chemical substance or mixture presents an unreasonable risk of injury to health or the environment, to impose:

> [a] requirement directing manufacturers or processors of such substance or mixture (A) to give notice of such determination to distributors in commerce of such substance or mixture and, to the extent reasonably ascertainable, to other persons in possession of such substance or mixture or exposed to such substance or mixture, (B) to give public notice of such determination, and (C) to replace or repurchase such substance or mixture as elected by the person to which the requirement is directed.

In its 2015 rejection, EPA indicated that it reads §6(a)(7)(C) "as applying when a distinct person or persons who received the chemical substance or mixture and from whom the manufacturer or processor can elect to repurchase or replace can be identified." EPA was therefore presuming that a requirement that it might impose under provision (C) in the above subparagraph must apply far more narrowly than requirements it may apply in response to provisions (A) and (B) – which, on their terms, apply not only where persons are "in possession

46 *See EPA's Action Development Process.* Guidance for EPA Staff for Developing Quality Actions (Revised 2011).

47 Nonetheless, to assist the Agency's preparation for its subsequent consideration of factors, including cost, that would be relevant to an appropriate rulemaking, Petitioners here provide facts deriving not only from scientific studies of major risks to health and the environment imposed by the subject chemical substances and mixtures, but also information that may aid EPA's evaluation of possible methods of risk reduction, including options for reducing atmospheric concentrations of CO2 and CH4 through economic incentives, trading, and regulation. However, Petitioners expressly reserve the option to submit additional material once the Agency commences a rulemaking process and opens a docket for the purpose. 15 USC §2691.

48 *Citizens for a Better Environment v. Thomas* No. 85 C 8000 (704 F. Supp. 149, 28 ERC 1841) (N.D. Ill. January 10, 1989) ("Section 2620 was adopted by Congress to allow citizens to prod the EPA into action by petitioning for the initiation of rulemaking procedure which must be carried out under the Administrative Procedures Act (APA) . . . .").

49 EPA, op. cit. nte. 33.

of such substance or mixture," but also where persons are "exposed to such substance or mixture," and to the "public" as whole.

Irrespective of the question whether EPA's interpretation of TSCA §6(a)(7)(C) was correct, Petitioners here note that an adjacent subparagraph of the statute, namely TSCA §6(a)(6)(A), clearly permits the Agency to address legacy emissions. Specifically, that provision authorizes EPA to impose requirements "prohibiting or otherwise regulating any manner or method of disposal of such substance or mixture. . .by its manufacturer or processor or by any other person who uses, or disposes of, it for commercial purposes." 16 USC §2606(a)(6)(A).

Moreover, EPA's prior thought that CO_2 cannot be both a substance that moves in the stream of commerce and a byproduct of global industrial activity is not correct. Fossil fuels are produced and distributed in the stream of commerce in full light of their CO_2-formation potential. Indeed, CO_2 is not a mere byproduct, but rather the intended chemical product of fossil fuel combustion. Energy released by combustion materializes only when the CO_2 carbon-oxygen double bonds are formed. It is therefore in the instant that CO_2 is formed that the energy can be captured. After that, the generated CO_2 is either emitted to the atmosphere (its predominant fate, to date) or else captured for disposal or commercial utilization.

Petitioners note, as well, that CO_2 is the chemical product that drives the pistons in an internal combustion engine. The pistons are moved only when the carbon in the fuel (gasoline, diesel, or natural gas) is combined with oxygen to form CO_2 – thereby increasing the number of moles of gas, and the pressure in the pistons, and thus powering the engine to do the required work. In addition, the heat released from forming the carbon-oxygen double bonds expand all the other gases (principally, N_2) in the piston as well. Again, the CO_2 may then be discarded as (increasingly dangerous) exhaust – but only after it has been employed to power the internal combustion engine.

Further, CO_2 itself is manifestly moving in the stream of commerce. According to a 2019 IEA report, some 130 million tonnes (MMT) of CO_2 is used in urea manufacturing for fertilizers, and 70 to 80 MMT CO_2 is used in enhanced oil recovery. "Other commercial applications include food and beverage production, metal fabrication, cooling, fire suppression and stimulating plant growth in greenhouses."[50] Moreover, a carbon removal market is fast developing. Indeed, recent action by the US government evinces a vigorous determination – to the tune of tens of billions of taxpayer dollars – to develop a wide-reaching carbon removal industrial base.[51] Federal carbon removal action extends beyond research and development to substantial, if capped, taxpayer funding of actual CO_2 removals. Indeed, a "credit for CO_2 sequestration was added to the tax code in . . . 2008," considerably enlarged in the Bipartisan

50 IEA, Putting CO_2 to Use, September 2019, available at https://www.iea.org/reports/putting-co2-to-use.

51 *See* Congress' recent commitment of $11.5B to carbon capture pilots and demonstrations, including $6.5B for "new carbon management" projects – $3.5B of which is for direct air capture regional "hubs" (each of which is to have the capacity to capture, store or utilize 1MMT of CO2/year) and $2.5 billion of which is targeted to "new or expanded large-scale commercial carbon sequestration projects and supporting transport infrastructure." In addition, "[t]he newly established Office of Clean Energy Demonstrations was allocated $3.5 billion in the bi-partisan infrastructure bill, for carbon capture demonstrations and large pilots and $8 billion for hydrogen hubs including at least one utilizing fossil fuels with carbon management." Meanwhile, the US Department of Energy Loan Programs Office "will coordinate the Carbon Dioxide Transportation Infrastructure Finance and Innovation Program Account" with $2.1 billion to finance CO2 transportation. US Department of Energy, Fact Sheet: The Infrastructure Investment And Jobs Act: Opportunities to Accelerate Deployment in Fossil Energy and Carbon Management Activities, at https://www.energy.gov/sites/default/files/2021-12/FECM%20Infrastructure%20Factsheet.pdf, visited April 20, 2022.

Budget Act of 2018, and is anticipated by the Joint Committee on Taxation to cost the Treasury an estimated $0.6 billion over the 2021-30 period.[52,53] Significant carbon removal investments also have been announced recently by a consortium of big tech and financial services firms,[54] while one company has committed not only to going carbon negative by 2030 but also to removing, by 2050, "all the carbon the company has emitted either directly or by electrical consumption since it was founded."[55] In pursuit of those goals, Microsoft recently purchased "carbon removal credits from 21 projects"[56] utilizing, in part, funds raised by an internal carbon fee that the company charges its business groups.[57, 58] A database maintained by CarbonPlan details 219 such projects worldwide with, by our count, 89 projects by 44 companies operating throughout the US.[59]

Moreover, TSCA is not limited to restricting only those chemical substances that are "in commerce" or that present no global scale challenge. For one thing, such *distribution* is but one of five activities within the reach of the statute. TSCA §6(a).[60] Also, PCB-contaminated rags and sewage sludge were restricted under TSCA, yet neither were is in commerce to the extent of CO_2.[61] As to global scale, CFCs and dioxin were properly regulated at one time pursuant to TSCA even though they were at one time produced on a global scale. Moreover, the Agency

52 Congressional Research Service, "The Tax Credit for Carbon Sequestration (Section 45Q)," as updated June 8, 2021, and available at https://sgp.fas.org/crs/misc/IF11455.pdf.

53 The credit "is computed per metric ton of qualified carbon oxide captured and sequestered." Id.

54 These include, most recently and prominently, a $925 million commitment by Google, Meta (formerly known as Facebook), Shopify, Stripe. Robinson Meyer, We've Never Seen a Carbon-Removal Plan Like This Before, The Atlantic, https://www.theatlantic.com/science/archive/2022/04/big-tech-investment-carbon-removal/629545/. Visited April 20, 2022. According to Meyer, "In a world awash in overhyped corporate climate commitments, this is actually a big deal."

55 https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

56 Microsoft Carbon Removal: An update with lessons learned in our second year (March 2022) at 9, available at https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE4QO0D (visited April 21, 2022). Id. at 13-17.

57 Microsoft Carbon Removal: An update with lessons learned in our second year (March 2022) at 9, available at https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE4QO0D (visited April 21, 2022).

58 In addition, in recognition that "market needs to go even further, faster," the company recently made a $100 million grant to a Bill Gates company aimed at accelerating "the development of technology solutions needed to reach global net zero," including direct air capture, energy storage and sustainable fuels. Lucas Joppa, Further, faster, together: Microsoft donates $100 million to Breakthrough Energy Catalyst to accelerate and scale climate tech (September 19, 2021), available at https://blogs.microsoft.com/blog/2021/09/19/further-faster-together-microsoft-donates-100-million-to-breakthrough-energy-catalyst-to-accelerate-and-scale-climate-tech/ (visited April 21, 2022).

59 *See* https://carbonplan.org/research/cdr-database, visited April 23, 2022. Petitioners here observe, as well, that in TSCA Congress established that "'commerce' means trade, traffic, transportation, or other commerce . . . between a place in a State and any place outside of such State. . ." TSCA §2(3), 16 USC 2602(3).

60 15 USC §2605(a). Unreasonable risk may be determined, as well, on the basis of injury to health or the environment stemming from the chemical substances' manufacture, processing, use, or disposal. Further, the Agency is also authorized to base its determination on "any combination of such activities." Id.

61 40 CFR §761 (Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions) at §761.61 (PCB Remediation Waste).

restricted CFCs under TSCA even though it believed, in 1978, that the health and environmental consequences of ozone depletion and global warming were not well understood.[62]

By its terms, TSCA is not constrained to bite-sized problems. Indeed, Congress charged EPA with protecting not only public health but also "the environment," and expressly defined the term expansively to include "water, air, and land *and the interrelationship which exists among and between water, air, and land and all living things*." TSCA §2 (6), 15 USC 2603 (6). (Emphasis added.) The definition admits of no local or locale limitation.[63]

VI. ARGUMENT, REQUEST, and PETITION

The present Petition aims in part to further the nation's international commitments and interests,[64] yet it is based squarely on existing federal law. In particular, Petitioners aim to establish a firm foundation for an effective US decarbonization program. That firm foundation is constructed herein pursuant to the clear terms of the Toxic Substances Control Act (TSCA), as amended in 2016, along with related statutes administered in whole or in part by EPA.

On the basis of their review of the relevant science (*see* Part II of the instant petition) Petitioners think that there is no question but that the subject chemical substances and mixtures present an unreasonable risk of injury to health or the environment, compelling the requested determination and then a subsequent rulemaking action under TSCA §6, 15 USC 2605. Indeed, the evidence further establishes that the subject chemical substances and mixtures present "an imminent and unreasonable risk of serious or widespread injury to health or the environment," requiring EPA to commence legal action in the absence of an immediately-effective rule. TSCA

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62 EPA, Fully Halogenated Chlorofluoroalkanes, Final Rules, 43 FR 11318, stating, *inter alia*, that:

"Chlorofluorocarbons produce a risk to human health and the environment by causing depletion of the ozone layer. Upon release from an aerosol product or other source, the compounds diffuse slowly to the stratosphere. When they reach the stratosphere, they undergo photochemical decomposition which liberates free chorine radicals. The chlorine radicals enter into a catalytic chain reaction with ozone molecules, and the net result is a depletion of the ozone layer. . .

"While the effects of ozone depletion are very difficult to quantify, they are quite serious. The major immediate concern is that increased UV radiation leads to a statistically significant increase in skin cancer. Some negative effects on plants and animals are likely. There are also predictions of adverse effects because of an increase in the Earth's temperature ("green house effect") and changes in climate. The health and environmental consequences of these and other changes are not well understood. However, there is considerable concern that these consequences will produce significant adverse effects."

63 On the other hand, Petitioners observe that the Agency may specify the geographic reach of TSCA §6(a) requirements that it applies to deal with the unreasonable risk of injury to health or the environment: "Any requirement (or combination of requirements) imposed under this subsection may be limited in application to specified geographic areas." 16 USC §2606(a)(final sentence of subsection).

64 The present petition's demand for a phaseout of the subject chemical substances and mixtures is also necessary to meet the aims of the pending international covenant to limit the severe imposition of plastics on human health and the environment. *See* United Nations Environment Assembly of the United Nations Environment Programme, End plastic pollution: Towards an international legally binding instrument (Draft Resolution: March 2, 2022)(Noting with concern that "the high and rapidly increasing levels of plastic pollution represent a serious environmental problem at a global scale, negatively impacting the environmental, social and economic dimensions of sustainable development"); Altman and Dey, The World Has One Big Chance to Fix Plastics, The Atlantic (March 15, 2022)(observing, inter alia, that "the response of producer nations, especially the U.S., the largest contributor to plastic waste, could ultimately shape the treaty's success"); CIEL et al, Plastic & Climate: The Hidden Costs of a Plastic Planet (May 2019)(concluding that "[n]othing short of stopping the expansion of petrochemical and plastic production and keeping fossil fuels in the ground will create the surest and most effective reductions in the climate impacts from the plastic lifecycle.").

§7, 15 USC 2606. *See also*, 15 USC 2601(b)(2) ("It is the policy of the United States. . . to take action with respect to chemical substances and mixtures which are imminent hazards.").

Under the Act, "chemical substances" include those with a particular molecular identity, whether occurring in nature or as the result of a chemical reaction. TSCA §3; 15 USC §2602(2)(A). The greenhouse gases CO_2 and CH_4, as well as nitrous oxide (N_2O) and certain fluorinated gases, fit squarely within TSCA's definition of *chemical substances*.[65]

We note, as well, that Congress incorporated into its definition "*any combination* of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature." 15 USC §2602(2)(A)(i). Certain fossil fuels occurring in nature, including coal and crude oil, are thus TSCA chemical substances. So too are certain petroleum products derived in part from the *chemical processing* of reforming, cracking, and coking; these include jet fuel, LPG and gasoline.

Other petroleum products derived from the *physical processing* of crude oil via distillation are deemed *chemical mixtures* under TSCA, and these include naptha, kerosene, diesel distillate, medium and heavy gas oil, and crude residuum. Such fossil fuel mixtures also may be restricted under TSCA, where their manufacture, distribution, use or disposal presents an unreasonable risk.[66]

That the subject chemical substances and mixtures present not only an unreasonable but also an imminent risk of serious and widespread injury has been exhaustively established in credible reports and documents available to the Agency, including many adopted by the Agency or by other US government units. Petitioners, in Part II of this Petition, present relevant evidence. In addition, the Agency should also credit supplemental information available to it, where warranted by their merits, of relevant risks arising from subject chemical substances and mixtures that, for reasons *inter alia* of manageability and brevity, Petitioners neither expressly address nor incorporate into the Petition. Indeed, the Agency undoubtedly retains considerable relevant information in the form of submissions from fossil fuel companies and other sources of the risks presented by subject chemical substances and mixtures. After all, each of them is bound by law to submit information in their possession "immediately" to EPA, which information "reasonably supports the conclusion that such substance or mixture presents a substantial risk of injury to health or the environment." 15 USC 2607(e).

A. EPA Legal Action Against Imminent, Serious, Widespread, Unreasonable Risk

1. Right to Demand Legal Action and thus an Immediately Effective Proposed Rule

Petitioners retain a derivative right to demand that EPA exercise its authority to take legal action to contain and eliminate the unreasonable, imminent, serious and widespread risk of injury to health and the environment presented by the subject chemical substances and mixtures. Petitioners here invoke that right and demand such action. Further, in light of their grievances concerning the nation's to-date failure to seriously confront the climate emergency, the undersigned petition here, as well, under the first amendment to the Constitution.

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65 *See* US EPA, Overview of Greenhouse Gases, available Aug. 5, 2021 at www.epa.gov/ghgemissions/overview-greenhouse-gases.

66 *See* The process of crude oil refining, Department of Energy and Mineral and Engineering, PennState, https://www.e-education.psu.edu/eme801/node/470, visited April 19, 2022.

Pursuant to TSCA §20, Petitioners may petition for a §6 rule addressing the unreasonable risk presented by the subject chemical substances and mixtures. Upon its acceptance of the Petition, EPA must open a rulemaking docket and issue a proposed rule for notice and comment." Administrative Procedure Act (APA), 5 USC 553.[67] In light of the emergency nature of the climate crisis, Petitioners here also urge EPA to issue a proposed rule that is not only appropriately strong but immediately effective,[68] so as to at least constrain if not eliminate the risk involved – one that is also imminent, serious, and widespread.[69] TSCA 6(d)(3). It is only in this way that Petitioners can reasonably ensure that their requested rulemaking will not serve as a vehicle for further delay as to actions our nation needs to take to secure our children's future. Congress anticipated this type of situation and, accordingly, specified that such an unreasonable, serious and widespread risk "shall be considered imminent if it is shown that the manufacture, processing, distribution in commerce, use, or disposal of the chemical substance or mixture, or that any combination of such activities, is likely to result in such injury to health or the environment *before a final rule under [TSCA §6] can protect against such risk.* TSCA §7(f), 15 USC §2606 (f) (emphasis added).

Materials in Part II of this Petition establish that the subject chemical substances and mixtures "present an imminent and unreasonable risk of serious or widespread injury to health or the environment.15 USC §2606 (f). Indeed, Petitioners establish, herein, that these substances and mixtures are *already* the cause of serious and widespread injury to health and the environment. Accordingly, no final rule under TSCA §6 can *prevent* such injury entirely; it is only *additional* injury that can be prevented. The risk presented by the subject chemical substances and mixtures is therefore "imminent" under the law. TSCA §7(f), 15 USC 2606(f). Because delay will compound the relevant injury, a highly protective and immediately effective proposed rule is required.

TSCA provides, however, that before EPA can file any such immediately-effective proposed rule, to constrain the risk, the Agency must first file a legal action in district court and secure relevant relief. TSCA §6(d)(3)(A)(ii)., 15 USC 2605(d)(3)(A)(ii). Accordingly, EPA **must** bring legal action in a district court to address the problem. 15 USC 2606(a)(2) ("[t]he Administrator *shall* commence in a district court. . . with respect to such substance or mixture.") (Emphasis added.). 15 USC §2606 (a)(2).

The federal court considering such legal action retains authority to "grant such temporary or permanent relief as may be necessary to protect health or the environment from the unreasonable risk." 15 USC §2606 (b)(1). That relief may run against "any person who manufactures, processes, distributes in commerce, uses, or disposes of the imminently hazardous chemical substance or mixture [here, the oil, gas or coal] or any article containing such a

67 In the alternative, under the APA, EPA could publish a mere "description of the subjects and issues involved," but doing so, although preferable to doing nothing, would not adequately address the present crisis.

68 Immediately effective, that is, "upon publication in the Federal Register of the proposed rule." TSCA 6(d)(3)(A), 15 USC 2605(d)(3)(A).

69 Serious or widespread injury to health or the environment stemming from subject chemical substances and mixtures is already apparent and severe, but much injury is still to come, as Petitioners make clear in Part II of the Petition, stemming from the combination of legacy and continuing emissions. The risk therefore is also imminent. *See*, e.g., House Report 94-1341 (July 14, 1976) at 4 ("[W]hile the unreasonable risk of harm must be imminent, the physical manifestations of the harm itself need not be. An imminent hazard may be found at any point in the chain of events which may utimately result in damage to the health or environment.").

substance or mixture." 15 USC §2606(a)(1)(B). Congress even authorized the courts to compel EPA to seize such chemical substances or mixtures, 15 USC §2606(a)(1)(A), that present "an imminent and unreasonable risk of serious or widespread injury to health or the environment." 15 USC §2606(f). Again, that unreasonable risk is to be identified by EPA "without consideration of costs or other nonrisk factors."[70]

2. Demand for Legal Action

Accordingly, Petitioners here request that the Agency take legal action, in federal court against, at minimum, the major fossil fuel producers and importers with operations or assets in, or doing business within, the United States, and demanding in relief that they:

(a) Provide public notice

Fossil fuel defendants must be required to give public notice that the manufacture (including production and importation), processing, distribution in commerce, use, and disposal ("the Activities") of the subject chemical substances and mixtures, and emissions stemming from such activities, present an imminent and unreasonable risk of serious and widespread injury to human health and the environment, and

(b) Provide a detailed accounting

Fossil fuel defendants must be required to provide a detailed accounting of the quantity of Scope 1, Scope 2, and Scope 3 emissions[71] attributable to each company's Activities, along with a detailed accounting of legacy GHG emissions they have removed and durably sequestered from the atmosphere.

The requested Order should direct Defendant producers to issue such public notices on an annual basis, which notices shall reprise the content of subparagraph (a) above, until such time as the subject chemical substances and mixtures no longer present an unreasonable risk of injury to health or the environment, and the content of subparagraph (b) above, updated to show both prior year and cumulative figures, until such time as the company has verifiably caused the removal of a CO2-equivalent amount of legacy GHG emissions. The Agency should further request, in relief, that the court deciding the case retain continuing jurisdiction to ensure compliance with its Order.

B. Petition for Unreasonable Risk Determination and Subsequent Rulemaking

Irrespective of whether EPA brings a civil action, Petitioners are entitled, where the subject chemical substances and mixtures present an "unreasonable risk of injury to health and the environment," to petition the Administrator for a rulemaking under TSCA §6, 15 USC 2605. TSCA §21, 15 USC §2620. Petitioners invoke that right here and so petition.

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70 EPA's use of its authority to commence such a civil action to phaseout production, release and disposal of imminently hazardous substances is not affected by any prior determination under TSCA Section 6, 15 USC §2605. 15 USC §2606 (a)(1)(C).

71 "Scope 1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization. . . Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling." https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance

"Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain." https://www.epa.gov/climateleadership/scope-3-inventory-guidance

1. Necessary

TSCA §21 requires petitioners for a TSCA §6 rulemaking to "set forth the facts which it is claimed establish that it is necessary to issue, amend, or repeal a rule. 15 USC 2620(a)(1).

Petitioners aver such facts below and throughout the Petition. As well, Petitioners establish in Part II that it is critically important that the subject chemical substances and mixtures be phased out and their atmospheric surfeit reduced.[72] In that context, EPA action pursuant to the requested rule is necessary. Three sets of additional facts support that assertion:

(a) Insufficient US action to date

EPA has been attempting, in fits and starts,[73] to restrict fossil fuel and other GHG emissions since at least 2007 – albeit pursuant to other statutes. But those efforts to date have set no fossil fuel phaseout course. Neither have they put the United States on track to meet its own nationally-determined obligation[74] to slash net greenhouse gas emissions 50-52 percent below 2005 levels by 2030, nor to achieve "100 percent carbon pollution-free electricity" by 2035,[75] nor to "exceed [] a straight-line path to achieve net-zero emissions, economy-wide, by no later than 2050."[76] The President has both acknowledged and emphasized that unabated GHG emissions present an existential threat to the nation and humanity, but that articulated reality has yet to be reflected in US policy. The mismatch is reflected, in part, in exceptionally high US per

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72 Petitioners observe, as well, that the set of actions they propose for consideration in a TSCA §6 rulemaking may be necessary even if not sufficient to address the climate crisis. We take a moment here also to preemptively answer one possible objection, namely that strong "unilateral" US action to phase out GHG emissions might relieve pressure on other nations. Petitioners actually think the reverse would be true, namely that strong climate action in the US would encourage similarly strong (or stronger) action in other nations. But in order to ensure a level playing field for highly trade-exposed US business, the Agency in rulemaking should take care to impose on imports restrictions that are no less rigorous than those imposed on US products. That aspect of the program should be backed up, moreover, by the exercise of authority residing with the Secretary of Treasury, where warranted, to restrict or even "refuse entry into the customs territory" of the US for any noncompliant "chemical substance, mixture, or article containing" such a restricted substance or mixture. TSCA §13, 15 USC §2612.

73 For instance, with respect to "the third largest greenhouse gas (GHG) emitting industrial sector among stationary sources behind Power Plants and Petroleum and Natural Gas Systems," EPA, 2013 GHGRP Industrial Profiles, https://www.epa.gov/sites/default/files/2016-11/documents/refineries_2013_112516.pdf, see, EPA, Standards of Performance for Petroleum Refineries, 73 FR 35838, 35859 (June 24, 2008) (declining to restrict GHG emissions from petroleum refineries on the ground, among others, that "the regulation of GHG emissions raises numerous issues that are not well suited to initial resolution in a rulemaking directed at an individual source category," but promising to explore "the many complex interconnections between the relevant sections of the Clean Air Act" and "lay[] the foundation for a comprehensive path forward with respect to regulation of all GHG.").

74 The United States of America Nationally Determined Contribution: Reducing Greenhouse Gases in the United States: A 2030 Emissions Target, submitted pursuant to Article 4 of the Paris Agreement to the United Nations Framework Convention on Climate Change, April 21, 2021, at pages 3 and 6. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

75 *Id.*

76 *See also*, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/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/.

capita GHG emissions, [77] and US commitments submitted pursuant to the Paris Agreement to date have been honored in the breach.[78]

The rulemaking requested in the Petition is necessary, then, because the Agency has declined to date to undertake the requested or equivalent actions on its own.

(b) Untouched legacy carbon emissions

The Agency has not yet imposed *any* requirement pursuant to *any* statute upon *any* fossil fuel company, or indeed, upon *any* other source of GHG emissions, to remove all, or even a share, of such source's legacy GHG emissions.

Indeed, Petitioners aver that **no other federal statute** – that is, none other than TSCA – authorizes the Agency, even pursuant to rule, to compel the sources of the subject chemical substances and mixtures, including fossil fuel producers and importers (or other potentially liable parties) to remove and securely sequester their legacy GHG emissions. The scientific consensus is that humanity has already far overshot the safe level of atmospheric CO_2 and other GHGs so that, even in conjunction with a rapid yet feasible phaseout of additional quantities of the subject chemical substances and mixtures, at least some substantial carbon removal will be necessary to protect and restore a viable climate system,[79] and thus to protect our children's future.[80]

The rulemaking sought herein, then, is necessary because the Agency has not commenced any significant effort to compel the removal of legacy GHG emissions, and because no other statute confers upon the Agency such authority.

(c) A firm statutory basis for deep decarbonization

No federal statute, other than TSCA, provides the Agency with the needed comprehensive authority and duty to impose requirements prohibiting or restricting the

77 *See* UNEP, Emissions Gap Report 2021 at 15 (deeming the United States and Canada to be "not on track to meet their earlier NDC targets with implemented policies" and 17 (illustrating that US per capita emissions remain far larger than the G20 average, and 4th highest – among those nations in terms of current policies). Available at https://wedocs.unep.org/bitstream/handle/20.500.11822/36992/EGR21_CH2.pdf. *See also*, Carbon Action Tracker, USA Country Summary, Nov. 2021 (rating US climate policies and action as in need of "substantial improvements to be consistent with the Paris Agreement's 1.5°C temperature limit. If all countries were to follow the US approach, warming would reach over 2°C and up to 3°C. The range of policy projections for the US spans two rating categories: 'Highly insufficient" and "Insufficient'.").

78 Jackson, et al., 2019, Persistent fossil fuel growth threatens the Paris Agreement and planetary health. Environ. Res. Lett., 14(12), 121001, doi: 10.1088/1748-9326/ab57b3; Hansen, et al, 2017, Young people's burden: requirement of negative CO2 Emissions, Earth Syst. Dynam., 8, 577–616, 2017, at https://doi.org/10.5194/esd-8-577-2017.

79 Petitioners do not suggest that action solely by US-based producers and importers to phase out and remove a large share of their associated subject chemical substances and mixtures will suffice to restore a viable climate system. We note, however, that pursuant to TSCA §21(b)(1), 15 USC 2620(b)(1), it is petitioners' burden to establish necessity, not sufficiency. Relevant to that burden, therefore, Petitioners have herein adduced facts establishing that humanity has already overshot the safe level of atmospheric GHGs on a CO_2-e basis, so that it is necessary both to rapidly phase out, to the extent feasible, fossil fuel GHG emissions and also remove a substantial share of such legacy GHG emissions. Further, Petitioners aver, based on historical experience, that it is exceedingly improbable that the other major emitting nations, as a whole, will so overachieve their proportionate decarbonization duties as to offset continuing high emissions from the US. It is on a practical basis then, that Petitioners assert that a serious program of deep carbonization is necessary in the US – one that aims with high confidence to ensure that *on net* the aggregate of US sources are carbon-negative by or before 2050.

80 James Hansen, et al., Young people's burden: requirement of negative CO_2 emissions, Earth Syst. Dynam., 8, 577–616, 2017, https://doi.org/10.5194/esd-8-577-2017, July 2017. [DG also cite to recent IPCC reports.]

manufacture, processing, distribution, use or disposal of the subject chemical substances and mixtures until the point that their unreasonable risk is abated. Further, the crystal-clear terms of the statute confer capacity and corresponding duty upon citizens to defend human health and "the water, air, and land and the interrelationship which exists" among them "and all living things" from the onslaught of impacts associated with the subject chemical substances and mixtures emissions.[81]

2. Required determination and mandatory duty

The Agency's first step in response to the Petition must be to determine whether the subject chemical substances and mixtures present an unreasonable risk of injury to health or the environment.

EPA has previously determined that "greenhouse gases in the atmosphere may reasonably be anticipated both to endanger public health and to endanger public welfare." 74 FR 66496, 66497 (Dec. 15, 2009) (evaluating "the mix of six long-lived and directly emitted greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6))." In considering the threat to public health, the Agency evaluated "the risks associated with changes in air quality, increases in temperatures, changes in extreme weather events, increases in food- and water-borne pathogens, and changes in aeroallergens." *Id.*

The Agency reaffirmed its endangerment finding in 2015, upon promulgating a rule under the Clean Air Act governing GHG emissions standards for new or modified fossil fuel-fired electric utility steam generating units and stationary combustion turbines. 80 FR 64510,[82] 64530 (Oct. 23, 2015) (citing its enhanced understanding "of the near- and longer-term impacts emissions of CO_2 are having on Earth's climate and the adverse public health, welfare, and economic consequences that are occurring and are projected to occur as a result").

The term "unreasonable risk" is not expressly defined in TSCA, but Congress' intent is nonetheless clear from the plain language and statutory history. Thus, whereas for its first 40 years the statute compelled EPA to consider costs of regulation in its determination of whether an imposed risk was unreasonable, pursuant to the 2016 amendments, Congress directed EPA henceforth to determine whether a chemical substance or mixture presents an unreasonable risk "without consideration of cost or other nonrisk factors." TSCA §6(a), 15 USC 2606(a). Congress further specified that the unreasonable risk determination should include consideration of "a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator, under the conditions of use." *Id.*

Upon its unreasonable risk determination, EPA **must** commence a rulemaking proceeding. Specifically, TSCA §6 provides that where the Administrator determines that "the manufacture, [83] processing, distribution in commerce, use, or disposal of a chemical

81 "[B]y providing for the protection of the environment [TSCA] includes protection for all living things within the environment." House Report 94-1341, July 14, 1976, at 12.

82 EPA, Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units, https://www.federalregister.gov/documents/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary.

83 As employed in the statute, and so in this Petition, the term "manufacture" includes within its meaning "import" and "produce." 15 USC § 2602(9). As also employed there and herein, the statutory term "environment" includes "water,

substance . . . presents an unreasonable risk of injury to health or the environment, the Administrator *shall* by rule" (emphasis added) impose requirements, as necessary, so that the chemical substance "no longer presents such risk"). *Id.*

3. Evaluation of the risk

The top-level statutory subsection as to unreasonable risk, TSCA 6(a), instructs EPA to base its determination on TSCA 6(b)(4)(a). That subparagraph, in turn, provides, as indicated *supra*, that the Administrator, in determining whether the manufacture, processing, distribution, use or disposal of the subject chemical substances and mixtures "present an unreasonable risk of injury to health or the environment," must do so "without consideration of costs or other nonrisk factors. . . ." TSCA §6(a), 2605(b)(4)(A).

EPA is also required to consider "an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant . . . by the Administrator, under the conditions of use." *Id.* As for "conditions of use," Petitioners suggest consideration of the present and historic use of fossil fuels including, in particular, the hydrocarbon combustion process that aims to form CO_2 and H_2O, releasing energy in the process.[84]

As for candidate susceptible subpopulations to be considered as at unreasonable risk, Petitioners suggest these include, but are not limited to,[85] children and future generations, individuals at increased personal risk such as the elderly and persons with disabilities, populations at increased risk due to their socioeconomic status or homelessness, and Indigenous and Native communities as well as communities of color.[86]

As explained in Part II, it is not necessary to generate prodigious quantities of subject chemical substances and mixtures to avoid some greater injury to health and the environment; indeed, the generation of GHG emissions by the manufacture and use of fossil fuels presents an unparalleled risk of injury to health and the environment.

In the considered view of the Petitioners, on the basis, in part, of facts they adduce in Part II of this Petition as to associated elevated risks of sea level rise, heat waves,

air, and land and the interrelationship which exists among water, air, and land and all living things." 15 USC § 2602(6). For completeness, here, we note as well that the term "commerce" includes within its meaning "trade, traffic, transportation." 15 USC § 2602(3).

84 *See* University of Calgary, Energy Education, Hydrocarbon combustion, https://energyeducation.ca/encyclopedia/Hydrocarbon_combustion, visited April 20, 2022.

85 Other susceptible subpopulations suitable for such Agency consideration in such an unreasonable risk assessment of subject chemical substances and mixtures could include communities identified as disadvantaged pursuant to the beta version of the Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST). *See* https://screeningtool.geoplatform.gov/en/#16.79/11.94947/-121.670349, visited April 19, 2022.

In the CEJST, vulnerability factors accounted for include household and median income, the poverty rate, unemployment, housing costs, median home value, and the proportionate burden of energy costs; anticipated agricultural, population and building loss due to climate linked natural hazards; air-borne PM2.5, traffic density, diesel particulate matter and lead-paint exposures, and proximity to hazardous waste sites, superfund sites, and chemical facilities at high risk for accidents; share of population with asthma, diabetes, or heart disease; high school degree attainment and higher education enrollment; linguistic isolation; and low life expectancy. See Methodology at https://screeningtool.geoplatform.gov/en/methodology#life-exp.

86 *See* Makati et al., Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status, Am J Public Health 2018 Apr;108(4):480-485. doi: 10.2105/AJPH.2017.304297. *See also*, John Oliver, Environmental Racism, Last Week Tonight (May 1, 2022) https://youtu.be/-v0XiUQIRLw.

extreme weather events, drought, wildfire, ocean acidification, and air quality, et al. – and taking account of the present surfeit of legacy anthropogenic GHG emissions, global warming to date, ocean acidification to date, and the planet's present energy imbalance – it is manifest that the manufacture, processing, distribution in commerce, use, or disposal of the subject chemical substances and mixture, including combinations of such activities, present an unreasonable risk of injury to health or the environment. The Agency should render the determination.

Moreover, because that risk is not unreasonable merely, but also serious, widespread, and imminent, the Agency should commence legal action against producers and importers, at least. Moreover, the Agency should – as soon thereafter as is practicable -- proposed a strong rule with immediate effect.

4. Commencement of rulemaking

Assuming the Agency renders its unreasonable risk determination, it must, within a year following its final risk evaluation, *propose a rule* and publish it in the Federal Register. 15 §2605(c)(1)(A). Moreover, within two years of that final risk evaluation, EPA must also *publish a final rule* in the Federal Register. 15 §2605(c)(1)(B). EPA's rule must include a statement that considers the effects of the subject chemical substances and mixtures on health and the environment, as well as "the reasonably ascertainable economic consequences of the rule" including the rule's "likely effect on the national economy, small business, technological innovation, the environment and public health." 15 §2605(c)(2). Petitioners expressly reserve the option to provide comments to the Agency regarding these consequences and effects.

The above considerations should be factored in by the Administrator, "to the extent practicable," "[i]n selecting among prohibitions and other requirements" for a final rule, §2605 (c)(2)(B), including in evaluating prohibitions or restrictions of use, in assessing whether there are preferable feasible alternatives, and "in setting an appropriate transition period for such action." §2605 (c)(2)(C).

5. Immediate Effect and Unreviewability of Proposed Rule

As was noted, *supra*, EPA's Administrator is authorized to declare a proposed rule effective upon publication in the Federal Register where necessary to protect the public interest from a chemical substance whose production, distribution, use, or disposal imposes an "unreasonable risk of serious or widespread injury to health or the environment," and where, pursuant to 15 USC §2606, a court has granted relief. In this circumstance, the proposed but effective rule will not be considered final agency action for purposes of judicial review. 15 USC §2605(d)(3)(A).

C. Agency Rulemaking Under TSCA

Petitioners, as emphasized *supra*, expressly reserve their option to propose to the Agency further specifications for consideration in a TSCA §6 rulemaking after EPA has rendered the requisite unreasonable risk determination and opens such a rulemaking docket.

Upon EPA's determination that the manufacture, processing, distribution, use, or disposal of the subject chemical substances and mixtures GHG emissions present an unreasonable risk, then TSCA directs EPA to impose one or more of a set of requirements specified by Congress "to the extent necessary so that the chemical substance or mixture no longer presents such risk." These include:

- "prohibiting or otherwise restricting the manufacturing, processing, or distribution in commerce of such substance or mixture." 15 USC §2605 (a)(1), and
- prohibiting or otherwise regulating *any manner or method of disposal* of such substance. 15 USC §2605(a)(6) and 15 USC §2606.[87] (Emphasis added.)

Petitioners note that where the combustion or other use of fossil fuels, as well as other sources of the subject chemical substances and mixtures, results in GHG emissions, such emissions amount to a "manner or method of disposal" of the chemical substance CO_2 and the other subject GHGs. It is indeed a disposal, as Petitioners show herein, that imposes a catastrophically "unreasonable risk of injury to health and the environment."[88]

Indeed, although a fraction of atmospheric CO_2 is captured and used for commercial purposes, or is otherwise removed by human effort and natural processes, a substantial share of it is emitted to and will remain in the atmosphere for millenia (unless otherwise removed).[89] Accordingly, at least with respect to CO_2, the dominant to-date manner or method of its disposal – dumping it into the air – serves only to exacerbate the planet's energy imbalance, and on a timeframe that far exceeds usual human considerations, until the point that natural processes (primarily, weathering) remove them -- again, over many millennia.

There is no question but that such disposal of subject chemical substances and mixtures includes GHG emissions. TSCA does not expressly define "disposal," so we take the term with its ordinary meanings. *Sandifer v. United States Steel Corp.*, 571 U.S. 220, 227 (2014). Considering Webster's, the closest relevant definition to "dispose of" is "to get rid of."[90] Under a pertinent ordinary definition, then, the major producers of it get rid of waste CO_2, that is, dispose of that chemical substance, generally by providing for its unregulated emission.

87 Under TSCA, the Agency is also able to prohibit, restrict or limit the production or distribution of a substance for a particular use; limit the volume or concentration of the chemical produced; prohibit or regulate the manner or method of commercial use; require warning labels and/or instructions on containers or products; require record-keeping by producers; and require replacement or repurchase of products already distributed. TSCA §6, 15 USC §2605.

88 Other methods of disposal of CO2, such as its removal from the air and sequestration, may not present any such risk, depending in part on the permanency of the sequestration and offsetting associated deleterious consequences if any.

89 *See* Archer et. al, Atmospheric Lifetime of Fossil Fuel Carbon Dioxide, Annu. Rev. Earth Planet. Sci. 2009. 37:117–34, at http://climatemodels.uchicago.edu/geocarb/archer.2009.ann_rev_tail.pdf (concluding that for the emissions of CO2following fossil fuel consumption (burning) that "[e]quilibration with the ocean will absorb most of it on a timescale of 2 to 20 centuries. Even if this equilibration were allowed to run to completion, a substantial fraction of the CO2, 20–40%, would remain in the atmosphere awaiting slower chemical reactions with CaCO3 and igneous rocks. The remaining CO2is abundant enough to continue to have a substantial impact on climate for thousands of years.).

Accordingly, by their Activities, fossil fuel corporations including, as above, fossil fuel producers, among others GHG emitters, must be deemed to be continuously disposing of their associated CO2or, in the alternative, imposing a continuing injury on health and the environment. That would be the case until they have removed and securely sequestered, or paid for the same to be verifiably done, an equivalent amount of CO2-e.

90 https://www.merriam-webster.com/dictionary/dispose%20of

EPA itself has clearly held this view, including rulemaking under TSCA to restrict formaldehyde emissions from pressed wood products.[91] Indeed, EPA clearly held this view at least as far back as 1977 when, under its TSCA authority, the Agency proposed to "eliminate almost all of the manufacture, processing, and distribution in commerce of fully halogenated chlorofluoroalkanes used as aerosol propellants." 42 FR 24542 (May 13, 1977).[92]

The Agency specified then that its intent was "*to reduce the emissions* of such fully halogenated chlorofluoroalkanes to the atmosphere, thereby reducing the health and environmental risks caused by depletion of the ozone layer." *Id.* (Emphasis added.) The Agency based its strong action upon its concern, among others, that "continued release of these compounds at current levels for an indefinite period will have adverse environmental consequences, potentially affecting the entire global population now and in future generations." *Id.* at 24544. EPA therefore concluded that "the continued depletion of stratospheric ozone as the result of discharges from nonessential aerosol products containing fully halogenated chlorofluoroalkane propellants presents an unreasonable risk of injury to health and the environment." *Id.* at 24545. "Mindful, however, of the economic impact of such action, an 18-month phase out schedule" was permitted in order to "insure that such products are removed from the economy in a manner which allows for an orderly adjustment to the introduction of substitute products." *Id.*

Pursuant to a TSCA rule, then, manufacturers – and others, if the Agency deems it warranted – must be required not only to phase out their associated activities but also to phase out their utilization of the atmosphere for continuing disposal of their legacy emissions.[93] That is to say, they must be required to clean up their mess.

(i) Security and Burden-Sharing Accommodation (SBSA)

Petitioners recognize that a certain share of fossil fuels produced, including that imported to the US, has been or continues to be relied upon by US and allied armed forces, as well as for international peacekeeping, humanitarian relief, and domestic and international disaster assistance efforts. In addition, a certain share of fossil fuels produced in the US derive from public lands leased at the discretion of the federal government to private concerns for coal, oil and gas production.

Furthermore, Petitioners advance the following, both in fairness but also, perhaps, in a spirit of generosity towards an industry that has heavily profited by its ability to utilize our

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91 *See* EPA. Formaldehyde Emissions from Composite Wood Products; Advanced notice of proposed rulemaking and notice of public meetings. 73 FR 73620 (Dec. 3, 2008) (proposed rulemaking to determine "whether EPA should take action, which may include regulatory action under TSCA section 6(a), action under TSCA section 6(b), voluntary or regulatory (e.g., under TSCA section 6) application of a voluntary consensus standard, or other approaches"). *See also*, EPA, Formaldehyde Emission Standards for Composite Wood Products, "On March 29, 2021, EPA opened a public comment period on proposed updates to the Formaldehyde Emission Standards for Composite Wood Products rule under TSCA." https://www.epa.gov/formaldehyde/formaldehyde-emission-standards-composite-wood-products (including technical corrections to "better align EPA's rule with the California Air Resources Board (CARB), allowing the two programs to work in tandem with one another in order to create an effective and efficient formaldehyde emissions regulatory system").

92 *See also*, EPA, PARTS 712, 762: Fully Halogenated Chlorofluoroalkanes, Final Rule, 43 FR 11318 (March 17, 1978).

93 *See*, e.g., Shue, H. Responsible for what? Carbon producer CO2 contributions and the energy transition. Climatic Charge 144, 591–596 (2017). https://doi.org/10.1007/s10584-017-2042-9

common atmosphere as a free, open sewer. Petitioners therefore stipulate here, solely for the sake of advancing a necessary rulemaking without undue delay, the possibility that key decision-makers in the US fossil fuel industry may have been unclear or unaware, through June 24, 1988,[94] about the nature of the risk their Activities imposed on health and the environment. Certainly, and very conservatively, their actual or constructive knowledge must be presumed onward at least from October 7, 1992.[95] According to the calculations of Petitioner Richard Heede, about 50% of all historic-to-date fossil fuel consumption – and the corresponding disposal in the atmosphere of their associated emissions – has occurred since 1992.

We account for these facts in a Security and Burden-Sharing Accommodation (SBSA) below, wherein Petitioners here urge the Agency's initial imposition of a *carbon take-back obligation*[96] equivalent to, at minimum, 50 percent of each producer's and importer's Scope 1, 2 and 3 CO_2-e GHG emissions stemming from 1992 through 2022.[97] Petitioners recognize that this departs from more protective equitable standards, including under CERCLA, wherein it is usual practice to impose joint and several (and strict) liability upon owners and operators of facilities that have contaminated land or water. Petitioners reserve the option, therefore, to seek further relief via other administrative or legal action, as warranted, but they here suggest a generous to industry public burden-sharing arrangement in part to expedite the effort to secure, at long last, a genuine national effort aimed at deep decarbonization.

The carbon-take-back obligation should grow, however, with each succeeding year of continued production, and pursuant to the following schedule: 50% of a company's legacy emissions plus 51% of such emissions associated with a producer's Activities in the first year of implementation of the contemplate rule, 52% for 2024, 53% in 2025, and so on until, by ~2073, 100% of each producer's such annual CO_2-e GHG emissions must be removed and securely sequestered. The obligations can be satisfied by a producer's submission of verifiable evidence of such removal and secure sequestration, or else by its payment into an Atmospheric Carbon Abatement Fund that EPA will establish for the purpose of reducing atmospheric concentration of GHGs, and thus protecting and restoring a habitable climate system. Clearly, relevant details of an adequate program to be administered by the Agency would be need to be hammered out in rulemaking, and again, on that point, Petitioners reserve the option to provide additional relevant comment and testimony during such a proceeding.

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94 On that date, Dr. James E. Hansen – Petitioner here, but then with the National Aeronautics and Space Administration – provided widely-covered testimony to the US Senate, during which he maintained that it was then already "99 percent certain" that the buildup of CO_2 and other greenhouse gases accounted for observed global warming. Philip Shabecoff, Global Warming Has Begun, Expert Tells Senate, NY Times (June 24, 1988) at https://www.nytimes.com/1988/06/24/us/global-warming-has-begun-expert-tells-senate.html, visited April 5, 2022.

95 On that date, the U.S. Senate ratified the United Nations Framework Convention on Climate Change, which international treaty stipulated, among other things, that human activities were "substantially increasing the atmospheric concentrations of greenhouse gases," a develop that, if maintained, would "adversely affect natural ecosystems and humankind," so that, among other things, developed nations were obliged to take "immediate action," to limit "emissions of greenhouse gases and [protect and enhance] greenhouse gas sinks and reservoirs" – in order to "protect the climate system for the benefit of present and future generations of humankind."

96 The evocative name derives from Stuart Jenkins, et al., Upstream decarbonization through a carbon takeback obligation: An affordable backstop climate policy, Joule (Oct. 26, 2021) at https://www.cell.com/joule/fulltext/S2542-4351(21)00489-X#relatedArticles, visited April 13, 2022.

97 Petitioners observe that such "upstream" imposition of requirements makes sense based on considerations of simplicity and efficiency, but in rulemaking EPA might seek to somewhat broaden the list of parties on whom such obligations should attach.

Pursuant to the above discussion, with further detail to be developed in the course of rulemaking, and in light of the unreasonable risk that the manufacture, processing, distribution in commerce, use, and disposal of the subject chemical substances and mixtures, including legacy GHG emissions, impose on health and the environment, Petitioners herein urge the Agency to commence rulemaking aimed at the imposition on fossil fuel manufacturers, and others if warranted, of requirements to:

1. phase out their production (etc.) of fossil fuels and other sources of the subject chemical substances and mixtures, on a timeline that is at least as stringent as that required to secure the US nationally-determined contribution under the Paris Agreement, and,

2. remove and securely sequester legacy GHG emissions, or else to pay into an Atmospheric Carbon Abatement Fund in an amount to be determined that is nonetheless sufficient to satisfy each producer's carbon take-back obligation, accounting for the SBSA and pursuant to a schedule consistent with the discussion above, with further detail, again, to be developed during rulemaking.

D. Agency Action under other authority

In general, TSCA instructs the Agency to "coordinate actions" taken under that law "with actions taken under other Federal laws" that it administers. Petitioners here list several such statutory provisions outside of TSCA where rulemaking by the Agency could substantially complement efforts under TSCA. Petitioners caution, however, that the present listing is partial, and they reserve the right to supplement once the Agency opens a rulemaking docket.

1. Independent Offices Appropriations Act

Under the Independent Offices Appropriations Act (IOAA), 31 U.S.C. §9701 (as amended in 1982) EPA or any other federal Agency is authorized to impose "a charge" for "a thing of value" that is provided to any person.[98] This may include "a charge for using the public's air to dispose of carbon dioxide and other wastes," as one former EPA General Counsel has put it.[99] Such a user fee may be based not only on "the costs to the Government," but also the "value of the service or thing to the recipient," the "public policy or interest served" and "other relevant facts." 31 U.S.C. §9701. The full cost to the government component of the user fee

98 The term "person" must be read to include the term "corporation." Historical and revision note, US Code, 31 USC §9701 ("The words "(including groups, associations, organizations, partnerships, corporations, or businesses)" are omitted as being included in 'person'," in the statute). *See* https://uscode.house.gov/view.xhtml?req=(title:31%20section:9701%20edition:prelim)#sourcecredit.

99 E. Donald Elliott, EPA's Existing Authority to Impose a Carbon "Tax," 49 ELR 10919 (2019), available at https://www.eli.org/sites/default/files/docs/49.10919.pdf.

should include "all direct and indirect costs."[100] Imposition of a meaningful and rising fee on oil, gas and coal would induce utilities and consumers to switch to carbon-free energy.[101]

The International Monetary Fund advises that a carbon price may need to rise to at least $75 per ton of CO_2 emissions to induce such meaningful action as required under the Paris Agreement.[102, 103]

Petitioners note that a rising carbon fee in itself would not *directly* prohibit or restrict "the manufacturing, processing, or distribution in commerce, use or disposal" of the fossil fuel GHG emissions, as may be contemplated by Agency action taken pursuant to TSCA, 15 USC 2605(a). However, a rising user fee, depending in part on the use of its revenues, may at least partly compensate the government (or the public, if revenues are recycled as carbon dividends) for the period of time in which EPA continues to provide a special benefit to fossil fuel producers by its forbearance – that is, the Agency's decision not to immediately exercise its authority to prohibit fossil fuel GHG emissions. During that period of forbearance, the user fee will, if substantial and growing, function to constrain emissions as producers and consumers attempt to minimize costs.

Accordingly, Petitioners urge that EPA commence a parallel rulemaking to impose a rising fee on the manufacturing, distribution, use and disposal of oil, gas and coal, on the basis of foreseeable GHG emissions, and to align that rule with the one in development with respect to the instant petition.

2. Clean Air Act §§108-110

Pursuant to the Clean Air Act, EPA's Administrator is required to periodically revise ambient air quality standards for air pollutants the "emissions of which, in his (sic) judgement, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare." 42 USC 7408(a)(1). The Agency must then issue air quality criteria, 42 USC 7408(a)(1), and publish national ambient air quality standards (NAAQS) for such pollutants, 42 USC 7408, which standards are then enforced largely through state implementation plans, 42 USC §7410, and via citizen suits. 42 USC §7604.

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100 OMB Circular No. A-25 at §6(d). Available at https://www.whitehouse.gov/omb/information-for-agencies/circulars/. It may also be based on the "market price" for the resource where "based on competition in open markets." As well, in TSCA §26, 15 USC §2625, Congress authorized the Agency to collect fees to "defray the cost related to such chemical substance[s] of administering sections 4, 5, and 6." Those sections concern (TSCA §4) the testing of chemical substances and mixtures -- including evaluating the feasibility of remedial action; (TSCA §5) manufacturing and processing notices; and (TSCA §6) requirements to eliminate unreasonable risks of injuries to health or the environment from such chemical substances and mixtures.

101 J. Hansen and D. Galpern, President Biden Should Impose a Carbon Fee Immediately, Boston Globe (June 1, 2021), available at https://cprclimate.org/biden-should-impose-a-carbon-fee-immediately/. *See also*, Petition to the President at https://cprclimate.org/take-action/.

102 As noted in the text, to ensure that low and moderate-income families are not disadvantaged by fossil fuel companies that pass on their user fees in the form of increased fuel prices, user fee revenues might be returned to consumers as lump-sum rebates on a roughly per capita basis. Such a scheme would more than offset the higher price burden for low and moderate-income taxpayers. Ian Parry, Putting a Price on Pollution: Carbon-pricing strategies could hold the key to meeting the world's climate stabilization goals, International Monetary Fund (Dec. 2019) available at https://www.imf.org/external/pubs/ft/fandd/2019/12/the-case-for-carbon-taxation-and-putting-a-price-on-pollution-parry.htm.

103 Rosenberg et. al, "Distributional Implications of A Carbon Tax," Columbia Center on Global Energy Policy (2018), available at https://www.energypolicy.columbia.edu/sites/default/files/pictures/CGEP_Distributional_Implications_CarbonTax.pdf.

The materials in Part II of this petition, in conjunction with other material already within the grip of the Agency, more than amply demonstrate that fossil fuel GHG emissions "cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare."

In 2009, the citizen groups 350.org and the Center for Biological Diversity petitioned the Agency for a rulemaking to develop a NAAQS for GHG emissions.[104] On the last day of the Trump Administration, EPA rejected that petition, but the Biden Administration is taking another look. For reasons well outlined in a recent article,[105] whose reasoning we incorporate by reference here, **Petitioners urge that EPA grant the 350/ CBD petition and commence a parallel rulemaking to develop air quality standards for CO_2, CH_4 and other GHGs and to align that rule if warranted with the one in development with respect to the instant petition.**

3. Clean Air Act §115

GHGs comprising in part subject chemical substances and mixtures readily mix in the atmosphere, and the ensuing impacts from such emissions stemming from US sources perforce affect every nation. The Clean Air Act anticipated the possibility that such US emissions might impact other nations and that, just as we would wish to have a say in "foreign" emissions that impact the US, the interests of other nations should matter in the formation of US air pollution regulatory policy. Accordingly, in §115 of the Clean Air Act, Congress provided that upon its receipt of information that sources of air pollution in the US cause or contribute to pollution that endangers the health or welfare of a foreign jurisdiction, the Agency then needs to compel states to amend their implementation plans "to prevent or eliminate the endangerment." 42 USC §7415(b).

The materials in Part II of this petition, in conjunction with other material already with the Agency, more than amply demonstrate that fossil fuel and other sources of the subject chemical substances and mixtures from within the United States "cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare in a foreign country." In 2013, the New York University School of Law's Center for Public Integrity petitioned the EPA for rulemaking to limit such US-based GHG emissions that endanger public health and welfare in foreign nations.[106]

Petitioners here urge EPA to grant the Center's petition so as to commence a parallel rulemaking pursuant to CAA §115, and to align that rule if warranted with the one in development with respect to the instant petition.

4. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA

Pursuant to CERCLA, upon the President's determination that an "actual or threatened release of a hazardous substance" presents "an imminent and substantial endangerment to the

104 Petition to Establish National Pollution Limits for Greenhouse Gases Pursuant to the Clean Air Act (Dec. 2, 2009), http://www.biologicaldiversity.org/programs/climate_law_institute/global_warming_litigation/clean_air_act/pdfs/Petition_GHG_pollution_cap_12-2-2009.pdf.

105 Eric Laschever, Environmental Law Institute, Rebutting Administrator Wheeler's Denial of a NAAQS for Greenhouse Gases (2021) available at https://www.eli.org/sites/default/files/files-pdf/51.10923.pdf.

106 Petition for Rulemaking and Call for Information under §115, Title VI, §111 (Feb. 19, 2013) at www.epa.gov/sites/default/files/documents/policy_integrity_omnibus_ghg_petition_under_caa.pdf.

public health or welfare or the environment," the President is authorized to go to federal court to secure "such relief as may be necessary to abate such danger or threat." CERCLA §106, 42 USC §9606. In the alternative, the President is also authorized to "take other action" including "issuing such orders as may be necessary to protect public health and welfare and the environment." *Id.*

In addition, CERCLA §107, 42 USC §9606, authorizes the federal government, as well as states and Tribes, to remove hazardous substances that have been released into the environment, or otherwise to remediate an impacted site, and then to recover costs incurred from liable persons. The statute also authorizes federal, state and tribal governments to seek recovery for damages to natural resources – defined to include, among others, land, fish, wildlife, biota, air and water CERCLA §101(16), 42 USC §9601(16) — with recovered funds then to be used "to restore, replace, or acquire the equivalent of such natural resources." §107(f)(1)(a), 42 USC §9601(f)(1)(a).

However, certain express exemptions within CERCLA may limit its utility here.

First, CERCLA by its terms excludes from the definition of hazardous substance petroleum, crude oil and its distillates (which includes fuel oil, diesel, regular gasoline),[107] as well as "natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas)."[108] CERCLA §101(14).

Second, CERCLA excludes from the definition of "release," all "emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine." CERCLA §101(22). And third, releases (including emissions) from facilities that are federally-permitted under the Clean Air Act are exempt from CERCLA. §107(j).[109] [110]

However, CO_2 and other GHGs emitted by sources not expressly exempted from CERCLA may be the subject of federal action for abatement, CERCLA §105, or removal and cost-recovery, CERCLA §§106 and 107, upon their designation as hazardous substances.

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107 The statute, however, provides an exception to the petroleum exclusion. CERCLA §101(14). In particular, one or other of petroleum products become CERCLA hazardous by operation of law where "specifically listed or designated as a hazardous substance" under the Clean Water Act (CWA) §311 or §307(a), Clean Air Act (CAA) §112, Resource Conservation and Recovery Act (RCRA) §3001, and the Toxic Substance Control Act" (TSCA) § 7. To date, however, fossil fuel GHGs have not been designated as hazardous under the CAA, CWA or RCRA, and "no substances [have been] designated under [] authority" of TSCA §7. EPA, Hazardous Substance Designations and Release Notifications, at https://www.epa.gov/epcra/hazardous-substance-designations-and-release-notifications, visited April 30, 2022.

108 The statute provides no exception to its definitional exclusion from "hazardous waste" of natural gas, natural gas liquids, liquefied natural gas, or synthetic gas. Accordingly, these substances simply may not be deemed hazardous under CERCLA, that is, not without a statutory amendment.

109 *See also*, EPA, Scope of federally permitted release exemption ("CERCLA section 101(10) defines federally permitted releases in terms of releases permitted under a number of other environmental statutes. Releases that are federally permitted are exempt not only from CERCLA section 103 and EPCRA section 304 notification requirements, but from CERCLA liability as well.") at https://www.epa.gov/epcra/scope-federally-permitted-release-exemption, visiting May 1, 2022.

110 CERCLA also authorizes the US or a State or a Tribe to recover for natural resource damages, §107(f), including for harm to the air, deriving from a person's release of a hazardous substance. §107(a)((C). The above discussion is thus relevant to the question whether its exemptions and limitations constrain CERCLA's utility in natural resource recovery from GHG damages.

CERCLA §§101(14)[111] and 102(a). Because, however, CO_2 and CH_4 are also "naturally occurring substances," such action under CERCLA would require a presidential finding that release of these substances "constitutes a public health or environmental emergency," and that executive action is required because "no other person with the authority and capability to respond. . .will do so in a timely manner." CERCLA §104(a)(3)(A), 42 USC §9604(a)(3)(A) and §104(a)(4), 42 USC §9604 (a)(4).[112]

Accordingly, Petitioners herein urge EPA to consider whether its authority under CERCLA, accounting for the statute's exemptions and limitations, provides the Agency with significant authority to compel fossil fuel manufacturers to remove legacy GHG emissions associated with their Activities. If the Agency so finds, then Petitioners urge it to recommend that the President issue findings that the emissions associated with fossil fuel Activities, including combustion of fossil fuels, "constitute a public health and environmental emergency."

5. EPA referral to *other agencies* for exercise of other authority

If the Administrator determines that action under federal law that is not administered by EPA *may be sufficient* to eliminate the risk to health and the environment presented by the manufacture, processing, distribution, use or disposal of fossil fuel greenhouse gases, the Administrator *must* inform such other agency or agencies by report that "describes such risk and includes . . .a specification of the activity or combination of activities that the Administrator has reason to believe so presents such a risk." 15 USC § 2608(a). Petitioners believe that the authorities administered by other agencies are not at all sufficient. Nothing in TSCA, however, precludes the Administrator from so informing any other agency, by report, wherein the control of such activities as they regulate under law is *necessary, even if insufficient*, to eliminate the risk, **and Petitioners here request that the Agency take such acion where warranted**.

111 Among other authorities, CERCLA §101(14) contemplates Agency designation of hazardous substances pursuant to TSCA §6. That provision requires the Agency, in certain circumstances to seek relief against "imminently hazardous chemical substance[s] or mixture[s]," 15 USC §2606(a)(1) that the Agency "identifies,"§2606(b)(1), whose production, processing, distribution, use or disposal presents an "imminent and unreasonable risk of serious or widespread injury to health or the environment." §2606(f).

112 Petitioners establish in Part II of this petition that the release of CO2 and other fossil fuel GHG emissions have created a public health and environmental emergency, one of such severity that it requires Presidential action – in part because no other person with the authority and capability to respond will do so in a timely manner. The subject matter of this petition therefore fits precisely with the §104(a)(4) exception to the limitation, and so, on its face, the statute would allow federal action to remove legacy CO2 and CH4 and recover the costs for such removal. That would be allowable, that is, but for CERCLA's additional exclusions and exemptions.

VII. OUTLINE OF ACTIONS

Entities subject to restrictions to be imposed pursuant to a rule or legal action as described herein or *supra* shall be referred to herein, as warranted, as "responsible parties," or as "manufacturers," "distributors," "users," disposers," or "other responsible parties."

Responsible parties for the manufacture, distribution, use, or disposal of subject chemical substances and mixtures, where not in compliance with the rules to be established by the Agency pursuant to this Petition, shall be subject to civil and criminal enforcement according to law.

"Legacy GHG emissions" refers to Scope 1, Scope 2, and Scope 3 GHG emissions associated with a responsible party's prior-year manufacture, distribution, use or disposal of a subject chemical substance or mixture.

"Residual GHG emissions" refers to such Scope 1, Scope 2, and Scope 3 GHG emissions associated with a responsible party's current-year manufacture, distribution, use or disposal of a subject chemical substance or mixture, whether the GHG emissions are within or out of compliance with the party's Reduction Obligation.

A. Legal action and immediately effective proposed rule

The Agency should take legal action in a district court to secure relief against manufacturers or other responsible parties as discussed herein and, upon securing that relief, EPA shou;d promulgate an immediately-effective proposal for rulemaking in order to constrain or phase out the unreasonable, imminent, serious and widespread risk of injury to health and the environment presented by the subject chemical substances and mixtures.

B. Unreasonable risk determination

On the basis of the facts adduced in this Petition and otherwise available, the Agency should render a determination as to whether the manufacture, processing, distribution in commerce, use, or disposal, or any combination of those activities, of the subject chemical substances and mixtures present an unreasonable risk of injury to health or the environment.

To so determine, EPA first must identify subpopulations susceptible to injuries to health or the environment that may be presented by the subject chemical substances and mixtures.

The determination as to unreasonable risk herein must be rendered solely on the basis of the risks imposed on those subpopulations, others, and the environment, and without consideration of costs or other nonrisk factors.

C. Rulemaking

Upon its unreasonable risk determination, or as soon as practicable thereafter, EPA should commence a rulemaking to impose requirements to phase out the subject chemical substances and mixtures, to the maximum extent feasible, with respect to their manufacture, processing, distribution in commerce, use, or disposal, or any combination of those activities, to ensure they no longer present an unreasonable risk of injury to health or the environment.

The Agency should also impose upon manufacturers and, in its discretion, other responsible parties, the obligation to reduce (Reduction Obligation) the Scope 1, Scope 2 and Scope 3 GHG emissions associated with their manufacture, processing, distribution in commerce, use, or disposal, of subject chemical substances and mixtures.

EPA also should impose upon manufacturers and, in its discretion, other responsible parties, the obligation to remove from the environment and securely sequester (Take-Back Obligation) legacy and residual GHG emissions.

1. Phaseout/ phase-in period.

EPA needs to identify a phaseout/ phase-in period consistent with the goal of ensuring that, on the basis of their CO_2 climate forcing potential, GHG emissions within reach of US law are net negative prior to 2050. In the interim, the manufacture, processing, distribution in commerce, use, or disposal of the subject chemical substances and mixtures may continue only at increasingly reduced levels, on a schedule to be developed by EPA in conjunction with Petitioners herein and others.

EPA should develop and implement a certification program with respect to responsible parties' reduction and take-back obligations, to ensure that every such anthropogenic GHG that is emitted, released, or resident in the environment is subject to such an obligation or exemption.

2. GHG Emissions Fees

EPA should, by rule pursuant to the IOAA or other authority, as described in this Petition, impose a rising annual fee on GHG pollution, on the basis of CO_2-equivalence, stemming from the manufacture, processing, distribution in commerce, use, or disposal of the subject chemical substances and mixtures. The fee should be imposed on fossil fuel manufacturers and, in the Agency's discretion, upon other responsible parties, on the basis of Scope 1, Scope 2, and Scope 3 GHG emissions arising from the production, distribution, use, and disposal of the oil, gas and coal they produce. The rising GHG emissions fee to be imposed should be in addition to, and not in lieu of, requirements compelling the phaseout of subject chemical substances and mixtures.

Revenues collected under this paragraph by the Agency, except for administrative purposes, should be returned by dividend to US residents, on terms as Congress or the Agency specify, to the maximum extent allowed by law, in order to amplify residents' purchasing power for climate-related home weatherization, carbon-free energy, carbon removal investing, or other use under law in the full discretion of the dividend recipient. The program should be tailored, if practically feasible, to preclude receipt of such dividends by high-income earners, or those with high disposable wealth, accounting for family size and special needs.

The fee shall be set on a per-tonne of CO_2-equivalent emission basis, commencing at \$50/ tonne in 2023, rising annually thereafter by \$10 per-tonne plus an adjustment for inflation. The imposition (or consideration) of a rising GHG pollution fee shall not be taken to displace any other authority administered by the Agency or other regulatory body to impose additional restrictions on the manufacture, distribution, use or disposal of subject chemical substances and mixtures.

3. Legacy and Residual GHG Emissions

EPA shall establish an Atmospheric Carbon Abatement Fund ("the Fund").

The Agency shall impose carbon take-back obligations with respect to manufactures and, as warranted in the Agency's discretion, upon other responsible parties, concerning subject chemical substances and mixtures associated with their activities, including associated Scope 1, Scope 2 and Scope 3 GHG emissions, to ensure these parties remove, or sufficiently pay into the Fund to remove, legacy and residual GHG emissions, on a CO_2-equivalent basis, according to a schedule to be established by the Agency, similar to the following, in amounts that satisfy their obligations.

Those minimum obligations are at least 50 percent of each such responsible party's cumulative Scope 1, 2 and 3 CO_2-e GHG emissions in the 1992 through 2022 period; 51% of such 2023 emissions, 52% of such 2024 emissions, 53% in 2025, and so on until, by ~2073, 100% of each producer's residual GHG emissions are removed and securely sequestered from the environment.

No responsible party's to-date carbon take-back obligation shall be relieved by its sale of assets to any buyer with respect to any subject chemical substances or mixtures it produced, distributed, used, or disposed of prior to such sale.

4. Other authority

The Agency, in addition to the above-denoted requirements, shall consider utilization of additional authorities outside of TSCA but within its control where, in its expert judgment as to the public interest, doing so will accellerate reduction of the unreasonable risk imposed on health and the environment from the manufacture, processing, distribution in commerce, use, or disposal of the subject chemical substances and mixtures.

5. Public participation

At every step of the rulemaking, the Agency must take special care to ensure the full participation of highly impacted persons and traditionally under-represented communities, as these are among the most likely groups to be at unreasonable risk from present and anticipated climate impacts. As Petitioners discussed *supra*,[113] these include, but are not limited to, children and future generations, individuals at increased personal risk such as the elderly and persons with disabilities, populations at increased risk due to their socioeconomic status or homelessness, and Indigenous and Native communities as well as communities of color.

Petitioners emphasize that the Agency must take special care to ensure that the interests of these groups are taken fully into account, including by the direct participation of informed representatives, as the Agency develops rules governing the phaseout of GHG pollution to restore a stable and healthy climate.

[113] *See* §VI(B)(3): Evaluation of the Risk

Petition to Phase Out Greenhouse Gas (GHG) Pollution to Restore a Stable and Healthy Climate

Table of Contents—Part II: Select Scientific and Economic Considerations

I. Executive Summary: Unreasonable Risk

The evidence adduced in this Part supports the conclusion that the subject chemical substances and mixtures – fossil fuels and their emissions, and greenhouse gases (GHGs), including legacy GHGs – present an unreasonable risk of injury to health and the environment.

That unreasonable risk arises from the production, importation, processing, distribution, use and disposal of the subject chemical substances and mixtures. These activities are causing or contributing to higher ambient temperatures, stronger storms, accelerated sea level rise, more severe wildfire, loss of crops, wider vector spread, degraded air quality, an acidifying and warming ocean, disruptions in the food web, alteration and loss of habitat, loss of polar ice, sea ice, and mountain glaciers, and accelerated species loss. The list is partial. To summarize:

Earth's Energy Imbalance: In Section II of this Part of the Petition, we observe that humanity's reliance on fossil fuels to meet fundamental energy needs has caused a global energy imbalance – more energy from the sun arriving by way of solar radiation than escapes from Earth back to space from the top of the atmosphere. In Section II of this Part of the Petition, we review the evidence for, and some of the implications of, this energy imbalance, including that global average temperatures have now risen past the high point of the Holocene (approximately the last 12,000 years), the period marked by a relatively stable climate with moderate temperatures and stable coastlines.

CO_2 Emissions: Section III concerns CO_2 emissions sources and what is required to protect and restore the climate system. The to-date unceasing commitment to fossil fuels, coupled with the still-small contribution of carbon-free energy to the global energy, has ensured continually high CO_2 emissions and an increasing atmospheric concentration of CO_2. In light of the long-lived nature of atmospheric CO_2, responsibility for present and future global warming is a matter of cumulative emissions. The largest quantity of recent annual GHG emissions stem from activity in China, but the United States, with the highest cumulative total (and very high per capita emissions) bears highest responsibility.

CH_4 and other Short-Lived Climate-Forcing Pollutants: In Section IV, Petitioners discuss how other pollutants, some relatively short-lived, substantially augment the climate-forcing effect of CO_2 emissions. This is especially true of methane (CH_4), nitrous oxide (N_2O), the halocarbons, and certain aerosols including, black carbon. Action to reduce these pollutants would be beneficial not merely to stem global warming, but in the cases of some pollutants, to improve air quality.

Unreasonable Land-Based Risk: A Short Survey: Petitioners explain, in Section V, that GHG emissions deriving from fossil fuel combustion and other sources threaten land-based human and natural systems. These threats arise from global warming-induced severe heat, drought, and wildfire. They also arise from sea-level-rise-induced risks, including coastal flooding, erosion, and salinization of water supplies. The risks of injury arise, as well, from climate-induced weather extremes, including change in the frequency or intensity of heat waves, enhanced precipitation with resulting flooding and drought, and changes in the frequency and severity of tropical storms. Economic loss is discussed, though Petitioners understand that a shortened life is not readily described in financial terms.

Ocean-Based Risks – A Short Survey: In Section VI, Petitioners review the deleterious impact to the ocean from fossil fuel combustion, and other GHG emissions sources. With respect to ocean acidification, there is a clear consensus among leading national and international scientific bodies that anthropogenic CO_2 causes changes in ocean chemistry. Unabated, there will be increasingly severe and detrimental impacts on marine ecosystems, the economy, and public health. Injury to the ocean environment from acidification is compounded by ocean warming, a development that is already impacting corals worldwide, as well as the entire food chain since reproduction in certain organisms at its base is diminished with rising sea temperature.

Air Quality: In Section VII, Petitioners draw attention to the air pollutants produced by fossil fuel combustion, particularly PM2.5 that contributes to more than 10 million premature deaths annually, including an estimated 483,000 premature deaths in North America for people over the age of 14. Replacing fossil fuel combustion with clean energy sources will materially advance human health and survival.

Risk Reduction Methods: Section VIII summarizes action available to reduce risks associated with current and past GHG emissions. Among the most important are the timely phase out of fossil fuels and the removal and secure sequestration of CO_2 along with other GHGs. Improving energy efficiency is also highly beneficial. We review certain plans to reverse global warming in thirty years using solutions already aiming to hold global temperature rise to 2.0°C or, preferably, 1.5°C. Natural climate solutions (NCS) also are discussed, including reforestation, improved forest management, and improvements in agriculture and soils management. Market incentives and regulatory controls can be effective in increasing the rate of innovation aimed at reducing GHG emissions.

Need for Regulations for GHG Emission Reductions and Sequestration: In Section IX Petitioners discuss the two-fold market failure of (1) the environmental cost arising wherein GHGs are not included in the price of fossil fuel energy and (2) the removal and sequestration of carbon not being valued by the market. Such underpricing, or failure to internalize real costs, results in excess emissions far beyond what the environment can bear. This market failure needs to be addressed through Agency action. Agency assessment of regulatory approaches, including the assignment of a carbon price that increases over time, should take account of the possibility of catastrophic effects of continued emissions. Some of these include amplified climate change stemming from positive feedbacks in physical and chemical processes, including decreased arctic ice albedo, release of soil carbon as frozen soil warms, potential collapse of the marine food web, changes in cloud albedo, alterations in ocean circulations, more rapid than expected sea-level rise driven by West Antarctic Ice Sheet collapse, shifts in weather patterns like the Indian Summer Monsoon or the West African Monsoon, ecological regime shifts in the Amazon or the Sahel, and the potential for massive release of carbon from seafloor methane hydrates.

Risk Reduction Costs and Benefits: In Section X, in accordance with the Agency's guidance for this petition, Petitioners provide a preliminary analysis of the cost and benefits of GHG reduction, and emissions removal and sequestration. We include excerpts from Volume II of the Fourth National Climate Assessment, a document delineating "the human welfare, societal, and environmental elements of climate change and variability for 10 regions and 18 national topics, with particular attention paid to observed and projected risks, impacts, consideration of risk reduction, and implications under different mitigation pathways." Petitioners also discuss the economic costs of sea level rise, ocean acidification and potential climate extremes. Co-benefits are also discussed, including improved health due to air pollutant reduction.

In the view of Petitioners, the continuing imposition of risks associated with the subject chemical substances and mixtures is unreasonable under the Toxic Substances Control Act (TSCA). 15 USC §§2601 to 2696.

The operative term "unreasonable" merits comment, in the context of the climate crisis. To be clear: allowing continued high GHG emissions from fossil fuels and other sources will render large swaths of our nation (and the planet) far less habitable, as it will undermine natural and human systems that support civilization.[1] These consequences, which we outline in some detail below, will not be avoided with business as usual. But an alternative path is available and, as indicated in Part I, the Administrator of the Environmental Protection Agency (EPA) retains ample authority under TSCA to pursue it.[2] Failure to pursue such an alternative path will ensure the continuing diminishment of our children's future, and **that** would be unreasonable.

Petitioners present part of the basis for this conclusion in the material below, including at times in material incorporated by reference. The Agency should take account, as well, of additional material that is undoubtedly within its reach where that further supports Petitioners' demand for meaningful action without further delay.

II. Earth's Energy Imbalance

Humanity's reliance on fossil fuels to meet fundamental energy needs is imposing an increasing threat to human and natural systems, in large part because of the energy imbalance that fossil fuel emissions have imposed on our planet. Additional emissions only amplify that imbalance, pressing human and natural systems further toward the brink. Accordingly, in order to safeguard a viable future for humanity and nature, we must restore energy balance and allow Earth to cool back to a temperature no warmer than the mid-twentieth century.

The implication with respect to the object of this petition is clear: GHG emissions, particularly CO_2 and CH_4 deriving substantially from fossil fuels, have induced an energy imbalance that itself presents a current and unreasonable risk of serious and widespread injury to health and the environment, along with an imminent risk of far worse still to come.

Earth has gained substantial energy over the past four decades. In a careful international effort, von Schuckmann *et al.* was able to calculate that approximately 90 percent of the excess energy is taken up by the ocean – due to its large mass and high heat capacity. The balance is expended in melting ice (3-4%) and stored in the land (5-6%) and in the atmosphere (1-2%)."[3]

Figure 1 below depicts Earth's current energy imbalance due to more energy arriving by way of solar radiation than escapes back to space from the top of the atmosphere.

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[1] Business as usual emissions would also strike directly at US national security. Christopher Flavelle, Julian E. Barnes, Eileen Sullivan and Jennifer Steinhauer, *Climate Change Poses a Widening Threat to National Security: Intelligence and defense agencies issued reports warning that the warming planet will increase strife between countries and spur migration*, New York Times (Oct. 21, 2021, undated Nov. 1, 2021) https://www.nytimes.com/2021/10/21/climate/climate-change-national-security.html.

[2] The President appoints the EPA Assistant Administrator for Toxic Substances, TSCA §2625(g), and EPA in turn must report to the President annually about the rules it issues pursuant to TSCA §6, 15 USC §2605 -- including "a summary of major problems encountered" in their administration. The Agency is also required to waive compliance with a provision of TSCA if, in the President's determination, that is necessary in the interest of national security. TSCA §22, 15 USC §2621.

[3] Von Schuckmann, *et al.*, *Heat stored in the Earth system: where does the energy go?* Earth Syst. Sci. Data (September 7, 2020) https://essd.copernicus.org/articles/12/2013/2020/. Petitioner Hansen is a co-author.

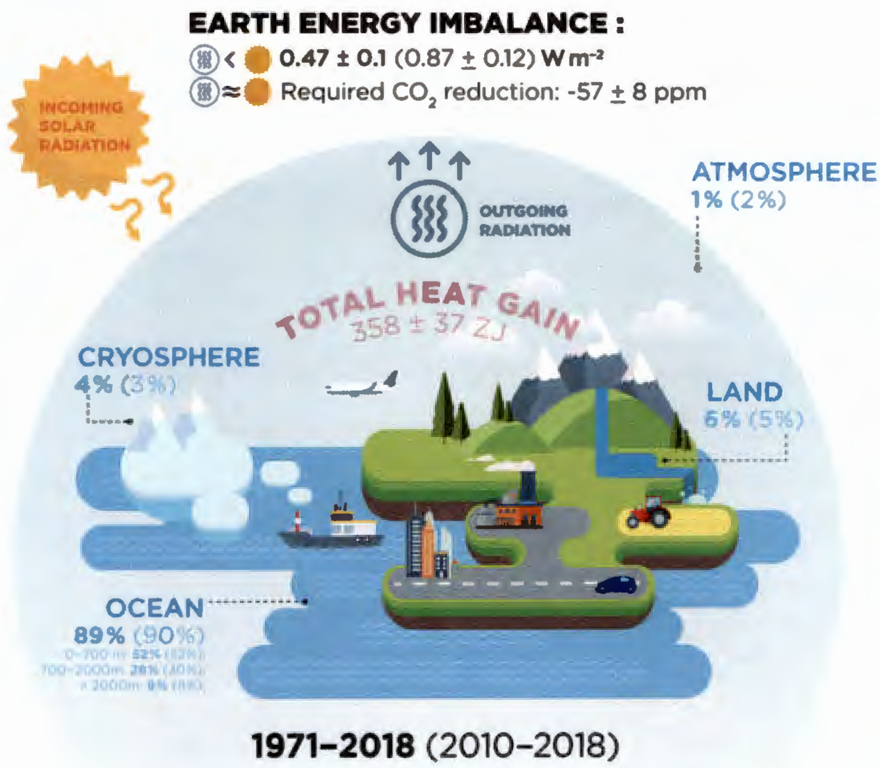

Fig. 1. Schematic presentation of Earth's heat inventory for the current human-caused energy imbalance. Graphic from von Schuckman *et al.*

As seen in Figure 1, GHGs cause an unimaginably large amount, about 358 Zettajoules ($358 \times 10_{21}$ Joules), of additional solar energy to be trapped within the Earth system of land, ocean, ice and atmosphere each year. In order to restore energy balance, we must act to reduce the atmospheric concentration of CO_2 to 353 ppm or less. That maximum safe GHG concentration value affirms the conclusion of an earlier study by Petitioner Hansen and colleagues: Target atmospheric CO_2: Where should humanity aim? (hereafter,"Hansen et al. (2008)").[4] That study concluded: "If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current [level] to at most 350 ppm." Petitioners hereby incorporate the principal conclusions and reasoning of von Schuckman et al. (2020) and Hansen et al. (2008) by reference. We also note that the average atmospheric CO2 concentration has risen from 385 to 416 ppm, an additional 31 ppm, since the publication of the Hansen et al. (2008) study.[5]

Earth's energy imbalance can be measured with good accuracy because of precise monitoring of the warming global ocean. The image in Fig. 1 reports that the average imbalance over the period 1971-2018 was 0.47 ±0.1 W/m^2, but Von Schuckmann *et al.* (2020) also report that, in the more recent period of 2010-2018, the imbalance was 0.87 ±0.1 W/m^2. As well, Petitioner Hansen argued in a recent widely distributed communication, "Earth's energy

[4] Hansen et al., Open Atmos. Sci. J. (2008), vol. 2, pp. 217-231, available at https://arxiv.org/abs/0804.1126

[5] NOAA CO_2 data available at https://gml.noaa.gov/ccgg/trends/data.html.

imbalance – which was less than or about half a watt per square meter during 1971-2015 – has approximately doubled to about 1 W/m^2 since 2015."[6]

This increased energy imbalance is the principal cause of global warming acceleration, which Petitioners illustrate in Figure 2 below.

Global Surface Temperature Relative to 1880–1920 Mean

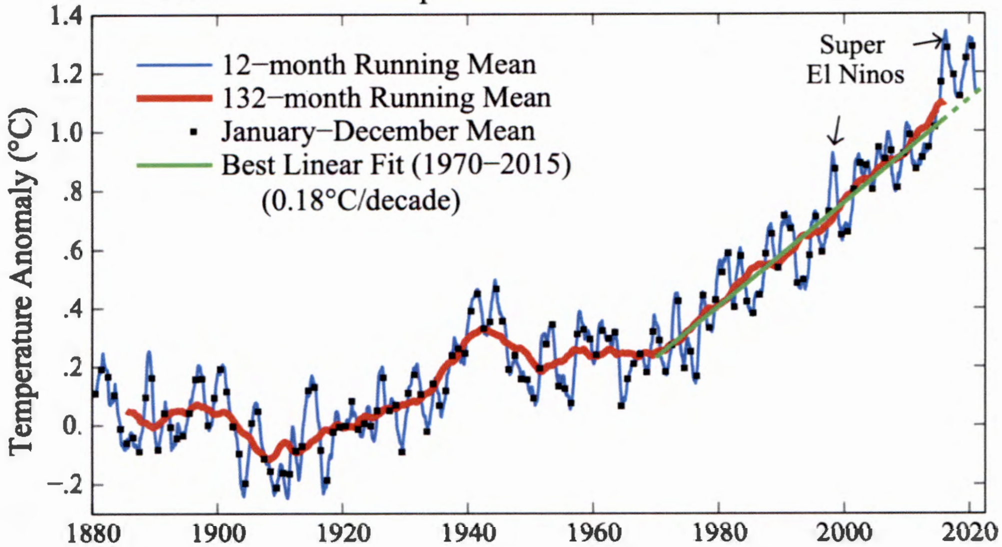

Fig. 2: From Climate Science Awareness and Solutions (CSAS) data pages.[7] Updated 8/13/2021.

The graphic shows global surface temperature relative to 1880-1920. The 1880-1920 mean temperature serves as our best estimate of the preindustrial level, because the small warming effect of anthropogenic GHGs that had been added by that period was approximately offset by greater than average volcanic activity in 1880-1920. The temperature in 1940-45 shown in the figure may be exaggerated by data inhomogeneity during WWII, but that does not materially distort the picture – which is a sharp rise in warming since 1960.

Global temperature is now well above the range that occurred in the balance of the Holocene, the last 11,700 years, as illustrated in Figure 3 below.

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[6] Hansen and Sato, *July Temperature Update: Faustian Payment Comes Due* (Aug. 13, 2021) from http://www.columbia.edu/~mhs119/Temperature/Emails/July2021.pdf.

[7] As also maintained by Makiko Sato, op cit. available at http://www.columbia.edu/~mhs119/Temperature/.

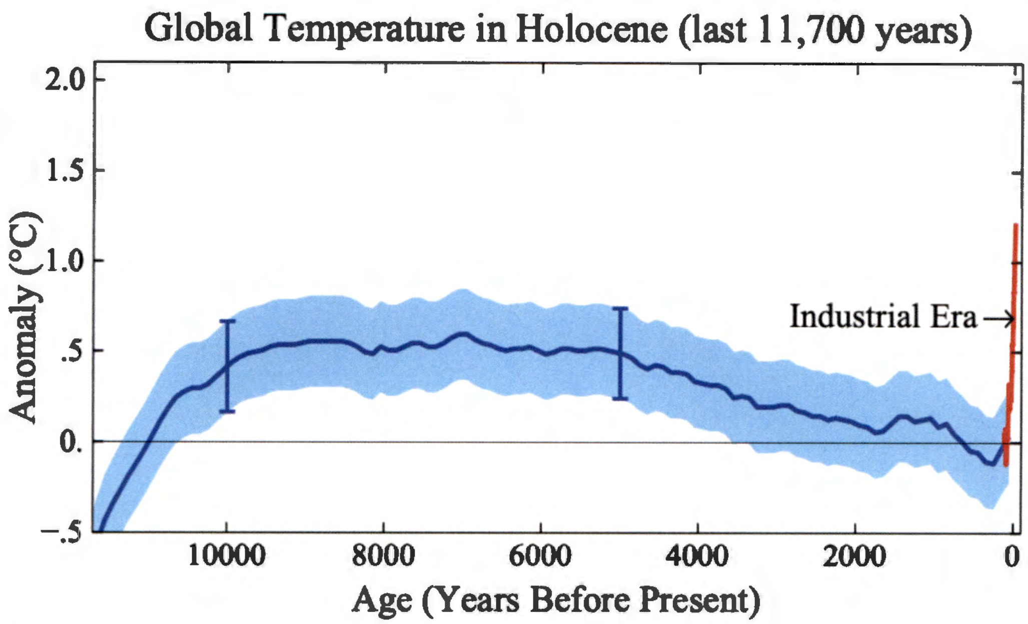

Fig. 3: Centennially smoothed Holocene temperature relative to 1880-1920.
From CSAS data pages.[8]

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 – including a phaseout of fossil fuel emissions and removal of excess atmospheric CO_2 and CH_4.

III. CO_2 Emissions: Sources and Required Reductions to Secure Safety

CO_2 emissions began to increase the global average atmospheric concentration beginning with the industrial revolution, in the mid-18th century, when coal began to be used as a fuel for home-heating, powering steam engines and eventually for electrical power generation. Petroleum (commonly, "oil"), another fossil fuel, began to contribute to CO_2 emissions at the beginning of the 20th century. Its products, including fuels like gasoline, kerosene, diesel fuel and jet fuel, made automobile and aircraft transportation possible. Natural gas, another fossil fuel extracted from the earth and consisting principally of methane (CH_4), has made heating of homes and commercial buildings convenient because of the ability to transport the gas from processing plants to end users via pipelines.

These fossil fuels – coal, petroleum and natural gas – are composed almost entirely of carbon and hydrogen that burn in the presence of oxygen to produce carbon dioxide and water.

The natural carbon cycle, in which carbon dioxide is removed from the atmosphere by the photosynthetic activity of land and ocean plants, and returned to it by respiration, also functions to return a portion of the CO_2 to soils and deeper earth formations by a wide range of processes. The cycling of carbon among the atmosphere, biosphere, hydrosphere and geosphere has many timescales, ranging from one year, for seasonal changes in photosynthetic uptake of CO_2, to tens to hundreds of millions of years, for exchange of fossilized carbon with the atmosphere and oceans. Over the past two centuries, and especially the past fifty years, humans

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[8] As also maintained by Makiko Sato at http://www.columbia.edu/~mhs119/Burden_figures/.

have introduced an enormous perturbation in the carbon cycle by extracting fossil fuels and burning them to release vast quantities of CO_2 to the atmosphere at an unprecedented rate.[9]

The to-date unceasing commitment to fossil fuels is illustrated in Figure 4 below, showing that while the contribution of carbon-free energy to the global energy supply is growing, it yet remains a small fraction of that provided by fossil fuels (Fig. 4(a)). This fact, coupled with continued energy demand, has ensured continually high CO_2 emissions (Fig. 4(b)). Even coal emissions remain near their peak, which surprises people who think of coal as a 19th century fuel. It is still with us, infusing the atmosphere with even more CO_2 than does the consumption of oil or natural gas.

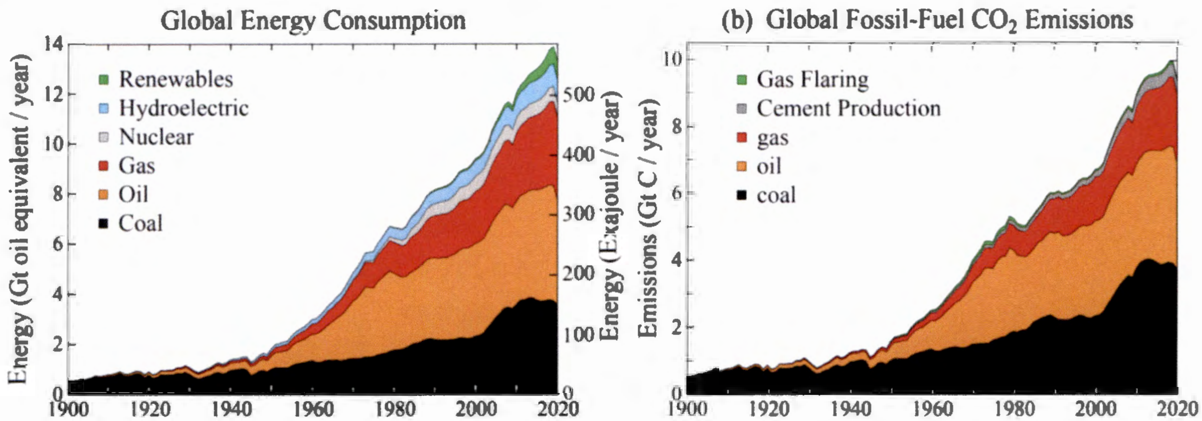

Fig. 4: From CSAS data pages.[10] Updated Aug. 18, 2021.

Accordingly, the extraction and burning of fossil fuels is overwhelming the natural carbon cycle. More than half of fossil fuel emissions is taken up by the Earth system, dissolved in the ocean (and there raising ocean acidity) and sequestered by the biosphere and soil. The balance of fossil fuel CO_2, approximately 44%,[11] *remains* in the atmosphere for centuries or millennia.[12] Figure 5, below, illustrates the fate of these emissions, the blue area showing the amount (a) and the fraction (b) of the emissions that remain in the air.

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9 IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. TS-46.

10 As maintained by Makiko Sato at www.columbia.edu/~mhs119/CO2Emissions/.

11 IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. TS-47.

12 Unless, that is, a serious effort commences to remove all or a portion of such legacy emissions, as we discuss *infra*.

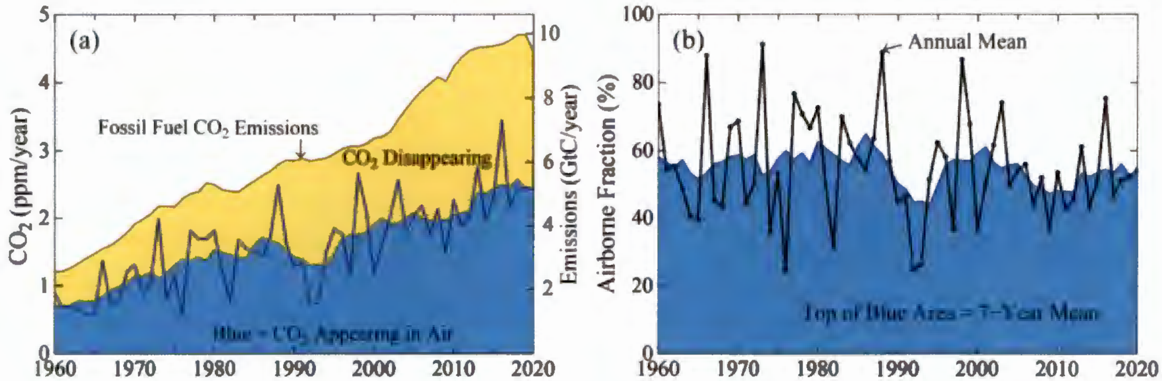

Fig. 5: From CSAS data pages.[13] Updated August 18, 2021.

One result is that the atmospheric CO_2 concentration is increasing, year after year, as shown in Figure 6 below, with data through April 2021. Indeed, the CO_2 concentration has risen 30 percent over the last six decades, from 316 ppm in 1959 to 416 ppm in 2021.[14]

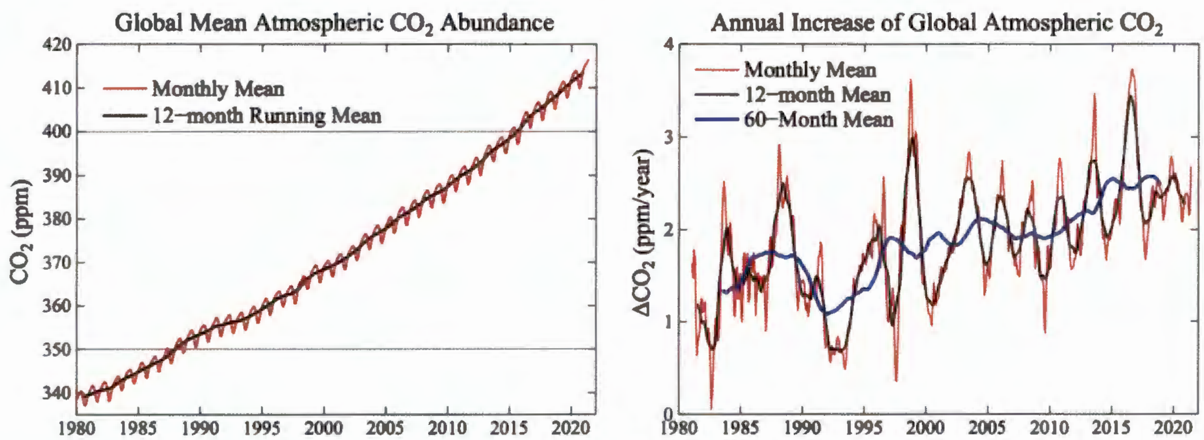

Fig. 6: Atmospheric CO_2 concentration. From CSAS data pages.[15] Updated August 18, 2021.

Moreover, atmospheric CO_2 is increasing today at least 10 times faster than the most rapid known prior change in Earth's history, that is, the rate of increase characterizing the Paleocene-Eocene Thermal Maximum (about 50 million years ago). The last time the atmospheric CO_2 concentration was this high, was more than 3 million years ago, when temperature was 2°–3°C (3.6°–5.4°F) higher than during the pre-industrial era, and sea level was 15–25 meters (50–80 feet) higher than today.[16]

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[13] As also maintained by Makiko Sato, at http://www.columbia.edu/~mhs119/GHGs/.

[14] Global Monitoring Laboratory, Mauna Loa CO_2 Annual Mean Data, https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html.

[15] As also maintained by Makiko Sato, at http://www.columbia.edu/~mhs119/GHGs/.

[16] Rebecca Lindsay, *Climate Change: Atmospheric Carbon Dioxide*, Aug. 14, 2020 available at https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide.

The atmospheric CO_2 concentration has increased by 136 ppm (from 280 ppm to 416 ppm[17]) to date, corresponding to an excess in the atmosphere of ~1.0 x 10^{18} g (1,000 Gigatons, GT) of CO_2 – that is, one trillion metric tons. This overburden is currently increasing by about 18 billion metric tons (18 Gt) per year, based on the current trend of CO_2 concentration increasing by ~2.3 ppm/yr.[18] There is a comparably large excess quantity of CO_2 and bicarbonate ion in the oceans that, as discussed below, is already having an adverse effect on marine life. As with other toxic substances regulated by the EPA, much of this legacy CO_2 will need to be removed in order to cool the planet and restore the climate system so that human and natural systems may continue to function as required by our children and future generations.

Because of the long-lived nature of atmospheric CO_2,[19] responsibility for present and future global warming is a matter of cumulative emissions. The largest quantity of annual GHG emissions now stems from activity in China, but the United States, with the highest cumulative total (and very high per capita emissions) still bears the lion's share of responsibility for present and future global warming. *See* Figure 7 below.

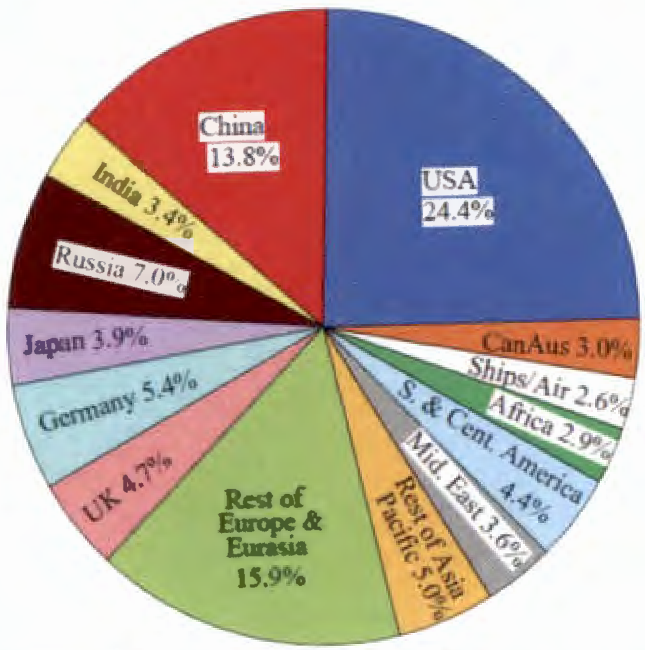

Fig. 7: 1751-2020 Cumulative Emissions (452 Gt). Source: Climate Science, Awareness and Solutions

[17] NOAA Global Monitoring Laboratory, Trends in Atmospheric Carbon Dioxide, as of Aug. 20, 2021, available at https://gml.noaa.gov/ccgg/trends/.

[18] *Id.*

[19] *See* Archer et. al., *Atmospheric Lifetime of Fossil Fuel Carbon Dioxide*, Annu. Rev. Earth Planet. Sci. 2009. 37:117–34, https://www.annualreviews.org/doi/pdf/10.1146/annurev.earth.031208.100206.

IV. Methane and Other Climate-forcing Pollutants

(A) Methane

Methane (CH_4) is the second most important anthropogenic greenhouse gas. The IPCC estimated that methane contributed about 0.5°C of warming during the period 2010-2019 in comparison to the period 1850-1900.[20]

Although its concentration in the atmosphere is relatively low, averaging about 1.89 ppm (1891.3 ppb) as of April 2021,[21] CH_4 absorbs infrared radiation much more strongly than CO_2 and thus has a much higher *global warming potential (GWP)*. Over a timescale of 20 years, on a mass basis, CH_4 is 82.5 times more effective at trapping heat[22] (30.1 times more effective on a molar basis) than CO_2.[23] Like CO_2, the atmospheric methane concentration has been increasing since the industrial revolution, from a level of about 0.73 ppm[24] to its current value of 1.89 ppm, a factor of 2.6. *See* Figure 8 below.

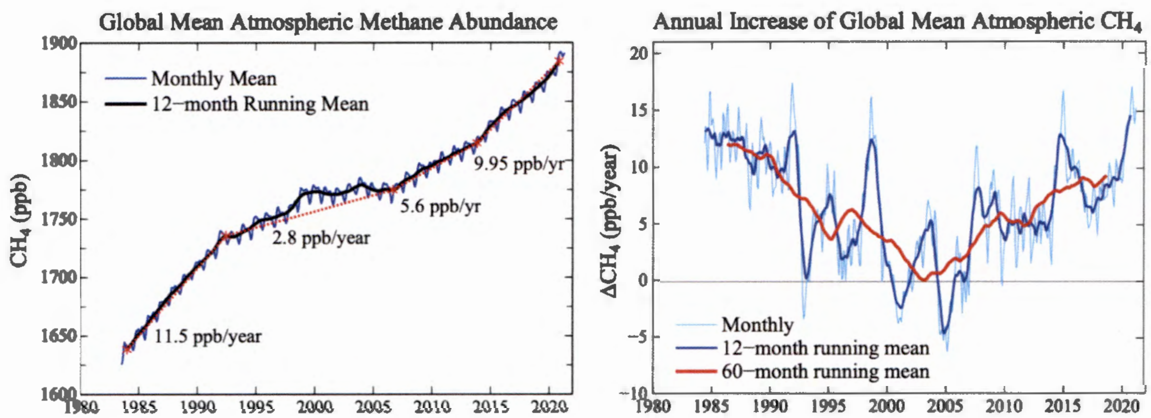

Fig. 8: Atmospheric CH_4 concentration. From CSAS data pages.[25] Updated June 24, 2021.

Since 2006, the annual increase in the global average atmospheric methane concentration has accelerated, increasing 15 ppb or 0.015 ppm between April 2006 and April 2021.[26]

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[20] IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. SPM-8, Figure SPM.2.

[21] NOAA Global Monitoring Laboratory, Trends in Atmospheric Methane, as of Aug. 20, 2021, available at https://gml.noaa.gov/ccgg/trends_ch4/.

[22] IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. 7-125.

[23] "When looking at its impact over 100 years, one tonne of methane is still equivalent to about 28 tonnes of CO_2." Quirin Schiermeier, Global methane levels soar to record high, Nature News (July 14, 2020).

[24] Nakzawa et al., Differences of the atmospheric CH_4 concentration between the Arctic and Antarctic regions in pre-industrial/pre-agricultural era, Geophys.Res. Lett. (2020) vol. 20, pp. 943-946, available at https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/93GL00776.

[25] As also maintained by Makiko Sato, at http://www.columbia.edu/~mhs119/GHGs/.

[26] NOAA Global Monitoring Laboratory, Trends in Atmospheric Methane, as of Aug. 20, 2021, available at https://gml.noaa.gov/ccgg/trends_ch4/.

Moreover, the period April 2020 to April 2021 saw the largest single-year increase for which accurate global measurements have been made. This increase in atmospheric methane is the equivalent (for a 20-year time scale) of ~0.47 ppm of CO_2 for that year. As a result, the effect of increasing emissions of CH_4 on the Earth's radiative balance during this past year amounted to about 20% of that of increasing levels of CO_2.

As with CO_2, there are both natural and anthropogenic sources of methane. Natural sources are dominated by anaerobic bacterial metabolism of organic matter, principally in wetlands and to a much lesser extent in the oceans (but also by termites).[27]

Anthropogenic sources are estimated to outweigh natural sources, though there remains some controversy.[28] Significant anthropogenic sources of methane include landfills, enteric fermentation in ruminants (livestock such as cattle), waste management, rice agriculture, biomass burning and fugitive emissions from oil and gas operations. The sum of all agricultural and waste management contributions to methane emissions constitutes about 65% of anthropogenic emissions while that of emissions from the oil and gas industry contribute about 35%.[29] The latter emissions have likely increased in recent years due to the advent of hydraulic fracturing ("fracking") and the increased production of natural gas. Fugitive emissions of natural gas include purposeful venting of wells, incomplete combustion of methane during flaring of wells, and leakage from capped wells, processing facilities, and the vast network of pipelines that transport natural gas to end users. According to the EPA, in 2019 U.S. methane emissions from oil and gas production amounted to a CO_2 equivalent of 197 million metric tons distributed as 48% gas production, 20% oil production, 6% processing, 19% transmission and storage, and 7% distribution.[30]

The excess atmospheric burden of CH_4 due to anthropogenic activities can be calculated as the difference in the current concentration of 1.89 ppm and the pre-industrial concentration of 0.73 ppm. This increase in atmospheric methane of 1.26 ppm corresponds to 3.5 billion metric tons of excess methane in the atmosphere or the GWP equivalent of 290 billion metric tons (0.29 Gt) of CO_2 – accounting for about 29% of the current excess burden (1,000 Gt) of CO_2 in the atmosphere.[31]

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[27] Saunois et al., The global methane budget 2000-2017, *Earth System Science Data* (2020), vol.12, pp. 1561-1623, available at https://essd.copernicus.org/articles/12/1561/2020/. *See also*, NOAA, Increase in atmospheric methane set another record during 2021 (April 7, 2022) (discussing "the largest annual [methane] increase recorded since systematic measurements began in 1983," observing that "carbon dioxide pollution has always been the primary driver of human-caused climate change," and noting that there has been "scientific debate on the cause of the ongoing surge in methane levels") at https://www.noaa.gov/news-release/increase-in-atmospheric-methane-set-another-record-during-2021. *See also*, Hmiel et al., Preindustrial $^{14}CH_4$ indicates greater anthropogenic fossil CH_4 emissions, Nature (Feb. 19, 2020) at https://www.nature.com/articles/s41586-020-1991-8.

[28] Saunois et al. (2020).

[29] *Id.*

[30] *U.S. Environmental Protection Agency, Estimates of Methane Emissions by segment in the United* States (2021), https://www.epa.gov/natural-gas-star-program/estimates-methane-emissions-segment-united-states/.

[31] Calculated as follows: (Increased fraction of molecules that are CH_4, 1.26×10^{-6}) × (Number of molecules in the atmosphere, 1.04×10^{44}) ÷ (Avagadro's number for molec/mol, 6.022×10^{23}) × (molecular weight of CH_4, 16.04 g/mol) ÷ (g/metric ton, 10^6) = 3.49×10^9 tons of excess CH_4 in the atmosphere. Multiply this by the GWP of 82.5 to obtain 2.88×10^{11} equivalent ton of CO_2 or 0.288 million metric tons of CO_2.

An important difference between CH_4 and CO_2 is that CH_4 has a much shorter atmospheric lifetime, namely, approximately ten years,[32] due almost entirely to oxidation to CO_2 by the hydroxyl radical.[33] This means that if we were to stop emitting anthropogenic methane to the atmosphere, the burden of legacy CH_4 would be reduced by a factor of ~63% every ten years.[34]

In addition to relying on its relatively short lifetime, one possible approach to reducing the effect of legacy CH_4 is to catalytically oxidize atmospheric methane to CO_2, thereby avoiding the necessity of its disposal. This would reduce the 20-year global warming effect of any methane converted to CO_2 by a factor of ~30 and the 100-year effect by a factor of ~9. Oxidation of legacy CH_4 is simpler in one sense than removal of legacy CO_2 because no concentration and disposal step is required. However, CH_4 is far more scarce in the atmosphere than is CO_2, so removal of an equivalent quantity "leads to a higher minimum energy requirement."[35] On the other hand, "because of the higher radiative forcing of methane, removing one mole from the atmosphere has a greater short-term climate impact than removing one mole of CO_2."[36] Oxidizing the 1.3 ppm of excess methane in the atmosphere would produce the equivalent effect of removing ~39 ppm of CO_2, or an amount equal to the past ~18 years of CO_2 emissions.

(B) Halocarbons

Halocarbons, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons (HFCs),[37] have 1,000 to 9,000 times the global warming potential of CO_2. Similarly, the halocarbon family of refrigerants are chemical compounds derived from hydrocarbons by

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[32] Naik et al., *Preindustrial to present-day changes in tropospheric hydroxyl radical and methane lifetime form the Atmospheric Chemistry and Climate Model Intercomparison Project* (ACCMIP), Atmos. Chem. Phys. (2013), vol. 13, pp. 5277-5298, available at, https://acp.copernicus.org/articles/13/5277/2013/acp-13-5277-2013.pdf.

[33] Fossil fuel CO_2, on the other hand, has an estimated mean atmospheric lifetime on order of tens of thousands of years, according to Archer et. al.: A burst of CO_2 takes 2 to 20 centuries to equilibrate with the ocean, but even after that process completes 20-40% of the CO_2 remains in the atmosphere subject only to far slower chemical reactions with CaCO3 and igneous rocks. Accordingly, the "climate effects of CO_2 releases to the atmosphere will persist for tens, if not hundreds, of thousands of years into the future." Archer et. al., *Atmospheric Lifetime of Fossil Fuel Carbon Dioxide*, Annu. Rev. Earth Planet. Sci. 2009. 37:117–34, https://www.annualreviews.org/doi/pdf/10.1146/annurev.earth.031208.100206.

[34] In particular, it would be reduced to $1/e$ of its original amount in 10 years, where e is Euler's number. *See* https://en.wikipedia.org/wiki/E_(mathematical_constant). Accordingly, again assuming the halting of methane emissions, there would be left 37% of the original amount in 10 years, 13.5% of that amount in 20 years, and slightly less than 5% in 30 years. That is, more than 95% of the original CH_4 would be oxidized within three decades.

[35] Robert B. Jackson, et al., 2021, Atmospheric methane removal: a research agenda, *Phil. Trans. R. Soc. A*.**379,** http://doi.org/10.1098/rsta.2020.0454 at 4.

[36] *Id.*

[37] Chlorofluorocarbons, hydrochlorofluorocarbons and halons are currently regulated under TSCA, in accordance with the Montreal Protocol and under the Clean Air Act (CAA), for their ability to destroy stratospheric ozone and thus allow increased levels of harmful UV radiation to reach the Earth's surface. Halogenated refrigerants that are much less destructive to stratospheric ozone but can have as great a global warming potential are being phased out under the Kilgali accord (not yet ratified by the US). Appliances discarded before 1/1/18 are not regulated under the CAA, and there is also illegal disposal that occurs. They are included in this petition because aggressive action to find and destroy discarded refrigerants in appliances and other disposed material can be required under TSCA section 2605 in the same way TSCA regulates discarded PCB-containing materials.

substitution of chlorine and fluorine atoms for hydrogen. EPA has taken action under TSCA to control other families/classes of compounds, before and after disposal, including poly-chlorinated biphenyls (PCBs), chlorofluorocarbons (because of their ozone depleting effects), friable asbestos in schools, and dibenzo-paradioxins/dibenzofurans.[38] The family of refrigerants shares common global warming effects and should be controlled and cleaned-up to prevent their additional climate impact.

Despite the decreased production of CFCs due to the regulatory control, over a million tons of CFCs remain in existing appliances (many disposed of in dumps), and these comprise a significant source of potential future emissions. Similarly, banks of HCFCs and HFCs are being established as some uses increase. The management of such CFC and HCFC stores are neither controlled by the Montreal Protocol nor taken into account in UNFCCC inventories. The problem is not small, as halocarbon releases are responsible for about 2-3% of the GWP of released gases.[39] It is estimated that there are over 57 GT[40] of carbon equivalents in disposed appliances that will be released as the appliances break down and emit their refrigerants.[41] These discarded units are physically an environmental problem similar to that of discarded capacitors containing PCBs and dioxin. EPA has a program to capture and destroy the latter such fluids under TSCA, and a similar program should be put in place as a matter of course for discarded refrigerants. Petitioners here request this be done without any delay; it need not await completion of the rulemaking requested herein.

(C) Nitrous Oxide

Nitrous Oxide (N_2O) is a long-lived species emitted to atmosphere by soil and sea microorganisms such as denitrifying bacteria and fungi. The atmospheric N_2O concentration has increased from about 270 ppb in 1750 to its present level of 335 ppb, and its concentration is currently increasing at a rate of about 1.3 ppb/year (1.35 ppb in 2020 and 1.26 ppb in 2021).[42] Nitrous oxide is unreactive in the lower atmosphere and thus has a long lifetime of slightly more than 100 years. Once mixed into the stratosphere, however, it undergoes photolysis and reaction with electronically excited oxygen atoms in the stratosphere where a small fraction is converted to nitric oxide (NO) which catalyzes ozone depletion.[43] Although N_2O has a very low atmospheric concentration, it contributes significantly to radiative forcing, with a global warming potential 273 times that of CO_2 over 20 years.[44] Thus, a 1.3 ppb increase in N_2O each

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[38] https://www.brown.edu/health-safety/topics/environmental-compliance/toxic-substance-control-act-tsca Last accessed 2/8/2021.

[39] https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks Last accessed and https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data, last accessed 2/10/21.

[40] https://www.drawdown.org/solutions/refrigerant-management Last accessed 2/10/21. A gigatonne (GT), also known as a petagram, is 1 billion (10^9) tonnes, or 1,000 megatonnes (MT) or 1 trillion kilograms (kg).

[41] IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System.

[42] NOAA Global Monitoring Laboratory, https://gml.noaa.gov/ccgg/trends_n2o/

[43] Ravishankara, A.R., Daniel, J.S. and Portmann, R.W., Nitrous Oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century, Science 326, 123-125 (2009). https://www.science.org/doi/10.1126/science.1176985

[44] IPCC AR6 WG1 Ch72021

year produces the same degree of warming as an increase of 0.35 ppm of CO_2. Since CO_2 is currently increasing at a rate of ~2.3 ppm/yr, N_2O emissions contributes about 15% as much as CO_2 to additional global warming each year. Nitrous oxide emissions to the atmosphere have both natural and anthropogenic sources. It is estimated that 62% of emissions are natural and 38% are due to human activity.[45] The principal anthropogenic sources are agricultural soil management (e.g., application of fertilizers; 74%), wastewater treatment (6%), stationary combustion (5%), chemical production and other product uses (5%), manure management (5%), transportation (4%) and other sources (1%).[46] Thus, large reductions in N_2O emissions could be achieved by reduced use of nitrate fertilizers, better management of farm wastes, and reduced combustion of fossil fuels.

(D) Black Carbon

Black carbon (BC), or "soot", is a component of atmospheric aerosols derived from incomplete combustion of fossil fuels and biomass. It is the black smoke you sometimes see belching out of tailpipes of vehicles, especially those such as trucks that make use of diesel fuel. But it is produced with varying efficiency in combustion of all fuels, higher rates of production occurring under fuel-rich conditions. BC particles are in the submicron size range and make up typically 10-30% of PM2.5 (mass of particles have diameters $\leq 2.5\ \mu m$) in urban atmospheres. Black carbon is "black," in that it absorbs all wavelengths of visible light from the sun. Thus BC, heats the atmosphere differently that GHGs, that is, by absorption of visible light from the sun (reducing the planetary albedo) rather than by absorption of infrared radiation emitted by Earth's surface.

Black carbon also differs from GHGs in that it deposits, after a short residence time (days to weeks) in the atmosphere, onto Earth's surface where it reduces the albedo (reflectivity) and can continue to absorb visible light. This is especially a problem for glaciers where black carbon deposition enhances ice melt. Black carbon has been found in Arctic haze[47] and in Arctic snow,[48] for example. It has been claimed that in some regions, such as the Himalayas, the impact of black carbon on melting of snowpack and glaciers may be equal to that of CO_2.[49] Indeed, past IPCC reports placed black carbon ahead of methane in terms of radiative forcing, but the most recent report assigns black carbon a more modest role. The current IPCC best estimate for contributions to global warming during the period 2010-2019 relative to 1850-1900 based on radiative forcing studies is about 0.1°C, comparable to that of halogenated gases and nitrous oxide, but with larger error bars than for either of those GHGs.[50]

45 K. L. Denman, G. Brasseur, et al. (2007), "Couplings Between Changes in the Climate System and Biogeochemistry." In Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

46 EPA, Overview of Greenhouse Gases, https://www.epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide

47 Rosen, H.; Novakov, T.; Bodhaine, B. (1981) Soot in the Arctic, *Atmos. Environ.* **15**, 1371–1374. https://www.sciencedirect.com/science/article/abs/pii/0004698181903437

48 Clarke, A.D.; Noone, K.J. (1985). "Soot in Arctic snowpack: A cause for perturbation in radiative transfer". Atmos. Environ. 19 (12): 2045–2053. https://www.sciencedirect.com/science/article/abs/pii/S1352231007009752

49 Ramanathan, V.; Carmichael, G. (April 2008). "Global and regional climate changes due to black carbon". Nature Geoscience. 1 (4): 221–227. https://www.nature.com/articles/ngeo156

50 IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. SPM-8, Fig SPM.2.

(E) Short-Lived Gases

Short-lived air pollutant gases such as sulfur dioxide (SO_2), the oxides of nitrogen (NO and NO_2) and volatile organic compounds (VOCs) contribute to radiative forcing principally though aerosol formation and ozone formation. As discussed earlier, nitrate and sulfate aerosol, formed from SO_2 and oxides of nitrogen produced in fossil fuel combustion processes, currently mask about 0.4°C (or more) of warming that would have occurred to date in their absence. As we reduce fossil fuel emissions, simultaneous reductions of these negative radiative forcings (due to scattering of solar radiation back to space) will work against the gains we make in reducing GHGs, making it all that more important to remove legacy GHGs in addition to cutting emissions.

Ozone is a short-lived gas (a few hours to days) that is continuously produced in the lower atmosphere by the NO_x-catalyzed photooxidation of CH_4, carbon monoxide (CO) and VOCs.[51,52] Tropospheric ozone has contributed about 0.2-0.3°C of warming relative to pre-industrial times.[53] The U.S. already regulates ozone under the Clean Air Act and its amendments as one of six Criteria Pollutants.[54] The precursor CO is also a criteria pollutant, as is NO_2, which photochemically cycles with NO to catalyze ozone formation. On a global scale, however, ozone will continue to be elevated due to large contributions from low-income countries that have not yet imposed stringent air pollution regulations. It will be important for the U.S. to share technologies and expertise in helping those countries reduce emissions of ozone precursors as a means of reducing the global contribution to radiative forcing from this greenhouse gas. The co-benefit to those countries will be improvements in the health and increased lifespans of their citizens.

V. Unreasonable Land-Based Risk: A Short Survey

(A) Heat, Drought, Wildfire

Fossil fuel-driven heat, drought, and wildfire impose a current, imminent and unreasonable risk of serious or widespread injury to health or the environment.

In its 2018 Special Report, Global Warming on 1.5 Degrees Celsius (2.7 Degrees Fahrenheit), the IPCC noted that as the Earth warms to 1.5°C about 14 percent of Earth's population will be exposed to severe heatwaves at least once every five years.[55] This level of high temperature exposure may be unavoidable, at least for a period.[56] Additional GHG emissions will ensure that extreme heatwaves become widespread – with 37 percent of the Earth's people experiencing severe heatwaves at least once every five years. Indeed, in its 2021 report, the IPCC notes that with warming of 2.6ºC heatwaves now experienced only once in a decade will likely occur as often as 6 times per decade.[57] Compounding the problem,

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51 A. J. Haagen-Smit, A.J. and Fox, M.M. (1954) Photochemical Ozone Formation with Hydrocarbons and Automobile Exhaust, Air Repair, 4:3, 105-136, DOI: 10.1080/00966665.1954.10467649.
52 Birks, J.W., "Oxidant Formation in the Troposphere," In *Perspectives in Environmental Chemistry*, D. L. Macalady, Ed., Oxford University Press, pp. 233-256 (1998).
53 IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. SPM-8, Fig SPM.2.
54 EPA, Criteria Pollutants, https://www.epa.gov/criteria-air-pollutants
55 From NASA article, https://climate.nasa.gov/news/2865/a-degree-of-concern-why-global-temperatures-matter/.

56 *See* July Temperature Update, *op cit* nte.34.

57 AR 6, SPM-23.

anthropogenic aerosols (fine particulate pollution) mask a significant fraction of global warming.[58] Accordingly, selective progress in combatting conventional air pollution – such as baghouse filters on coal plants – leads to additional warming, unless there are simultaneous efforts to eliminate GHG emissions.

Although the 2021 US wildfire season was not among the most severe in the modern era of consistent record keeping, four fires made the "Top 20 Largest California Wildfires" list in 2021, which includes the second largest wildfire in California's history – the Dixie Fire. Admittedly, the fires are the product of a number of relevant factors, including changes in meteorological conditions that carry their own internal variability, but climate warming and associated drought constitute two primary conditions. Petitioners illustrate the correlation between temperature change and wildfire over a 35-year period in Figure 9 below.[59]

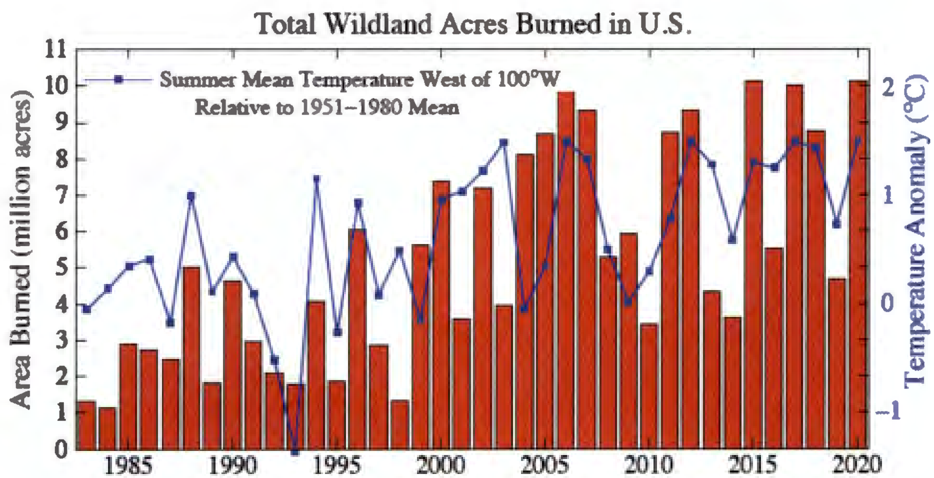

Fig. 9: Graphic by CSAS.[60]

We note that while the governmental dataset used for the histogram covers the continental U.S., the picture is reflective of western states where the vast majority of acres burned by U.S. wildfire are located. We illustrate this in Fig. 10 using the federal government's Monitoring Trends in Burn Severity tool, depicting over 25,000 fires in the 1984-2019 period.

[58] Petitioner Hansen and colleagues at Climate Science, Awareness and Solutions estimated in 2013 that the negative radiative forcing from aerosols could be up to 4x that amount, that is, ~ -1.6 ± 0.3 W/m². Hansen, J, Sato, M, Kharecha, P and von Schuckmann, K 2011 Earth's energy imbalance and implications Atmos. Chem. Phys. 11, 13421-13449.

[59] There were, of course, fires in western states prior to 1983, but we illustrate the point for the period during which the federal wildland agencies tracked the relevant data "using current reporting processes." https://www.nifc.gov/fire-information/statistics/wildfires (visited Aug. 18, 2021).

[60] As also developed by Makiko Sato, with wildland acreage data from the National Interagency Fire Center, https://www.nifc.gov/fire-information/statistics/wildfires.

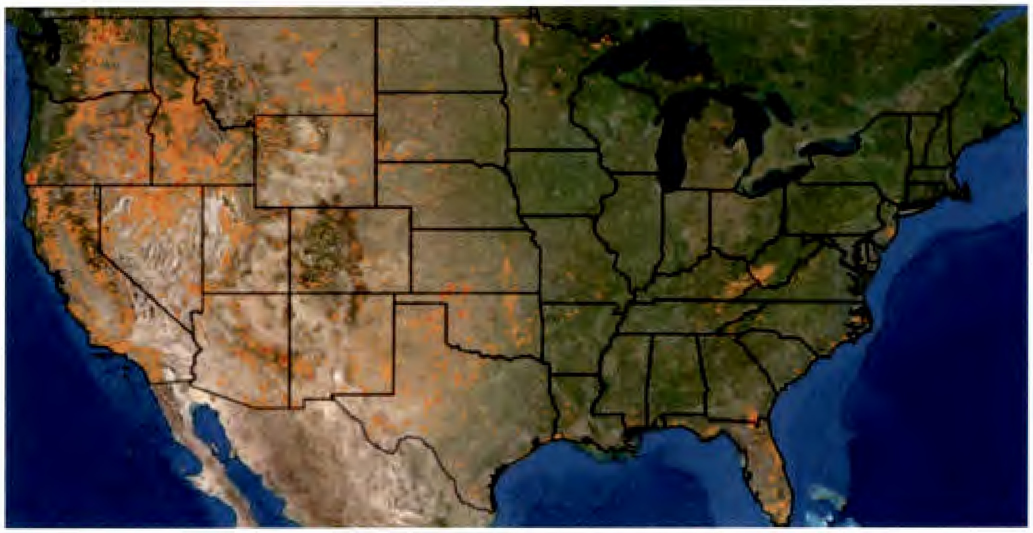

Fig. 10: USGS and Forest Service.[61]

Temperature and drought are related variables, and record warming led to severe to extreme drought conditions in much of the western states in recent years. Figure 11, taken from the United States Drought Monitoring (USDM) program, depicts the situation this past summer. If fossil fuel GHG emissions are not rapidly phased out and their atmospheric excess removed, then drought extent and severity will increase. The IPCC observed in 2018, as an implication of this, that about 61 million additional people in Earth's urban areas would be exposed to severe drought in a 2°C warmer world. [Relatedly, up to 270 million more people are projected to be exposed to increases in water scarcity in 2050 with warming at 2 ºC.[62]] Most recently, the IPCC observed that, with continued fossil fuel-driven warming, there will be an increase in the frequency and intensity of agricultural and ecological drought events. Where a drought occurred once in 10 years on average across drying regions in a climate without human influence, the IPCC anticipates that a drought of higher severity likely will occur 2.4 times more frequently in a 2°C world, and more than 4 times more frequently in a 4°C world.

Because wildfire is driven by such drought, in combination with heat, the risk of wildfire also is anticipated to be far higher in a 2°C warmer world than with warming of "only" 1.5 ºC.

61 Available at https://www.mtbs.gov/viewer/index.html. Visited August 18, 2021.

62 Again, from NASA here: https://climate.nasa.gov/news/2865/a-degree-of-concern-why-global-temperatures-matter/.

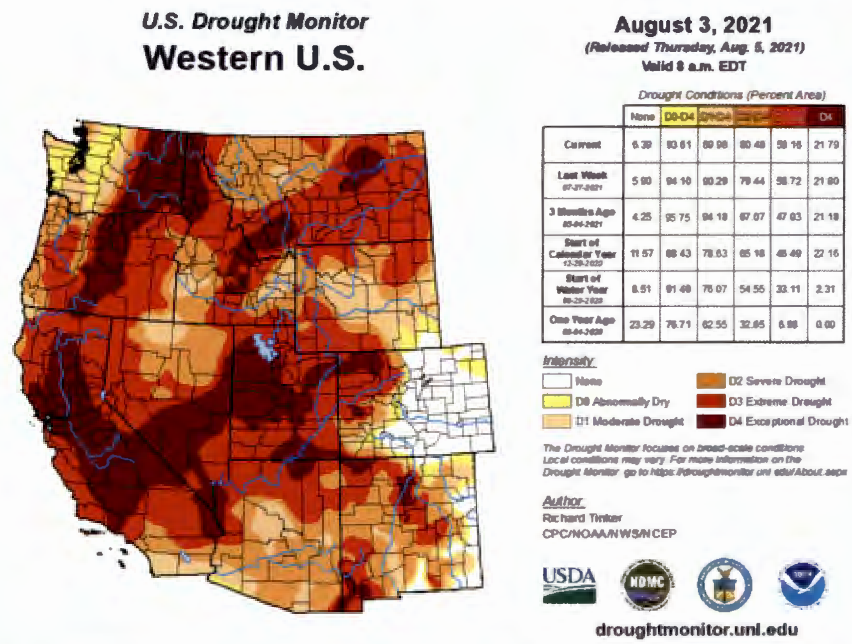

Fig. 11. Image from National Drought Mitigation Center.[63]

As USDM observed,[64] the share of the Western US in "moderate to exceptional drought peaked at 90.3 percent on July 27, 2021. This value exceeded the previous peak in the 21-year USDM record that occurred in August and September of 2003. The percent area in extreme to exceptional drought (D3-D4) peaked at 59.5 percent on July 20, which is a USDM record. This is due to record low precipitation and excessively hot temperatures during the last several years."

Similarly, conditions during 2020 led NOAA to note, in its annual drought report for that year,[65] that:

> *The increasing temperature trend . . . means more evapotranspiration is occurring than before and this makes the dry spells, when they happen, result in increasingly more intense droughts. . . [E]xcessive evapotranspiration and lack of rain dried soils across the West, with two-thirds or more of the topsoil moisture dry or very dry across most western states by the end of October. Several large wildfires sparked to life in parts of the West in the spring, with the wildfires spreading during June. They were burning across all of the western states during the summer and fall, and some had yet to be extinguished in California as the year ended. Nationwide, over 10 million acres burned in 2020, which is more than the 2010-2019 average of 6.79 million acres and the largest acreage consumed in the U.S. since at least 2000. The three largest wildfires in Colorado history, and five of the six largest wildfires in California history, occurred in 2020.*

63 Available at https://www.ncdc.noaa.gov/sotc/drought/202013#national-overview. Visited August 18, 2021.

64 *Id.*

65 National Centers for Environmental Information, Drought -Annual 2020. https://www.ncdc.noaa.gov/sotc/drought/202013#national-overview

While 2020 did not set the drought record for the western states as a whole, it did set wildfire records for west *coast* states.[66] The number and scale of California wildfires were unprecedented in that state's history, with its largest, the August Complex Fire, encompassing more than 1million acres – a gigafire.[67] In Oregon, fires broke out in areas not normally prone to fire, but many of these had experienced exceptional drought, and fire swept through them propelled by rare easterly winds during Sept. 8 to 9, 2020. A number of communities were simply wiped out. *See* Figure 12.

Fig. 12: Photos by wildlands ecologist Dominick DellaSala, Sept. 18, 2020, Talent, Oregon. (The trees weathered the fire storm better than many homes.) Used with permission.

The Western 2021 Fire Season was severe as the region was subjected to one heat wave after another – in some places, even before summer officially began.[68] Perhaps the worst of these resulted in part from the parking of a high-pressure system over the Pacific Northwest, a development caused in part by an undulation of the "normally" more tightly-wound jet stream. As Petitioner Hansen and his colleague Makiko Sato wrote in their *June 2021 Global Temperature Update:*

> *The jet stream is driven by the temperature gradient from middle to polar latitudes. An especially cold Arctic tends to cause a strong, tightly wound jet stream. However, an increased greenhouse effect warms the Arctic more than mid-latitudes, reducing the temperature gradient, thus slowing the jet stream and allowing it to have more extreme waggles. This was likely a contributing factor in the Pacific Northwest heat wave.*[69]

In the absence of climate change, according to the credible research of one rapid attribution analysis team, the extreme heat wave that followed would have been "virtually

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66 *See Record Wildfires on the West Coast Are Capping a Disastrous Decade*, New York Times, Sept 24, 2020 (usefully showing time lapse images from Sept. 6-11).

67 *See California wildfires spawn first 'gigafire' in modern history* at https://www.theguardian.com/us-news/2020/oct/06/california-wildfires-gigafire-first

68 *Climate Change Batters the West Even Before Summer Officially Begins*, NY Times, June 17, 2021 (updated June 27, 2021) at https://www.nytimes.com/2021/06/17/climate/wildfires-drought-climate-change-west-coast.html?action=click&module=RelatedLinks&pgtype=Article.

69 http://www.columbia.edu/~mhs119/Temperature/Emails/June2021.pdf. *See also* Jacob and Reeder, "The North American heatwave shows we need to know how climate change will change our weather," The Conversation (July 2, 2021) at https://theconversation.com/the-north-american-heatwave-shows-we-need-to-know-how-climate-change-will-change-our-weather-163802.

impossible."[70] Record-eclipsing temperature followed: Lytton, British Columbia (121 °F on June 29, 2021); Portland, Oregon (116 °F on June 28); Seattle, Washington (108 °F on June 28); Lewiston, Idaho (115 °F on June 29); and Missoula, Montana (101 °F on June 29). Heat-related deaths were estimated in the hundreds for humans, in the billions for animals.[71]

A series of fires ensued, some engulfing small towns from British Columbia to Northern California. The plumes of smoke from western wildfires were transported thousands of miles, creating the worst air quality ever experienced in many locations. According to the Swiss air quality measuring company, IQAir, Denver, Colordo experienced the worst air quality in the world, on August 7, 2021, with an air quality index (AQI) of 167 due to smoke produced mostly in California. The Dixie fire burned over 963,000 acres of forest[72] – rendering it the largest single fire in California recorded history. Of California's ten largest fires in recorded history, nine have occurred within the most recent decade while eight have been within the last four years.[73]

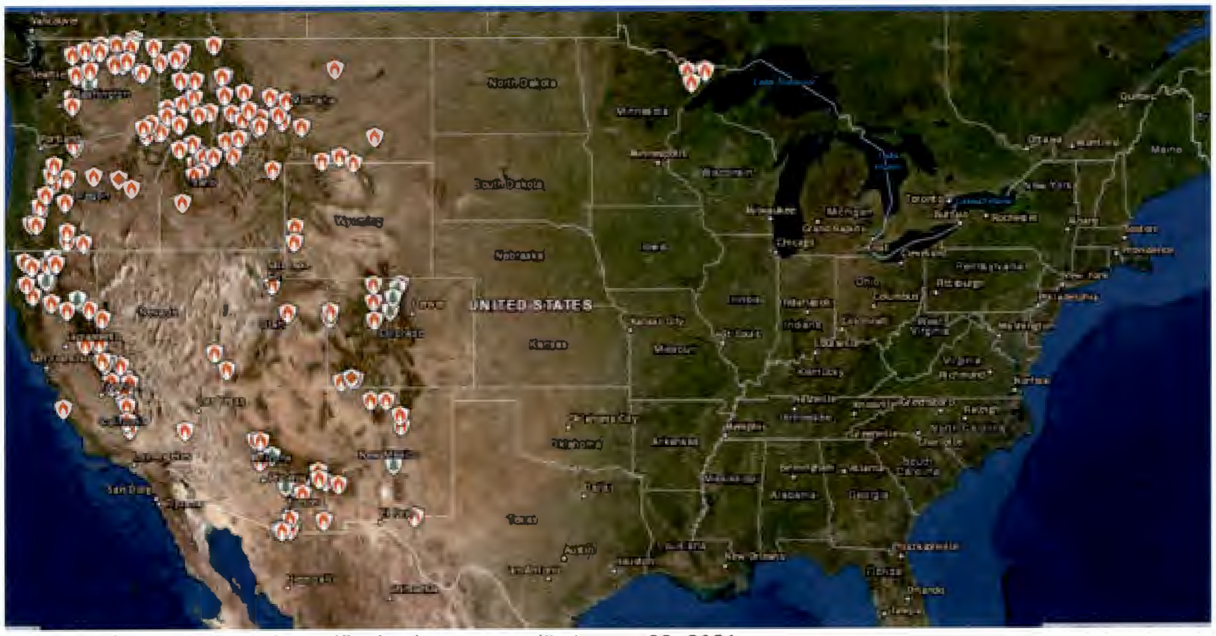

Figure 13: From https://inciweb.nwcg.gov/#. August 22, 2021.

[70] Philip et al, *Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021*, available at https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/.

See also AR6 IPCC Physical Science Basis report, sections 11.8.3 and 12.4.3.2 noting that "the attribution of extreme weather events has emerged as a growing field of climate research with an increasing body of literature. It provides evidence that greenhouse gases and other external forces have affected individual extreme events by disentangling anthropogenic drivers from natural variability." The IPCC finds "medium confidence" that "weather conditions that promote wildfires have become more probable in southern Europe, northern Eurasia, the USA, and Australia over the last century."

[71] Stephen Leahy, *If the Hardiest Species Are Boiled Alive, What Happens to Humans?* The Atlantic. July 31, 2021.

[72] The Dixie Fire, InciWeb, at https://inciweb.nwcg.gov/incident/7690/.

[73] CalFire, Top 20 Largest California Wildfires, Aug. 20, 2021.

(B) Sea-level Rise

Fossil fuel emissions-driven sea-level rise clearly presents an "unreasonable" as well as an "imminent" risk of serious or widespread injury to health or the environment.[74]

As the planet warms, sea level rises due to two factors: (a) thermal expansion of seawater, and (b) melting of glaciers and ice sheets.

Thermal expansion is estimated to account for 50% of the observed sea level rise since 1971, with melting of glaciers and ice sheets contributing 22% and 20% respectively.[75] Like temperature, sea level can be measured with high accuracy. We have tidal gauge measurements dating back to 1880, and more accurate satellite measurements unaffected by changes in land elevations beginning in 1993. These indicate that there has been a rise in average sea level by a total of 15-25 cm (~6-10 in) during the period 1901-2018, as shown in Figure 14.

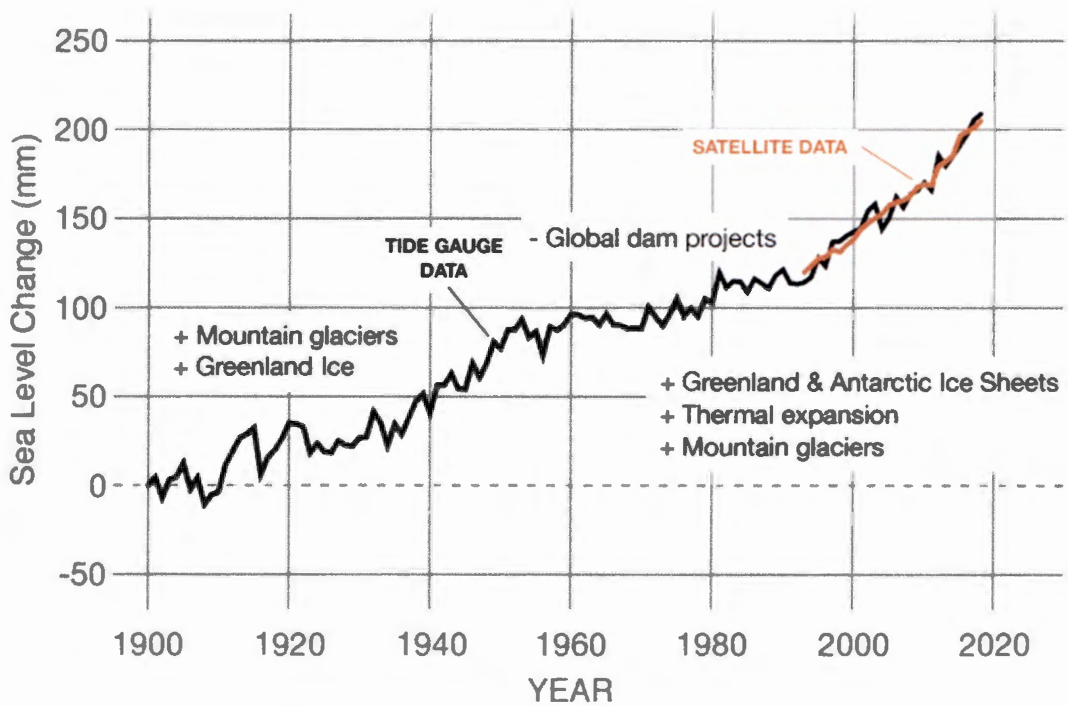

Fig. 14. Satellite observations of sea level rise from 1993 to 2021. Data Source: Frederikse et al. (2020).[76] From: https://climate.nasa.gov/vital-signs/sea-level/

The rate of sea level rise has been accelerating over at least the past century by about 0.1 mm/yr. The average rate of sea level rise increased from 1.3 mm/yr during the period 1901 to 1971 to 1.9 mm/yr during the period 1971-2006 and further increased to 3.7 mm/yr, during the period 2006-2018. In fact, the IPCC finds with high confidence that the global mean sea level

[74] Comparing 15 USC §2605(a) ("unreasonable risk of injury to health or the environment") with 15 USC §2606(f) ("imminent and unreasonable risk of serious or widespread injury to health or the environment").

[75] IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. SPM-6. Changes in land water storage account for 8%. *Id.*

[76] Frederikse *et al.*, The causes of sea-level rise since 1900, *Nature*, vol 584, pp. 393-397 (2020), at https://www.nature.com/articles/s41586-020-2591-3/.

has risen faster since 1900 than during any preceding century in the last 3000 years.[77] Even for IPCC's very low GHG emission scenario (SSP1-1.9), total sea level rise is predicted to reach 32 to 62 cm (12.6 to 24.4 in) by the end of this century. This 1-2 feet of sea level rise will be difficult enough for future generations to contend with, but even to keep sea level within that range requires drastic cuts in current GHG emissions. Other scenarios that include a range of likely future emissions if drastic cuts are not made predict sea level rises in the range of about 500 to 1,000 cm, or 1.6 to 3.5 ft.

While the IPCC assessment of sea-level rise is quite dire, Petitioners aver, nonetheless, that its reports underestimate the actual extent to which sea-level is likely to rise. A 2016 study by Petitioner Hansen and 18 other climate scientists, titled "Ice melt, Sea level rise and Superstorms" (hereafter, Ice Melt) warned, *inter alia*, that based on an analysis of paleoclimate evidence, ongoing observations, and modeling, continued high fossil fuel emissions may yield nonlinear ice mass loss sufficient to raise sea level several meters within 50-150 years.[78]

The major implications of the Ice Melt study include that (1) the (then) widely accepted target "of limiting global warming to 2°C . . . does not provide safety," (2) that "global surface air temperature, although an important diagnostic, is a flawed metric of planetary health," because faster ice melt has a cooling effect for a substantial period [so that] Earth's energy imbalance is a more fundamental climate diagnostic, and (3) the existence of amplifying feedbacks present a "real danger that we will hand young people and future generations a climate system that is practically out of their control."[79]

The described amplifying feedbacks include reduced Southern Ocean bottom water formation (and thus retention of subsurface heat), a slow-down and risk of shutdown of the Southern Ocean and Atlantic Meridional Overturning Circulations (SOMC and AMOC), increased temperature gradients and storminess in the North Atlantic region, as well as the potential for nonlinear disintegration of major ice sheets in West Antarctica and Greenland. Figure 15 depicts some of these feedbacks. In light of these additional "real dangers" the Ice Melt scientists concluded that "we have a global emergency [and that] fossil fuel CO_2 emissions should be reduced as rapidly as practical."[80] Petitioners here strongly concur with that conclusion.

[77] *Id.* at p. SPM-9.

[78] Hansen *et al.,* Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2°C global warming could be dangerous, Atmos. Chem. Phys., 16, 3761–3812 (2016) at www.atmos-chem-phys.net/16/3761/2016/. Hereinafter, "Ice Melt."

[79] *Id.*

[80] *Id.* at p. 3801.

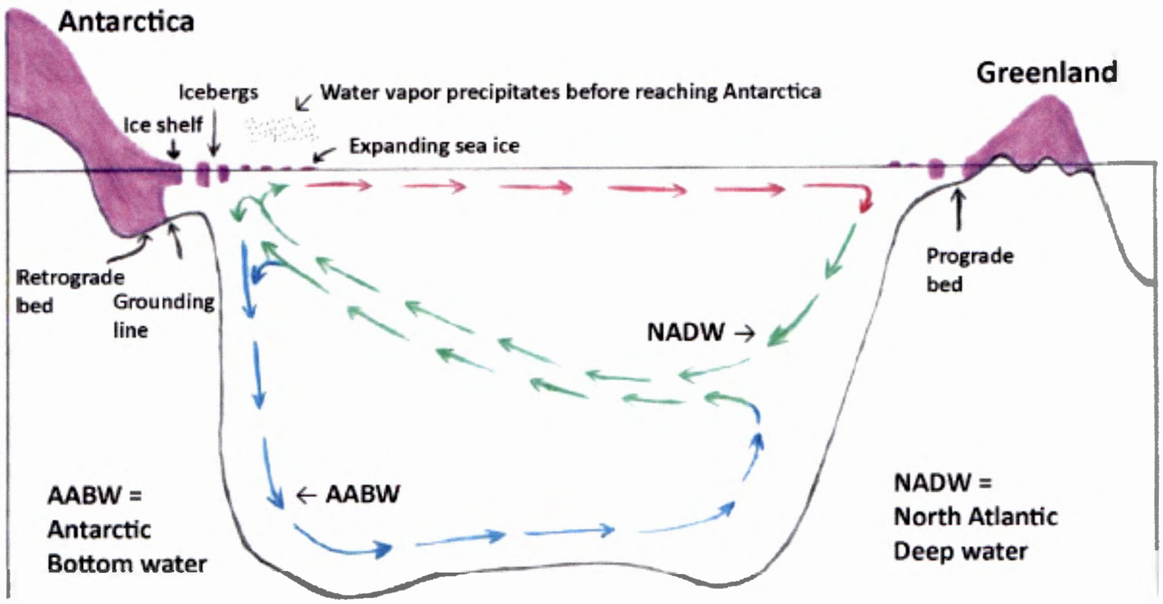

Fig. 15: Schematic of stratification and precipitation amplifying feedbacks. Increased freshwater flux reduces surface water density, reducing AABW formation, trapping NADW heat, and increasing ice shelf melt.

Present and imminent impacts from continued sea-level rise include the loss of habitable land and frequent flooding due to higher tides and bigger storm surges. River deltas in Africa and Asia, and low-lying small island nations such as Maldives, Tuvalu, Kirabati and Fiji, are immediately vulnerable to *any* additional sea level rise. The highest elevation in all of the Maldives – which consists of 26 atolls, supports a population of ~ 500,000 people, and has an average elevation of 1.8 m (6 ft) – is only 2.4 meters (7.9 ft). Thus, at current rates of sea level rise – even if rapid ice sheet disintegration is somehow staved off – the Maldives will be uninhabitable by 2100, as is true of many other island nations where tidal flooding is becoming more frequent.

Already five of the Solomon Islands, ranging in size from one to five hectares have been completely submerged due to sea level rise,[81] and king floods in the Marshall Islands capital Majuro that historically occurred every few decades are now occurring multiple times per decade. Worldwide, approximately 600 million people live directly on the coast, and 267 million people live on land less than 2 meters above sea level.[82] Further increases in sea level, especially when combined with increased storm intensity caused by global warming, will result in loss of habitable and agricultural land, forcing tens to hundreds of millions of people to migrate further inland and reducing food production.

US citizens and residents are also at great present and imminent risk due to sea level rise. As of 2014, 127 million people or 40% of the U.S. population lived in coastal counties, and effects of sea level rise are already being felt in many of these densely populated areas. Hurricane Katrina, one of the most damaging storms in U.S. history, caused $170 billion in

[81] Klein, *Five Pacific islands vanish from sight as sea levels rise*, *New Scientist*, 9 May 2016, available at https://www.newscientist.com/article/2087356-five-pacific-islands-vanish-from-sight-as-sea-levels-rise/.

[82] Hooijer and Vernimmen, Global LIDAR land elevation data reveal greatest sea-level rise vulnerability in the tropics, *Nature Communications*, vol. 12, p. 3592 (2021) at https://www.nature.com/articles/s41467-019-12808-z/.

damages, resulted in the displacement of hundreds of thousands of people, and killed more than 1,800. A 2013 study shows that the storm surge from Katrina would have been 15 to 60 percent lower for sea level conditions of 1900.[83] Similarly, the storm surge flooding of New York City and the New England coastline due to Superstorm Sandy in 2012 was amplified by the 12-inch rise in sea level, as measured by the tidal gauge at Battery Park, during the past century.[84]

A recent study estimates future flood losses stemming from already-realized sea level rise.[85] Miami ranks only slightly behind Guangzhou, China as the most vulnerable city worldwide in terms of risk of average annual loss of property from storm-related flooding, and New Orleans ranks just behind Guangzhou in terms of estimated annual loss as a percentage of GDP of that city. Three US cities – Miami, New York City and New Orleans – account for 31% of global aggregate losses from impacts on the 136 most vulnerable cities, due their high wealth and low protection level. With an assumption of 20 cm of additional sea level rise by 2050 and no additional adaptation, this study predicted aggregate losses due to flooding in excess of $1 trillion per year in the US. Although not meant to be predictive, the analysis illustrated the severe risk of continued sea-level rise to the United States.

The IPCC reports that if fossil fuel-driven warming is allowed to reach 2.0 ºC, then at least 10 million more people may be subjected to "sea-level rise greater than 0.66 feet (0.2 meters) [and will ensure] increased coastal flooding, beach erosion, salinization of water supplies" and other impacts on humans and ecological systems.

Petitioners here adopt the global emergency assertion of the *Ice Melt* authors in support of their request to EPA to restrict and remove continuing and legacy GHG emissions, and phase-out fossil fuels, under TSCA. In particular, the virtual certainty of accelerating sea level rise, if GHG emissions are not rapidly reduced, as described in the consensus IPCC report itself, fully establishes an actual (as well as imminent) and unreasonable risk of serious or widespread injury to health or the environment. The "real danger" of nonlinear ice sheet disintegration (with its correlated rapid sea level rise on the order of several meter) and likely increased superstorm activity supports the view that continued unabated fossil fuel emissions may prove calamitous – and thus an "existential" threat, to appropriate President Biden's term – a threshold well beyond that required to be established under TSCA.

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[83] Irish et al., Simulations of Hurricane Katrina under sea level and climate conditions for 1900, *Climatic Change*, vol. 122, pp. 635-649 (2014), at https://doi.org/10.1007/s10584-013-1011-1/.

[84] Kahn, B. Superstorm Sandy and Sea Level rise, NOAA Climate.gov (2020), at https://www.climate.gov/news-features/features/superstorm-sandy-and-sea-level-rise/.

[85] Hallegatte et al., Future flood losses in major coastal cities, *Nature Climate Change*, vol. 3, pp. 802-806 (2013) at https://www.nature.com/articles/nclimate1979/.

(C) Extreme Weather

1. Predicted Changes in Frequencies of High Temperature, Precipitation and Drought

Increased temperature over land results in increased evaporation of water. In many regions this results in a reduction of soil moisture and eventually drought, while in other regions the increased water vapor in the atmosphere results in increased precipitation. According to the IPCC,[86] the increase in average global temperature of about 1.2°C that we are experiencing so far is already resulting in increased frequencies of extreme temperature events, heavy precipitation events, and agricultural and ecological droughts, as shown in Figure 16.

Hot temperature extremes that historically (1850-1900) occurred once every 10 years now occur 2.8 times more often. For warmings of 1.5°C, 2°C and 4°C, such events are predicted to occur 4.1 times, 5.6 times and 9.4 times more frequently; that is, a temperature event that occurred previously only once every ten years would occur almost every year on average if the planet were allowed to warm by 4°C. And those extreme temperature events would be even more severe. As well, ten-year extreme temperature events are now 1.2°C higher than in the last half of the 18th century, with temperature records continually being set at locations around the world. As seen in Figure 16, global warmings of 1.5°C, 2°C and 4°C are predicted to result in 10-year events that are 1.9°C, 2.6°C and 5.1°C higher than historical values.

The effects of global warming on 50-year events are greatly amplified over that of 10-year events. For example, in the case of a 2°C warming of the planet, a 50-year event is predicted to occur 13.9 times more frequently, meaning that humans and the livestock, crops and natural ecosystems we depend on will experience what was a 50-year event once every 3.6 years on average. For a catastrophic warming of 4°C, 50-year events would occur 39 times more often or almost every year.

As also summarized in Figure 16, increases in the frequencies of heavy precipitation and droughts are predicted to increase further with increased average global temperatures. Ten-year events for heavy precipitation have already shortened to 7.7 years and will further decrease to 6.7, 5.9 and 3.7 years for warmings of 1.5°C, 2°C and 4°C, respectively. Ten-year agricultural and ecological droughts are estimated to already be occurring once every 5.9 years and those periods are predicted to be reduced to 5, 4.2 and 2.4 years for 1.5°C, 2°C and 4°C warmings. In the same way that extreme temperature events will also be hotter, the historically 10-year events will be wetter for heavy precipitation events and drier for drought events.

[86] IPCC AR6 WGI, Climate Change 2021, The Physical Basis, pp. SPM-20-24.

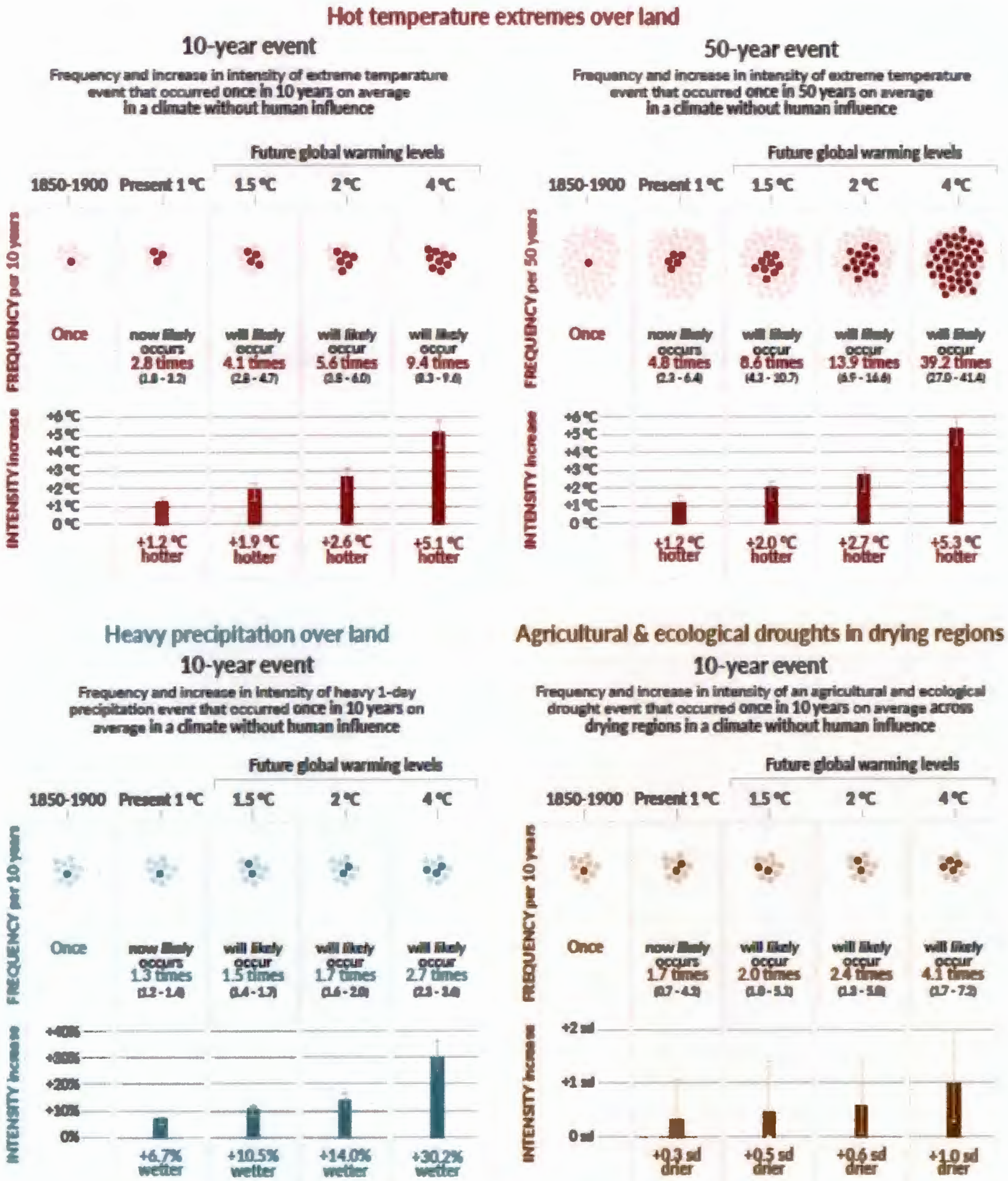

Figure 16. Projected changes in the intensity and frequency of hot temperature extremes over land, extreme precipitation over land, and agricultural and ecological droughts in drying regions. Figure SPM.6, p. SPM023 of the IPCC AR6 report, *Climate Change 2021, The Physical Science Basis*, 2021.

The 4°C scenario would be simply catastrophic in terms of high temperature extremes and heavy precipitation events that lead to flooding and droughts.

The 2015 Paris Agreement[87] committed signatory nations, including the US, to hold the increase in the global average temperature "to well below 2°C above pre-industrial levels" and to pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."

Clearly, 1.5°C is highly preferable to 2°C, but even 1.5°C is unacceptable considering that a large fraction of the population would then experience extreme temperature events once every 2.5 years. Indeed, Petitioners aver that it is necessary not only to phase out fossil fuel emissions, but also to remove a large fraction of the excess greenhouse gases from the atmosphere in order to return the planet to a temperature sustainable for human life, agriculture and the many delicate ecosystems on which we depend.

2. Changes in Frequency and Severity of Tropical Storms

The heat content of air, land and oceans and its distribution around the planet drive the weather we experience. Uneven heating results in pressure differences that produce winds. Because of the Coriolis effect, winds near the surface of our rotating planet result in cyclones that, depending on intensity and spatial scale, become tropical storms, hurricanes/typhoons, waterspouts and tornadoes. Water vapor plays a key role in the formation and intensities of storms, providing a means for heat to be transported from the surface of the ocean to the atmosphere. Evaporation of water at the surface provides water vapor to the atmosphere with potential energy (latent heat) that can be released again as kinetic energy (sensible heat) as it rises, cools, and condenses back to liquid water. The fundamental physics that drives weather is well understood: greater energy in the land/water/air system results in larger pressure differentials, more water vapor in the atmosphere, an an intensification of weather processes.

Global climate models find that although about half of the equilibrium response to a climate forcing, such as a radiative forcing due to added greenhouse gases, occurs within a few years, the remaining response is "recalcitrant"[88] – requiring many decades or even centuries for the complete response. This is primarily due to the slow mixing of the oceans, which act analogous to a capacitor in an electrical circuit, storing the excess energy provided by Earth's energy imbalance. Although the oceans serve to reduce the immediate climate response to some degree, they also ensure that it will take decades to centuries for the climate system to return to its balanced state – even after much of the excess radiative forcing due to greenhouse gases is removed.

Because many of the climate consequences for the excess energy we have already added to the oceans lie in the future, and because of the difficulty in detecting the climate change signal above the natural noise of weather, we must rely on our predictive models – taking into account our best understanding of the geophysical processes that drive them. Current model studies predict that although tropical cyclones may be fewer in number they will have increased intensity, result in increased rainfall and produce stronger storm surges.[89] Such changes are

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[87] As described by the United Nations, "[t]he Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016." https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

[88] Held, et al., Probing the fast and slow components of global warming by returning abruptly to preindustrial forcing, *Journal of Climate*, vol. 23, pp. 2418-2427 (2018), at https://journals.ametsoc.org/view/journals/clim/23/9/2009jcli3466.1.xml/.

caused primarily by rising sea temperatures, which result in higher water vapor content of the atmosphere. The condensation of lofted water vapor releases the latent heat that drives the winds of cyclones. The most recent U.S. National Climate Change Assessment concluded that "increases in greenhouse gases and decreases in air pollution have contributed to increases in Atlantic hurricane activity since 1970."[90] The amplification of cyclone strength from the decrease in certain air pollutants – in particular, SO_2, NO and NO_2 – reflects a partial unleashing of the full radiative forcing of greenhouse gases. Accordingly, as we reduce aerosol pollution to improve human health we also eliminate their cooling effect. This in turn allows the fuller warming effect of GHG emissions to be expressed. [91]

Although hurricane frequency may not have changed with statistical certainty, there is evidence that late-season Atlantic hurricanes are occurring more often. During the 140-year period of 1851-1990, only 30 hurricanes formed in the Atlantic on or after November 1, for a total of less than one late season hurricane every five years, and only four Category 3 or stronger late-season hurricanes occurred in those 140 years, with only three Caribbean hurricanes. However, during the 26-year period ending in 2017, there were 17 late-season hurricanes (only five expected based on historical data), with six in the Caribbean, four of which were Category 3 or above.[92]

The science of weather event attribution is rapidly advancing, and for two main reasons: "[1] the understanding of the climate and weather mechanisms that produce extreme events is improving, and [2] rapid progress is being made in the methods that are used for event attribution."[93] The IPCC now attributes at least the increases in precipitation from such storms to human activities with "high confidence." For example, there is high confidence that anthropogenic climate change contributed to extreme rainfall during hurricane Harvey and other intense tropical storms.[94]

Extreme weather events already cause enormous annual loss of life and property in the U.S., so that any significant potential amplification is of grave concern. During the decade 2010-2019, the U.S. sustained 258 weather and climate disasters where the overall damage costs reached or exceeded $1 billion, and the cumulative cost for those events exceeded $1.75 trillion.[95] These billion-dollar events included drought (26), flooding (32), freezes (9), severe

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89 Walsh et al., *Tropical cyclones and climate change*, *Tropical Cyclone Research and Review*, vol. 8, pp. 240-250, at https://www.sciencedirect.com/science/article/pii/S2225603220300047?via%3Dihub/.

90 *Fourth National Climate Assessment*, Chapter 2: Our Changing Climate (2018), at https://nca2018.globalchange.gov/chapter/2/.

91 Hansen and Sato, *July Temperature Update: Faustian Payment Comes Due* (13 August 2021) at http://www.columbia.edu/~mhs119/Temperature/Emails/July2021.pdf.

92 Masters, November Atlantic hurricane outlook: The season is not over yet, *Weather Underground*, 1 November 2017, at https://www.wunderground.com/cat6/november-atlantic-hurricane-outlook-season-not-over-yet/.

93 National Academies of Sciences Committee on Extreme Weather Events and Climate Change Attribution, *Attribution of Extreme Weather Events in the Context of Climate Change* (2016) at https://climatemodeling.science.energy.gov/system/files/private/meetings/attachments/Sobel_Extreme_Weather_Events.pdf

94 IPCC AR6 WGI, Climate Change 2021, The Physical Basis, p. TS-74.

95 Smith, 2010-2019: A landmark decade of U.S. billion-dollar weather and climate disasters, NOAA National Centers for Environmental Information, at https://www.climate.gov/news-features/blogs/beyond-data/2010-2019-landmark-decade-us-billion-dollar-weather-and-climate/.

storms (113), hurricanes (44), wildfires (17) and winter storms (17). It is especially noteworthy that the costs of inflation-adjusted billion-dollar disasters have increased steadily over the past four decades, averaging \$13B, \$27B, \$51B and \$80B per year during the decades of the 1980s, 1990s, 2000s and 2010s, respectively. Associated fatalities have increased as well, averaging 281, 217, 305 and 521 annually in each of those decades. The costs of severe weather events in terms of property and life clearly correlate strongly with the observation of increasing average global temperature. The observed trend over the past four decades agrees with the expectation that increasing the energy content of the land/ocean/atmosphere system will increase the frequency and intensity of severe weather events.

We note that the conclusions of the NAS and IPCC are based on climate modeling and observations of trends in severe weather in recent decades. They do not take into account the possibility of much more far-reaching consequences that may result from nonlinearities in the climate system, as has been proposed by Petitioner Hansen and colleagues (*Ice Melt*) based on paleoclimate studies coupled with climate system modeling discussed above in reference to increasing sea levels. With respect to the mechanism described above in Figure 12, freshwater released to the ocean by melting of West Antarctic and Greenland ice sheets results in a slowdown and possibly stopping of the thermohaline circulation in the vicinity of Antarctica due to the lower density of freshwater. This "stratification" process induces amplifying feedbacks that increase subsurface ocean warming and ice shelf melting. Another effect is expansion of sea ice off Antarctica as a result of the colder surface water, causing increased precipitation over the ocean and decreased precipitation over the ice sheet.

The transfer of ice and freshwater to the ocean could raise sea level by several meters. This mechanism could explain the 6-9 m sea level rise that occurred in the prior interglacial period. Near the end of that period (Eemian), 130,000-115,000 years ago, there is evidence of much larger global temperature gradients with resulting extreme storms while Earth was warmer by less than 1°C than it is today. The geologic evidence for the superstorms near the end of the Eemian period are reviewed in *Ice Melt* paper and include [1] megaboulders averaging 100 tons that were plucked from seaward middle Pleistocene outcrops and washed onto a younger Pleistocene landscape, [2] wave run-up deposits that reach heights of over 40 m along hundreds of kilometers of older built-up dune ridges in the Bahama Islands, and [3] chevron-shaped sand ridges standing ~5-15 m across several kilometers of broad, low-lying platforms or ramps throughout the Atlantic-facing, deep-water margins of the Bahamas.

A critical conclusion of the *Ice Melt* authors is that even a "... 2°C global warming above the preindustrial level could be dangerous." The study suggested that ice mass loss from the most vulnerable ice could rise exponentially rather than linearly in which case doubling times of 10, 20 or 40 years will yield multi-meter sea level rise in about 50, 100 or 200 years, respectively.

VI. Ocean-Based Risks – A Short Survey

(A) Acidification

There is clear consensus among leading national and international scientific bodies that anthropogenic CO_2 causes changes in ocean chemistry.

For one, the IPCC, comprehensively reviewing the evidence, determined in 2014 and in 2021 that human sources of CO_2 have caused a significant decline in surface ocean pH, with further increases in atmospheric CO_2 "virtually certain to further acidify the Ocean and change its carbonate chemistry."[96] *See* Figure 17 showing a slowing of acidification only under the most stringent of decarbonization scenarios considered recently by the IPCC.

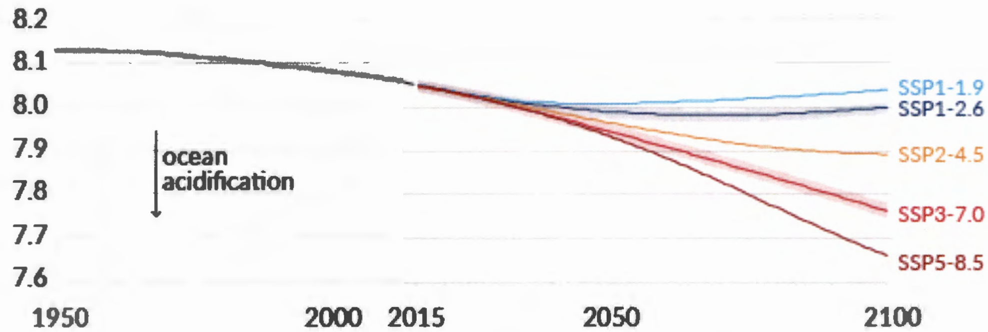

Fig. 17: Global ocean surface pH. Source: IPCC AR6 (2021) SPM-29.

The concern by the international scientific community is long-standing. More than a dozen years ago, for instance, 90 national academies of sciences, including that of the United States, warned that "[t]he average pH of oceanic surface waters [had] been lowered by 0.1 units since the pre-industrial period, representing a 30% increase in hydrogen ion activity," producing a situation in which carbonate ion concentrations – "needed by many marine organisms, such as corals and shellfish, to produce their skeletons, shells and other hard structures" – "are now lower than at any other time during the last 800,000 years."[97]

The Interacademy Panel concluded that CO_2 has increased ocean acidity with "potentially profound consequences for marine plants and animals" including severe threats to coral reefs, polar ecosystems, and a likely reduction in marine food supplies.[98] The National Research Council also acknowledges that "existing data support a growing consensus in the research community that most documented responses to acidification reflect impairment of physiological

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[96] Hoegh-Guldberg, O., R. Cai, E.S. Poloczanska, P.G. Brewer, S. Sundby, K. Hilmi, V.J. Fabry, and S. Jung, 2014: The Ocean. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. at 1674. *See also*, Rhein, M. et al., 2013. Observations: Ocean. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, at what page? And IPCC, 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, SPM-6.

[97] Interacademy Panel, 2009. IAP Statement on Ocean Acidification at https://oceanfdn.org/sites/default/files/International%20Academy%20Panel%20Statement%20on%20Ocean%20Acidification.pdf.

[98] *Id.*

capacity or performance" for marine life with likely substantial socioeconomic impacts.[99] The U.S. National Climate Assessment concluded that ocean acidification will alter marine ecosystems in dramatic ways including threatening coral reef habitats, inhibiting the ability of marine organisms to form their shells or skeletons[100] and causing reduced growth and survival of shellfish in all regions.[101]

EPA itself has already concluded that greenhouse gases, including CO_2 and CH_4, endanger public health and the environment in part because of ocean acidification,[102] and that "ocean acidification presents a suite of environmental changes that would likely negatively affect ocean ecosystems, fisheries, and other marine resources." [103]

That fossil fuel company-traced emissions make a huge contribution to ocean acidification is made clear by recent research by Petitioner Heede and colleagues.[104] They found that nearly two-thirds of all industrial carbon dioxide and methane emissions between 1880 and 2010 can be traced to the products of 83 large producers[105] of coal, oil, and natural gas, and 7 cement manufacturers. Ekwurzel et al.[106] found that between 1880 and 2010, emissions traced to these 90 largest industrial carbon producers contributed ~57% of the rise in atmospheric CO_2, 42%–50% of the rise in global mean surface temperature, and approximately 26%–32% of the rise in global sea level. Similarly, because the global surface pH is a function of the atmospheric concentration of carbon dioxide,[107] researchers led by R. Licker,[108] using the Heede data, quantified the contribution of fossil fuel producers to global-scale ocean acidification and found that "emissions traced to the 88 largest industrial carbon producers from 1880–2015 and 1965–2015 have contributed ~55% and ~51%, respectively, of the historical 1880–2015 decline in surface ocean pH. The latter 1965–2015 period, we note, also captures the timeframe in which

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99 National Research Council, 2013. Review of the Federal Ocean Acidification Research and Monitoring Plan Committee on the Review of the National Ocean Acidification Research and Monitoring Plan ; Ocean Studies Board ; Division on Earth and Life Sciences ; National Research Council.

100 https://nca2018.globalchange.gov/chapter/9/ Last accessed 2/12/21

101 Doney, S. et al., 2014. Ch. 24: Oceans and Marine Resources. In Climate Change Impacts in the United States: The Third National Climate Assessment, pp.557–578.

102 EPA, Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act 80 (Dec. 7, 2009).

103 75 Fed. Reg. 13538 (Mar. 22, 2010).

104 Richard Heede et al., Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010 Clim. Change.

105 These producers include investor-owned, state-owned, and nationalized companies.

106 Ekwurzel B, Boneham J, Dalton M W, Heede R, Mera R J, Allen M R and Frumhoff P C 2017 The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers Clim. Change 144 579–90.

107 National Academies of Sciences, Engineering and Medicine 2017 Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (Washington DC: The National Academies Press).

108 R. Licker et al, Attributing ocean acidification to major carbon producers
2019 Environ. Res. Lett. **14** 124060. Available at https://iopscience.iop.org/article/10.1088/1748-9326/ab5abc.

the major fossil fuel companies became aware that continued emissions from the intended use of their products imposed significant climate risks on public health and the environment.[109]

Ocean acidification already constitutes an unreasonable, serious and widespread injury to the marine environment. The oceans have absorbed CO_2 emitted into the atmosphere from coal and gas-fueled power plants, industrial facilities, internal combustion engine vehicles, cement production, and stemming from land use changes. From 1850 to 2019, 2,400 gigatons of CO_2 were emitted by human activity.[110] Around 950 (and now, ~ 1000) gigatons remain in the atmosphere,[111] with approximately half of the balance taken up by the oceans and the rest by the land.[112] Indeed, each day about 22 million metric tons of CO_2 is taken up by the oceans.[113] This uptake of CO_2 is changing ocean chemistry, causing the oceans to become more acidic. As we have indicated, since the industrial revolution surface ocean pH has declined by 0.11 units on average, corresponding to a 30% increase in acidity.[114, 115, 116] If emissions continue unabated, ocean acidity will increase up to 170% from pre-industrial levels by the end of the century.[117]

Figure 18 illustrates how the pH in the ocean decreases with increasing atmospheric CO_2 concentration. The time series shows atmospheric CO_2 at Mauna Loa (ppmv) and surface ocean pH and pCO_2 (μatm) at Ocean Station Aloha in the subtropical North Pacific Ocean. The increase in oceanic CO_2 over the period of observations is consistent with the atmospheric increase of CO_2 within the statistical limits of the measurements.[118]

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[109] Benjamin Franta, *Early oil industry knowledge of CO_2 and global warming,* Nat. Clim. Change 8 1024 (2018) available at https://www.nature.com/articles/s41558-018-0349-9.

[110] *See* https://www.theworldcounts.com/challenges/climate-change/global-warming/global-co2-emissions/story

[111] Available at https://www.theworldcounts.com/challenges/climate-change/global-warming/global-co2-emissions/story (accessed 4/8/21).

[112] Rhein, M. et al., 2013. Observations: Ocean. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[113] Feely, R.A. et al., 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. Science, 320 (5882), p.1490.

[114] Orr, J. et al., 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437 (7059), pp.681–686.

[115] Caldeira, K. & Wickett, M.E., 2005. Ocean model predictions of chemistry changes from carbon dioxide emissions to the atmosphere and ocean. J. Geophys. Res., 110(C9), p.C09S04.

[116] Because the pH scale is logarithmic a small decrease is a significant change in acidity; for example, a decrease of 0.1 pH is an approximate 30 percent increase in acidity. Can you refresh my mathematics knowledge of this?

[117] IBGP et al., 2013. *Available* at http://www.igbp.net/publications/summariesforpolicymakers/summariesforpolicymakers/oceanacidificationsummaryforpolicymakers2013.5.30566fc6142425d6c91114.html.

[118] Feely, R.A., Doney, S. & Cooley, S., 2009. Ocean acidification: Present conditions and future changes in a high CO_2 world. Oceanography, 22(4), pp.36–47.

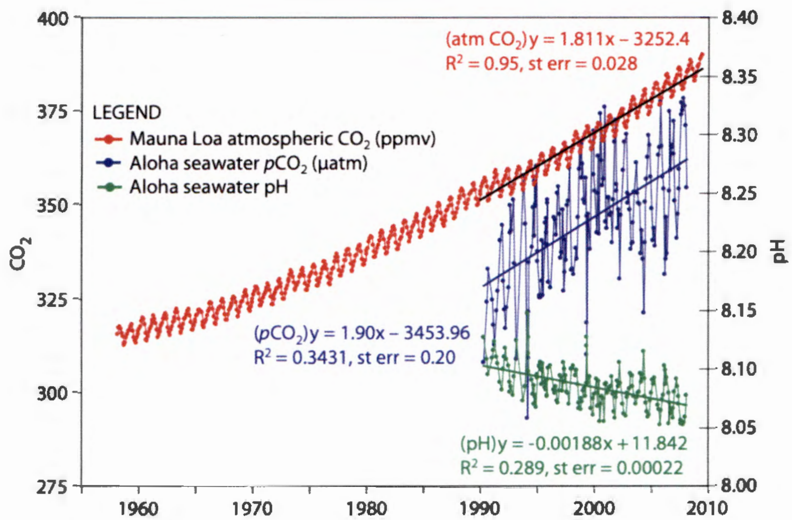

Fig. 18. Time series of atmospheric CO_2 at Mauna Loa (ppmv) and surface ocean pH and pCO_2 (µatm) at Ocean Station Aloha in the subtropical North Pacific Ocean (see inset map).[119]

Anthropogenic ocean acidification exceeds the level of natural variability up to 30 times in some regions.[120] The rate of change in ocean acidity is unprecedented in the past 300 million years, a period that includes four mass extinctions.[121, 122] The seawater chemistry change is an order of magnitude faster than what occurred 55 million years ago during Paleocene-Eocene Thermal (PET) Maximum, which is considered to be the closest analogue to the present. During the PET Maximum period, 96% of marine species went extinct.[123] Regrettably, the current changes in seawater chemistry are irreversible on human timescales.[124]

CO_2 pollution already is changing ocean chemistry and harming the marine environment. Unabated, there will be severe and detrimental impacts on marine ecosystems, the economy, and public health. On the other hand, fossil fuel emissions phaseout coupled with "[a]nthropogenic carbon dioxide removal (CDR) leading to global net negative emissions would lower the atmospheric CO_2 concentration and reverse surface ocean acidification."[125]

In light of their impact on ocean chemistry and associated impacts arising from such acidification, fossil fuel CO_2 emissions and excess atmospheric CO_2 from legacy emissions

[119] Feely, R.A., Doney, S. & Cooley, S., 2009. Ocean acidification: Present conditions and future changes in a high CO_2 world. Oceanography, 22(4), pp.36–47. The increase in oceanic CO_2 over the period of observations is consistent with the atmospheric increase within the statistical limits of the measurements.

[120] Friedrich, T., et al. "Detecting regional anthropogenic trends in ocean acidification against natural variability." Nature Climate Change 2.3 (2012): 167-171. https://www.nature.com/articles/nclimate1372

[121] Honisch, B. et al., 2012. The Geological Record of Ocean Acidification. Science, 335(6072), pp.1058–1063.

[122] Zeebe, R., 2012. History of Seawater Carbonate Chemistry , Atmospheric CO_2 , and Ocean Acidification. Annual Review of Earth and Planetary Sciences, (December 2011), pp.141– 165.

[123] Penn, Justin L., et al. "Temperature-dependent hypoxia explains biogeography and severity of end-Permian marine mass extinction." *Science* 362.6419 (2018).

[124] Royal Society, 2005. Ocean acidification due to increasing atmospheric carbon dioxide. *See also* IPCC AR 6 (2021) SPM-28 ("Changes are irreversible on centennial to millennial time scales in global ocean temperature (very high confidence), deep ocean acidification (very high confidence) and deoxygenation (medium confidence)."

[125] IPCC AR6 (2021), SPM-29. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.

clearly constitute both an unreasonable risk of injury to the environment and health, and also an imminent and unreasonable risk of serious and widespread injury to health of the environment.

(B) Ocean Warming

As climate change warms the Earth, the oceans respond more slowly than land environments.[126] The US National Academy of Science,[127] the Royal Society,[128] 377 members of the National Academy of Sciences, including 30 Nobel laureates,[129] the InterAcademy Partnership,[130] and scientists from around the world have identified increased ocean warming as a threat to marine ecosystems.

As the EPA itself has observed:[131]

> Changes in sea surface temperature can alter marine ecosystems in several ways. For example, variations in ocean temperature can affect what species of plants, animals, and microbes are present in a location, alter migration and breeding patterns, threaten sensitive ocean life such as corals, and change the frequency and intensity of harmful algal blooms such as "red tide" and threaten the ocean's primary producers. Over the long term, increases in sea surface temperature could also reduce the circulation patterns that bring nutrients from the deep sea to surface waters. Changes in reef habitat and nutrient supply could dramatically alter ocean ecosystems and lead to declines in fish populations, which in turn could affect people who depend on fishing for food or jobs.

Perhaps the ocean organism most vulnerable to temperature change is coral. Evidence establishes that reefs will eject their symbiotic algae at even a slight persistent temperature rise. Such "bleaching" slows coral growth, makes them susceptible to disease, and can lead to large-scale reef die-off. EPA has found that coral reefs are "already disappearing due to climate change and other non-climate stressors. Temperature increases and ocean acidification are projected to further reduce coral cover in the future. Without global GHG mitigation, extensive loss of shallow corals is projected by 2050 for major U.S. reef locations."[132]

Other organisms affected by ocean temperature change include krill,[133] an extremely important link at the base of the food chain. Research has shown that krill reproduce in significantly smaller numbers when ocean temperatures rise. This can produce a cascade effect

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[126] Sejas et al, Environmental Research Letters, Volume 9, Number 12, 2014

[127] Climate Change Evidence & Causes, http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf

[128] *Id.*

[129] An Open Letter Regarding Climate Change From Concerned Members of the U.S. National Academy of Sciences, September, 20, 2016

[130] Cheng, Lijing, et al. "Improved estimates of ocean heat content from 1960 to 2015." Science Advances 3.3 (2017): e1601545.

[131] USEPA "Climate Change Indicators in the United States. Accessed 12/22/2020 https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature. Internal citations omitted.

[132] EPA, *Climate Action Benefits: Coral Reefs* (Jan. 19, 2017). EPA Archive Pages.

[133] Flores et al.: Krill and climate change, Mar Ecol Prog Ser 458: 1–19, 2012

by disrupting the life cycle of krill eaters, such as penguins and seals—which in turn causes food shortages for higher predators.

When water heats up, it expands. Thus, the most readily apparent consequence of higher sea temperatures is a rapid rise in sea level, as discussed earlier. Sea level rise causes inundation of coastal habitats for humans as well as plants and animals, shoreline erosion, and more powerful storm surges that can devastate low-lying areas.

As Petitioners also discussed above, we are already seeing the effects of higher ocean temperatures in the form of stronger and more frequent tropical storms and hurricanes/cyclones. Warmer surface water evaporates more, making it easier for small ocean storms to escalate into larger, more powerful systems.[134] [135] These stronger storms increase damage to human structures when they make landfall. They can also harm marine ecosystems like coral reefs and kelp forests.

Warmer sea temperatures are associated with the spread of invasive species and marine diseases. The evolution of a stable marine habitat is dependent upon myriad factors, including water temperature. If an ecosystem becomes warmer, it can create an opportunity where outside species or bacteria, once excluded, can newly thrive, leading to forced migration and even extinction of endemic and specifically-adapted species.

Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns around the world. For example, warmer waters may promote the development of stronger storms in the tropics, which can cause property damage and loss of life. The impacts associated with sea level rise and stronger storms are especially relevant to coastal communities. Figure 19, from EPA's Climate Change Indicators project, shows the change in ocean heat content. The Agency pointedly noted that, "for reference an increase of 1 unit . . . (1×10^{22} joules) is equal to approximately 17 times the total amount of energy used by all the people on Earth in a year."[136]

[134] de Vries, Hylke, et al. "How Gulf-Stream SST-fronts influence Atlantic winter storms." *Climate Dynamics* 52.9 (2019): 5899-5909.

[135] Zhang, Li, et al. "Decadal coupling between storm tracks and sea surface temperature in the Southern Hemisphere midlatitudes." *Climate Dynamics* 56.3 (2021): 783-798.

[136] EPA, Climate Change Indicators, at https://www.epa.gov/climate-indicators/climate-change-indicators-ocean-heat.

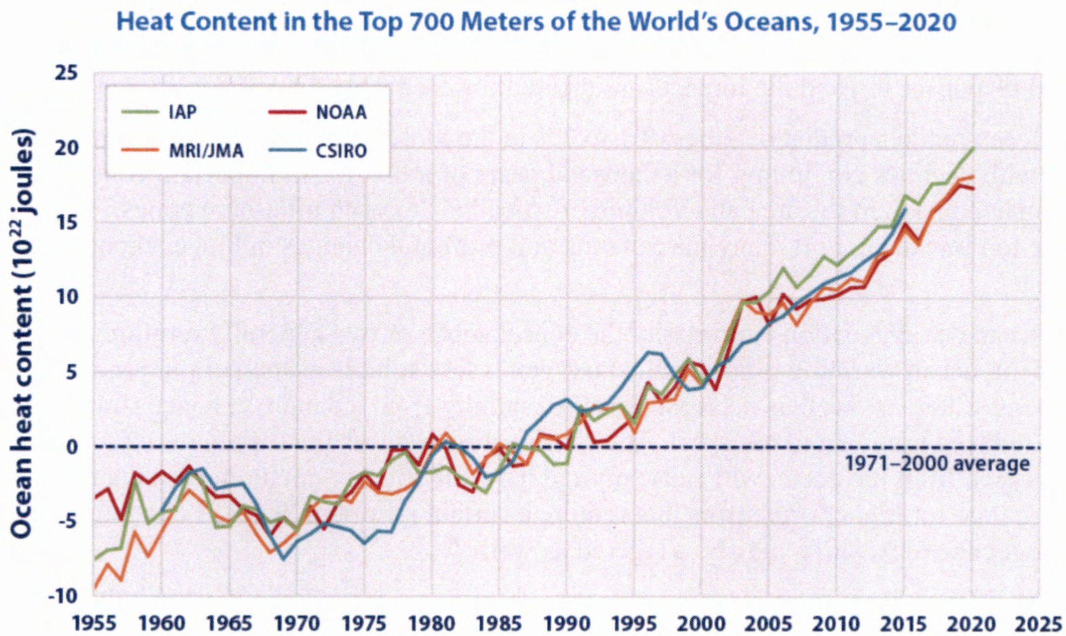

Fig. 19. Source: EPA based on data reported by the United States' National Oceanic and Atmospheric Administration et al.

In addition, recent research suggests that ocean warming is destabilizing ocean floor gas hydrates and inducing seafloor methane leakage.[137]

To reduce ocean temperatures, we must rapidly phase out fossil fuel GHG emissions and remove excess legacy GHGs. In light of their ocean warming impact and the train of impacts arising from such warming, additional fossil fuel emissions and legacy emissions impose both an unreasonable risk of injury to the environment and health as well as an imminent and unreasonable risk of serious or widespread injury to health or the environment.

(C) Ocean deoxygenation

Ocean warming also drives deoxygenation, through solubility and stratification effects. The effect is not merely to coastal waters: "Ocean warming and increased stratification of the upper ocean caused by global climate change will likely lead to declines in dissolved O_2 in the ocean interior, with implications for ocean productivity, nutrient cycling, carbon cycling, and marine habitat."[138]

Dissolved O_2 is essential for aerobic respiration, and low O_2 levels negatively affect the physiology of higher animals. This can lead to suboxic areas or even "dead zones" where many macrofauna are absent. Deoxygenation can also accelerate climate change, rendering it an amplifying climate feedback. Suboxic conditions can cause denitrification in the ocean, increasing production and release of nitrous oxide – a potent, long-lived GHG. In addition, the organic matter respiration that generates hypoxia (lowered-oxygen) also elevates CO_2, thus

[137] M. Ketzer et al., *Gas hydrate dissociation linked to contemporary ocean warming in the southern hemisphere*, Nature Communications (2020) at https://www.nature.com/articles/s41467-020-17289-z.

[138] Jewett, L., and A. Romanou, 2017: Ocean Acidification and Other Ocean Changes. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 364–392.

leading to coupled deoxygenation and ocean acidification in a future warmer, high-CO_2 world. The synergistic effects of these multiple stressors may amplify the negative physiological and microbial responses beyond the impacts anticipated for each perturbation considered in isolation.

Ocean models predict declines of 1 to 7% in the global ocean O_2 inventory over the next century, with declines continuing for a thousand years or more.[139] An important consequence may be an expansion in the area and volume of so-called "oxygen minimum zones," wherein O_2 levels are too low to support many macrofauna and profound changes in biogeochemical cycling occur.

Ocean deoxygenation is primarily the consequence of two generally reinforcing, but independent, ocean warming processes: (1) oxygen is less soluble as temperature increases and (2) warming waters, as well as decreased surface salinity from ice melt, enhance stratification and thus reduced mixing and transport. The combination reduces the supply of oxygen, and that loss of oxygen from the ocean will cause myriad harmful effects – including a reduction in the habitable range for higher organisms that require a certain minimum level of oxygen. Additional major biogeochemical shifts may be triggered as well.[140]

Significant deoxygenation has occurred over the past 50 years in the North Pacific and tropical oceans, and a convergence of evidence implies further significant changes. Changes in the North Pacific are tied to increased stratification in the subarctic region. O_2 declines are consistent with the predicted response to global warming in global ocean models, and the patterns of observed O_2 change can be reproduced with higher-resolution models driven by observed forcings. The relative rapidity of O_2 decreases in the subarctic Pacific and in coastal upwelling regions off the west coast of North America raises the specter of imminent impacts on marine habitat and fisheries.[141] There is potential for even larger O_2 declines in the future if levels of greenhouse gases in the atmosphere continue to increase.

Falkowski et al. analyzed relatively long-term databases of ocean conditions and found trends of deoxygenation in upwelling areas along continental margins and shoaling of the depths of critical oxygen concentrations. They concluded that even a moderately long-term decline in source-water oxygen and increasing nutrient concentrations will cause currently intermittent but extreme deoxygenation conditions to become more frequent, intense, and persistent, with a potentially profound impact on global fisheries.[142]

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[139] Keeling, Ralph F., Arne Körtzinger, and Nicolas Gruber. "Ocean deoxygenation in a warming world." Marine Science 2 (2010).

[140] Harvey et al., *Meta-analysis reveals complex marine biological responses to the interactive effects of ocean acidification and warming*, Ecology and Evolution 2013; 3(4): 1016–1030

[141] Keeling et al., Ocean Deoxygenation in a Warming World Annu. Rev. Mar. Sci. 2010. 2:199–229

[142] Falkowski et al., *Eos*, Vol. 92, No. 46, 15 November 2011

Petitioners note, as well, that the number of hypoxic (deoxygenated) ocean ecosystems may be underestimated in modeling by an order of magnitude in the tropics,[143] in part because of the skewed distribution of research capacity with respect to tropical ecosystems.[144]

There is no doubt that deoxygenation is occurring and accelerating.[145] Worldwide shoaling of the upper oxygen minimum zone (OMZ) boundaries has been documented in the eastern boundaries of all major OMZs over the past several decades. In some cases, the lower OMZ boundaries have also shifted to greater depths, and minimum oxygen concentrations in the OMZ cores have also decreased – intensifying the OMZ.[146] Keeling et al.[147] provides tabulations of oxygen declines and volume changes in different OMZs. Whitney et al.[148] provides time-series data that reveal an extensive oxygen decline in the northeast Pacific and a significant expansion of oxygen minimum zones in the tropical and sub topical ocean over the past half century. Using historical data (1960-2015) Santos et al.[149] identifies declines in the thickness and oxygen content of OMZs in the eastern tropical South Atlantic (ETSA) and eastern tropical North Atlantic (ETNA) over a 55-year period.

Long et al.,[150] in a study utilizing the Community Earth System Model (CESM), found that by the 2030s, under RCP8.5 (carbon emission business as usual), widespread loss of oxygen in the thermal layer will be seen. At a global scale, anthropogenic climate change in RCP8.5 drives a sharp acceleration of oceanic deoxygenation in the first half of the 21st century.

Suboxia can control the loss of fixed nitrogen via denitrification and therefore influence the availability of nitrate, a limiting nutrient for ocean productivity.[151,152] Oxygen levels also control ocean production of N_2O; production can increase under suboxic conditions as a product

143 Laffoley, Dan, and John M. Baxter. Ocean Deoxygenation: Everyone's Problem-Causes, Impacts, Consequences and Solutions. Gland, Switzerland: IUCN, 2019. Available at https://portals.iucn.org/library/sites/library/files/documents/2019-048-En.pdf.

144 Altieri, A.H., Harrison, S.B., Seemann, J., Collin, R., Diaz, R.J., & Knowlton, N. (2017). Tropical dead zones and mass mortalities on coral reefs. Proceedings of the National Academy of Sciences of the United States of America. https://www.pnas.org/content/114/14/3660.

145 IPCC Climate Change 2013: The Physical Science Basis (eds Stocker, T. et al.) (Cambridge Univ. Press, 2013).

146 Gilly et al., Oceanographic and Biological Effects of Shoaling of the Oxygen Minimum Zone, Annual Review of Marine Science, December 2011

147 Keeling et al. Ocean deoxygenation in a warming world.*Annu.Rev.Mar.Sci.* 2:199–229 (2010)

148 Whitney, F. A., Freeland, H. J. & Robert, M. *Prog. Oceanogr.* 75, 179–199 (2007).

149 Santos, Guilherme Cordova, et al. "Influence of Antarctic intermediate water on the deoxygenation of the Atlantic Ocean." *Dynamics of Atmospheres and Oceans* 76 (2016): 72-82.

150 Long, Matthew C., Curtis Deutsch, and Taka Ito. "Finding forced trends in oceanic oxygen." Global Biogeochemical Cycles 30.2 (2016): 381-397.

151 Codispoti LA, Brandes JA, Christensen JP, Devol AH, Naqvi SWA, et al. 2001. The oceanic fixed nitrogen and nitrous oxide budgets: Moving targets as we enter the anthropone? Sci. Marina 65:85–105 (revising "the prevailing oceanic N O 2 source term upwards by 2 Tg N yr-1 in our oceanic fixed N budget [] to account for the expan- sion of low oxygen conditions in coastal regions").

152 Gruber N. 2008. The marine nitrogen cycle: Overview of distributions and processes. In

Nitrogen in the marine environment, ed. DG Capone, DA Bronk, MR Mulholland, EJ Carpenter, pp. 1–50. Amsterdam: Elsevier. 2nd ed.

of denitrification.[153] Both of these effects – release of N_2O and limiting primary production (thus slowing the carbon pump) will amplify climate change. A reduction in the nutrient supply to the euphotic layer as a result of increased thermal stratification may also lead to a decreased efficiency of the biological pump in sequestering atmospheric CO_2. The concomitant loss of ocean buffering is another amplifying feedback.[154, 155]

On the other hand, fossil fuel phaseout and removal of excess legacy emissions, as Petitioners here propose, should reduce deoxygenation by more than half of what otherwise will occur from our current trajectory.[156]

In light of their impact on ocean oxygen levels and the train of impacts arising from such ocean deoxygenation, additional fossil fuel CO_2 emissions and legacy CO_2 must be deemed to impose both an unreasonable risk of injury to the environment and health, and also an imminent and unreasonable risk of serious or widespread injury to health or the environment.

(D) Widespread and Synergistic Ocean Risks

Although there is considerable uncertainty about the spatial and temporal details, climate change is clearly and fundamentally altering ocean ecosystems.[157] Further change will continue to impose enormous challenges and costs for societies worldwide, and adversely affect future generations.[158] The effects are widespread throughout the marine food web, impacting ocean biodiversity,[159] with severe effects on top predators,[160] mesopredators,[161] herbivores,[162] as well as

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153 Codispoti LA, Brandes JA, Christensen JP, Devol AH, Naqvi SWA, et al. 2001. The oceanic fixed nitrogen and nitrous oxide budgets: Moving targets as we enter the anthropocene? Sci. Marina 65:85–105. https://www.academia.edu/47919156/The_oceanic_fixed_nitrogen_and_nitrous_oxide_budgets_Moving_targets_as_we_enter_the_anthropocene.

154 Cermeno et al., The role of nutricline depth in regulating the ocean carbon cycle, PNAS V105 no. 51, 2008.

155 Viviani, Donn A., Spatial Variability in near-surface plankton metabolic rates. Diss. UNIVERSITY OF HAWAI'I.

156 IOC –UNESCO and UNEP (2016). Open Ocean: Status and Trends, Summary for Policy Makers. United Nations Environment Programme (UNEP), Nairobi.

157 Du Pontavice, Hubert, et al. "Climate change undermines the global functioning of marine food webs." *Global change biology* 26.3 (2020): 1306-1318.

158 Ove et al. The Impact of Climate Change on the World's Marine Ecosystems, Science 18 Jun 2010: Vol. 328, Issue 5985, pp. 1523-1528

159 Hillebrand, Helmut, et al. "Climate change: Warming impacts on marine biodiversity." *Handbook on marine environment protection*. Springer, Cham, 2018. 353-373.

160 Rosa, Rui, and Brad A. Seibel. "Synergistic effects of climate-related variables suggest future physiological impairment in a top oceanic predator." Proceedings of the National Academy of Sciences 105.52 (2008): 20776-20780.

161 Flynn et al. Ocean acidification exerts negative effects during warming conditions in a developing Antarctic fish, Oxford Journals, Conservation Physiology Volume 3, Issue 1, 2015

162 Poore et al. Direct and indirect effects of ocean acidification and warming on a marine plant-herbivore interaction. Oecologia. 2013 Nov;173(3):1113-24

substantial impacts to the base of the chain[163] – that is, to primary producers that supply half of our oxygen[164] and serve as engines for our planet's biological carbon pump.

Ocean impacts include warming, decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease. Recent research demonstrates that a combination of elevated temperature and acidification, both exacerbated by fossil fuel GHG emissions, particularly CO_2 and CH_4, has a synergistic effect on marine life[165] and the ocean.

1. Ocean Warming, Deoxygenation and Acidification's Synergistic Ecosystem Impacts

The full impact of elevated greenhouse gases on marine ecosystems is still being written, but there is high confidence that ecosystem impacts will be sharply negative – as has been established by recent meta-analysis into the multiplicative nature of ocean warming and acidification.[166] Demonstrated and anticipated impacts include loss of diversity,[167] loss of abundance of calcifying species, shifting prey and predator interactions, and loss of suitable habitat. As mentioned above, the synergistic impacts of ocean acidification and warming also stand to amplify climate change. Mesocosm studies found that ocean acidification may amplify global warming through decreasing biogenic production of the marine sulfur component dimethylsulfide, which can impact cloud albedo.[168] Similarly, ocean warming through a number of mechanisms (solubility and density) increases ocean stratification and deoxygenation, resulting in increased nitrous oxide formation and emissions.[169]

In 2011, Nicholas Gruber took a broad-level look at three stressors: ocean warming, acidification and deoxygenation, He found that each of them, unless strong climate mitigation measures are implemented, are bound to have profound effects on marine biogeochemistry and ecosystems, and that situation may be aggravated further if these three stressors act simultaneously.[170] Similarly, in 2010 Anlauf et al. looked at the joint effects of warming and acidification and found that although primary polyp growth was reduced only marginally by

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[163] Bopp *et al.*, Biogeosciences, 10, 6225–6245, 2013

[164] Field et al, Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components SCIENCE VOL 281 10 JULY 1998

[165] Cattano, Carlo, et al. "Living in a high CO2 world: a global meta-analysis shows multiple trait-mediated fish responses to ocean acidification." *Ecological Monographs* 88.3 (2018): 320-335.

[166] Kroeker, Karisty J., et al. "Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming." *Global change biology* 19.6 (2013): 1884-1896.)

[167] Colossi Brustolin, Marco, et al. "Future ocean climate homogenizes communities across habitats through diversity loss and rise of generalist species." *Global change biology* 25.10 (2019): 3539-3548.

[168] Six KD, Kloster S, Ilyina T, Archer SD, Zhang K, et al. 2013. Global warming amplified by reduced sulphur fluxes as a result of ocean acidification. Nature Climate Change.

[169] Keeling *et al.*, Annu. Rev. Mar. Sci. 2010. 2:199–2 29

[170] Gruber built upon the German Advisory Council on Global Change (WBGU)'s report entitled 'The future oceans: warming up, rising high, turning sour'; which summarized what was known at that time (2006) with regard to how the ocean might respond to global warming induced primarily by increases in greenhouse gases.

more acidic seawater, the *combined* effect of high temperature and lowered pH caused a reduction in growth of primary polyps by almost a third.[171]

The latest global coral reef assessment[172] estimated that "large scale coral bleaching events are the greatest disturbance to the world's coral reefs," and that a bleaching event in 1998 alone "killed 8% of the world's coral. Subsequent disturbance events, occurring between 2009 and 2018, killed 14% of the world's coral."[173] Other results suggest that up to 70% of the world's coral reefs may be lost within the next four decades if current trends in climate change and coastal human population growth persist.[174] Major threats to corals include warming sea-surface temperatures,[175] expanding seawater acidification[176] and deoxygenation[177] resulting from GHG emissions.

In 2013, Camilo Mora[178] found that "[o]cean warming and acidification... are causing a new set of conditions that are very close to the tolerance thresholds of corals, making them vulnerable to massive bleaching and mortality when long-term trends related to climate change are added to natural variability." The decay of coral reefs could potentially impair their ability to deliver goods and services such as fisheries and tourism, valued in 1997 at over US $375 billion annually.[179] Likewise, future changes in ocean temperature are expected to cause a redistribution in the global diversity of cetaceans,[180] which in turn could impact local economies that rely on tourism or the take of these species.

Anthony et al.[181] found that the combination of ocean warming and acidification from increasing levels of atmospheric CO_2 threaten coral reefs that are in many regions also subject to local-scale disturbances such as overfishing and conventional pollution.[182] Further, in 2014

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[171] Anlauf, Holger, Luis D'Croz, and Aaron O'Dea. "A corrosive concoction: the combined effects of ocean warming and acidification on the early growth of a stony coral are multiplicative." Journal of Experimental Marine Biology and Ecology 397.1 (2011): 13-20.

[172] Global Coral Reef Monitoring Network (GCRMN), The Sixth Status of Corals of the World: 2020 Report (October 5, 2021) at https://gcrmn.net/2020-report/.

[173] *Id.* Executive Summary at 19.

[174] Wilkinson, C., 2004. Status of Coral Reefs of the World: 2004. Australian Institute of Marine Science, Townsville, Australia, p. 301.

[175] Hoegh-Guldberg, Ove, et al. "Coral reefs under rapid climate change and ocean acidification." science 318.5857 (2007): 1737-1742.

[176] *Id.*

[177] Alva-Basurto, Jorge Christian, and Jesús Ernesto Arias-González. "Modelling the effects of climate change on a Caribbean coral reef food web." Ecological Modelling 289 (2014): 1-14.

[178] Mora et al., Biotic and Human Vulnerability to Projected Changes in Ocean Biogeochemistry over the 21st Century PLOS Biology, October 2013, Volume 11, Issue 10

[179] Costanza R, d'Arge RC, de Groot R, Farber S, Grasso M, et al. (1997), The value of the world's ecosystem services and natural capital. Nature 387: 253– 261.

[180] Whitehead H, McGill B, Worm B (2008) Diversity of deep-water cetaceans in relation to temperature: implications for ocean warming. Ecology Letters 11: 1198–1207.

[181] Anthony et al. , Ocean acidification and warming will lower coral reef resilience, Global Change biology, Volume 17, Issue 5 May 2011 Pages 1798–1808

[182] *Id.*

Basurto et al.[183] looked at coral bleaching from warming temperatures, the potential decreases in dissolved oxygen concentration (deoxygenation) and pH (acidification) in the oceans. These employed several dynamic models constructed from an extensive database of 171 reef fish species (abundance and biomass) and benthic communities from 13 coral reefs along 400 km of the Mexican Caribbean coast. When all the three sources of stress were combined, their simulations "found a general decrease of biomass in fish, non-fish, and some commercially valuable fish and macroinvertebrate functional groups, suggesting that the combined effects can result in a potential loss of biodiversity and ecosystem services in coral reefs."

Using a probabilistic resilience model (and conservative assumptions) and building on the dynamics of a species pair of corals (Acropora) and fleshy macroalgae (Lobophora), researchers have determined that the effects of ocean acidification and warming on coral growth and mortality will impact coral reef resilience – that is, will lower the threshold at which other, normally occurring, stresses can drive the study community from predominantly coral-dominated to predominantly algal-dominated states, specifically by reducing coral growth (due to acidification) and survivorship (due to warming).[184] Figure 20 illustrates their projection of the bleaching risk over time for the Great Barrier Reef from ocean acidification and temperature.

The researchers concluded that a failure to rapidly stabilize and reduce the concentration of CO_2 in Earth's atmosphere is likely to lead to significant loss of key framework builders such as Acropora, irrespective of the effectiveness of local management.[185]

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183 Alva-Basurto, Jorge Christian, and Jesús Ernesto Arias-González. "Modelling the effects of climate change on a Caribbean coral reef food web." Ecological Modelling 289 (2014): 1-14.

184 *Id.*

185 Similarly, Harvey et al., in a meta-analysis of 107 peer reviewed articles, containing 623 unique observations, found complex marine biological responses to the interactive effects of ocean acidification and warming. While biological responses varied across taxonomic groups, life-history stages, and trophic levels, combining stressors generally exhibited a stronger biological (either positive or negative) effect. Using a subset of orthogonal studies, they showed that four of five of the biological responses measured (calcification, photosynthesis, reproduction, and survival, but not growth) interacted synergistically, and negatively, when warming and acidification were combined. Harvey et al., *Meta-analysis reveals complex marine biological responses to the interactive effects of ocean acidification and warming*, Ecol Evol. 2013 Apr; 3(4): 1016–1030

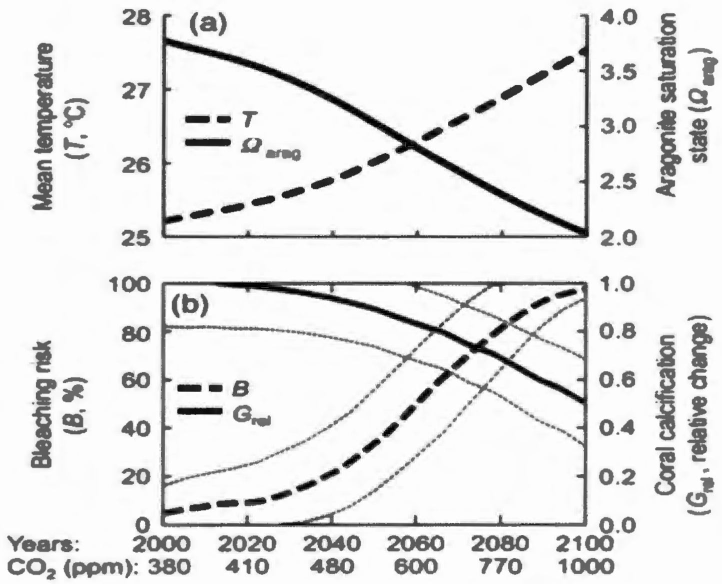

Figure 20[186] Projections of ocean warming and acidification and predicted responses by Acropora for the southern Great Barrier Reef, Australia.[187]

Nagelkerken et al.[188] performed a meta-analysis of 632 published experiments derived from multiple ecosystems and latitudes, that quantified the direction and magnitude of ecological change resulting from ocean acidification and warming. They looked at how these stressors (warming and acidification) affected the interactions between trophic levels and determined that there were important and deleterious mismatches between the trophic levels. As did Harvey, they found primary production by temperate noncalcifying plankton increases with elevated temperature and CO_2, (and tropical plankton decreases productivity because of acidification). Temperature increases consumption by and metabolic rates of herbivores as well, but this response didn't translate into greater secondary production, which instead decreases with acidification in calcifying and noncalcifying species.

This effect creates a mismatch with carnivores whose metabolic and foraging costs increase with temperature. Species diversity and abundances of tropical as well as temperate species decline with acidification, with shifts favoring novel community compositions dominated by noncalcifiers and microorganisms. Both warming and acidification instigate reduced calcification in tropical and temperate reef-building species. Acidification leads to a decline in dimethylsulfide production by ocean plankton which, as a climate gas, contributes to cloud formation and maintenance of the Earth's heat budget. Analysis of responses in short- and long-term experiments and studies at natural CO_2 levels reveal little evidence of acclimation to acidification or the temperature changes, except for microbes. This conceptualization of change

186 Kenneth RN, et al. "Ocean acidification and warming will lower coral reef resilience." *Global Change Biology* 17.5

187 (a) Mean sea surface temperatures (T) and aragonite saturation states (Oarag) for the A1FI carbon emission scenario for the southern Coral Sea as estimated by the UVicglobal carbon cycle model. (b) Projected bleaching risk (dashed lines) and projected relative change in coral calcification of Acropora intermedia for the 6-month period (October–March) that includes the Austral summer.

188 Nagelkerken and Connell, Global alteration of ocean ecosystem functioning due to increasing human CO_2 emissions, PNAS vol. 112 no. 43, 2015.

across whole communities and their trophic linkages forecast a reduction in diversity and abundances of various key species that underpin current functioning of marine ecosystems.

Nagelkerken and Connel[189] observe that ocean acidification and warming are fundamentally changing the globe's largest ecosystem that sustains economic revenue and food for many countries. Their meta-analysis shows that many species and ocean habitats will change from their current states, warning that ocean acidification and warming "increase the potential for an overall simplification of ecosystem structure and function with reduced energy flow among trophic levels and little scope for species to acclimate. The future simplification of our oceans has profound consequences for our current way of life, particularly for coastal populations and those that rely on oceans for food and trade."

Nagelkerken et al.[190] recently simulated the effects of multiple stressors in a mesocosm study and found that the multiple stressors, acidification and warming had a catastrophic effect on the marine food web. The researchers filled 12 pools with 5700 gallons of seawater, put in sand, rocks and a medium for algae to grow, added invertebrates to graze on the algae and a predator fish – a complete food web. They found that CO_2 benefited growth, but that warming nonetheless not only wiped out that benefit but the invertebrate population collapsed. Warm water increased the metabolism of the predator fish, so they ate more, but while there was more algae growth the invertebrates did not grow enough under the new conditions. This mismatch between the availability of food and the need for food was predicted by the earlier meta-analysis.[191]

Pistevos et al.[192] also showed how warming and acidification harms the marine food web. Combining long term laboratory and mesocosm studies with sharks, they found detrimental effects on predators. Elevated CO_2 and acidification amounted to an "anagonistic effect," causing a mismatch by, e.g., higher metabolic demand and decreased ability to locate prey – all of which may have cascading top-down controls over food webs through altered predator-prey relationships.[193]

In 2016, Bednaršek et al.[194] summarized the threats that ocean acidification, warming, and deoxygenation pose to pteropod populations.[195] They suggested that pteropods were most

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[189] *Id.*

[190] Nagelkerken., et al. "Boosted food web productivity through ocean acidification collapses under warming." Global Change Biology (2017). Available at https://www.researchgate.net/publication/316531707_Boosted_food_web_productivity_through_ocean_acidification_collapses_under_warming.

[191] Nagelkerken Global alteration of ocean ecosystem functioning due to increasing human CO2 emissions, PNAS vol. 112 no. 43, 2015

[192] Pistevos, Jennifer CA, et al. "Ocean acidification and global warming impair shark hunting behaviour and growth." Scientific reports 5 (2015): 16293.

[193] Similarly, *see* Goldenberg, Silvan U., et al. "Boosted food web productivity through ocean acidification collapses under warming." Global Change Biology (2017) and Kroeker et al, Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming, Glob Chang Biol. 2013 Jun; 19(6): 1884–1896.

[194] Bednaršek, Nina, et al. "Pteropods on the edge: Cumulative effects of ocean acidification, warming, and deoxygenation." Progress in Oceanography 145 (2016): 1-24.

[195] "Pteropods are abundant aragonitic calcifiers, contributing up to 89% of total pelagic calcification. Because of their delicate shells, they are considered "canaries in the coalmine" to indicate impacts of ocean acidification." Peijnenburg

likely to become extinct in the polar oceans, where the entire water column could become undersaturated in aragonite (a naturally occurring crystal form of calcium carbonate ($CaCO_3$) *this century*. Pteropods play an extremely important role in many ocean ecosystems. In the Ross Sea, the pteropod *Limacina helicina* sometimes replaces krill as the dominant zooplankton species in the ecosystem. In many polar and subpolar regions, pteropods are an important food source for a wide range of species, including North Pacific salmon, mackerel, herring, cod, large whales, and other important species that provide food and livelihood. Overall, pteropods are responsible for an estimated 20%– 42% of total carbonate production in the ocean,[196] so the aragonite undersaturation risk to the marine carbon pump (the ocean's biologically-driven sequestration of carbon) is enormous.

The Southern Ocean (SO), covering about 34.8 million km^2, will be one of the first and most severely affected regions from ocean acidification (OA) due to naturally low levels of $CaCO_3$. It is estimated that under the current trajectory much of the SO will be unsaturated in aragonite within two or three decades,[197] and it is expected that the seawater of the entire Southern Ocean south of 60° S and a part of the subarctic Pacific will become unsaturated with aragonite by 2100.[198] A recent meta-analysis found that many primary calcifiers are extremely vulnerable to acidification and warming (Figure 18), and that their shells would be thermodynamically predisposed to dissolve rather than form. This could eventually collapse the marine food web and induce major alterations in the biogeochemical cycle of carbon.[199]

et al., The origin and diversification of pteropods precede past perturbations in the Earth's carbon cycle, PNAS, Sept. 24, 2020 at https://www.pnas.org/doi/10.1073/pnas.1920918117.

196 Bednaršek N., Možina J, Vogt M, O'Brien C, Tarling GA. 2012. The global distribution of pteropods and their contribution to carbonate and carbon biomass in the modern ocean. Earth Systems Science Data 4: 167–186.

197 Hossain, M. Belal, and Mahabubur Rahman. "Ocean Acidification: an impending disaster to benthic shelled invertebrates and ecosystem." *Journal of Noakhali Science and Technology University (JNSTU)* 1.1 (2017): 19-30.

198 Kuroyanagi, Azumi, et al. "Decrease in volume and density of foraminiferal shells with progressing ocean acidification." *Scientific reports* 11.1 (2021): 1-7.

199 Figuerola, Blanca, et al. "A review and meta-analysis of potential impacts of ocean acidification on marine calcifiers from the Southern Ocean." *Frontiers in Marine Science* 8 (2021): 24.

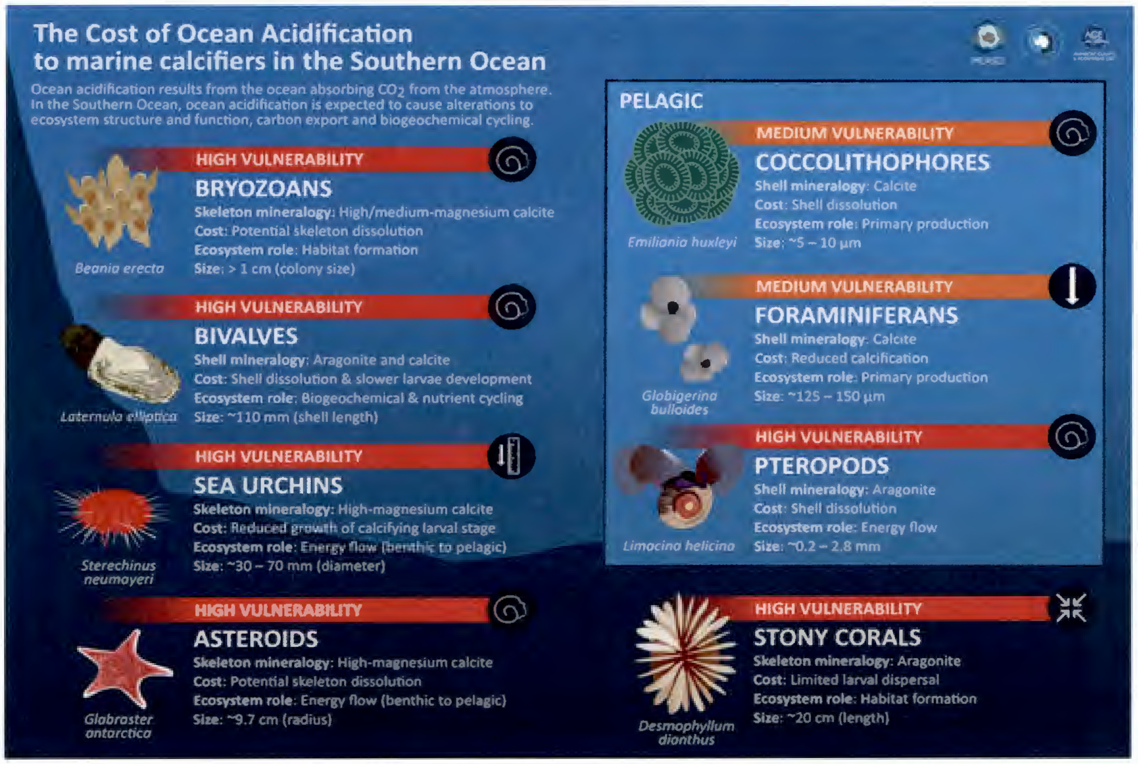

Figure 18: Vulnerability of Marine Calcifiers to Ocean Acidification[200]

2. Additional Ocean Impacts

Climate change is rendering certain ocean waters more conducive to waterborne pathogens. In particular, inland and coastal warming is accelerating the release of dissolved organic matter (DOM) through increases in precipitation, thawing of permafrost, and changes in vegetation. The selective absorption of ultraviolet radiation (UV) by DOM can decrease the valuable ecosystem service provided by sunlight inactivation of waterborne pathogens. Additional warming thus threatens increased exposure to infectious diseases in humans, through drinking water and other exposures, as well as to wildlife.[201]

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200 *Id.*

201 Williamson, Craig E., et al. "Climate change-induced increases in precipitation are reducing the potential for solar ultraviolet radiation to inactivate pathogens in surface waters." *Scientific Reports* 7.1 (2017): 1-12.

VIII. Air Quality

In a later section, Petitioners touch on some of the direct health benefits deriving from a phaseout of fossil fuels. We summarize here, however, recent evidence of excess death that is a direct consequence of fossil fuel utilization.

In particular, in 2021, leading academic researchers established that the total global annual burden of premature deaths due to particulate pollution from fossil fuel combustion was ~10.2 million in 2012.[202] For persons over the age of 14, these included an estimated 483,000 premature deaths in North America, 187,000 deaths in South America, 1,447,000 deaths in Europe, 7,916,000 deaths in Asia, and 194,000 deaths in Africa.[203]

The same researchers also estimated "mortality due to lower respiratory infections (LRI) among children under the age of five in the Americas and Europe" and calculated that an estimated 876 such children in North America, 747 in South America, and 605 in Europe died from fossil fuel-induced LRI in 2012 alone.[204]

The researchers advised that their study "demonstrates that the fossil fuel component of PM2.5 contributes a large mortality burden. The steeper concentration-response function slope [that they found] at lower concentrations leads to larger estimates than previously found in Europe and North America, and the slower drop-off in slope at higher concentrations results in larger estimates in Asia. Fossil fuel combustion can be more readily controlled than other sources and precursors of PM2.5 such as dust or wildfire smoke, so this is a clear message to policymaker and stakeholders to further incentivize a shift to clean sources of energy."

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[202] KarnVohra et al., Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem, Environmental Research, Volume 195, April 2021, 110754, at https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487#!.

[203] *Id.*

[204] *See also*, Fuller, Pollution and health: a progress update, The Lancet Planetary Health, May 17, 2022DOI:https://doi.org/10.1016/S2542-5196(22)00090-0 (finding that "pollution remains responsible for approximately 9 million deaths per year, corresponding to one in six deaths worldwide. . . [D]eaths from household air pollution and water pollution are offset by increased deaths attributable to ambient air pollution and toxic chemical pollution (ie, lead). Deaths from these modern pollution risk factors, which are the unintended consequence of industrialisation and urbanisation, have risen by 7% since 2015 and by over 66% since 2000. Despite ongoing efforts by UN agencies, committed groups, committed individuals, and some national governments (mostly in high-income countries), little real progress against pollution can be identified overall, particularly in the low-income and middle-income countries, where pollution is most severe. Urgent attention is needed to control pollution and prevent pollution-related disease, with an emphasis on air pollution and lead poisoning, and a stronger focus on hazardous chemical pollution. Pollution, climate change, and biodiversity loss are closely linked. Successful control of these conjoined threats requires a globally supported, formal science–policy interface to inform intervention, influence research, and guide funding. Pollution has typically been viewed as a local issue to be addressed through subnational and national regulation or, occasionally, using regional policy in higher-income countries. Now, however, it is increasingly clear that pollution is a planetary threat, and that its drivers, its dispersion, and its effects on health transcend local boundaries and demand a global response. Global action on all major modern pollutants is needed.").

XI. Risk Reduction Methods

There are several ways to mitigate risk from CO_2 and CH_4. EPA should use a suite of tools to lower atmospheric concentrations of CO_2 and CH_4, including by the timely phaseout of fossil fuels, removing and sequestering CO_2 (including compelling such sequestration, or payment to ensure sequestration, by responsible parties) along with other GHGs so as to mitigate and repair, to the degree possible, additional injury to health and the environment.

There is evidence that many industries could employ existing technology to achieve meaningful emissions reductions affordably. EPA's own data demonstrate that lower pollution rates are readily achievable for many industrial sources of CO_2 and CH_4. For example, the Agency has identified dozens of "control measures and energy efficiency options that are currently available for pulp and paper mill processes," ranging from technological upgrades to improved equipment maintenance.[205] Similarly, EPA has compiled more than a decade of reports on "cost-effective" control strategies and other approaches available to reduce cement plant CO_2 emissions, "includ[ing], for example, energy efficiency measures, reductions in cement clinker content, and raw materials substitution."[206] EPA also has a number of voluntary programs to reduce methane emissions. These could be made compulsory or incentivized.[207]

In 2017, the non-profit Project Drawdown[208] laid out a comprehensive plan to reverse global warming in thirty years using only solutions currently in place. The diverse group of international researchers, [209] modeled the 100 most substantive, existing solutions to address climate change. Their research shows a pathway,[210] using currently available technology, from 2020 to 2050 that reduces CO_2-eq emissions by 1050 GT.[211] Benefits and savings estimated from implementation of this strategy far outweigh costs. Project Drawdown has since developed two scenarios[212] to assess what global efforts to address climate change might look like. Both scenarios are plausible and economically realistic. Drawdown Scenario 1 is roughly in-line with 2°C temperature rise by 2100, while Drawdown Scenario 2 is roughly in-line with 1.5°C temperature rise at century's end. The first removes 998 Gigatons CO_2 Equivalent while the second removes 1,576 Gigatons CO_2 Equivalent.

The potential for so-called "natural climate solutions" (NCS) – reforestation, improved forest management, and improvement in agriculture and soils management – holds special attraction for their availability, in theory, not only to safely sequester a portion of excess

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205 *See* EPA, Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Industry at 11 (2010).

206 EPA, National Emission Standards for Hazardous Air Pollutants From the Portland Cement Manufacturing Industry and Standards of Performance for Portland Cement Plants, 75 Fed. Reg. 54,970, 54,997 (Sep. 9, 2010).

207 https://www.epa.gov/natural-gas-star-program

208 Drawdown, Ed. Paul Hawken, Penquin Books, 2017

209 http://www.drawdown.org/advisors,

210 http://www.drawdown.org/solutions-summary-by-rank

211 The change in CO2-EQ, cost and benefits is the marginal difference between a reference case that assumes 2014 levels of adoption continue in proportion to the growth in global markets.

212 https://drawdown.org/solutions/table-of-solutions

atmospheric CO_2 but also for the co-benefits they promise – including with respect to ecosystem and hydrologic restoration. In 2017, an international team published a comprehensive review of the potential, nation by nation, for such natural atmospheric carbon removal.[213] Petitioners graphically depict the potential of the top 20 of them in Figure 19, below.

The potential varies widely depending on a nation's land area, present conditions of its forests, lands and soils, latitude, and other factors. A fossil-fuel company's payments to remove its share of legacy GHG emissions generated in or connected to its US operations in theory could pay for verified, effective natural climate solutions projects located outside the United States. But any associated credit generated towards such an emitter's carbon removal obligation would need to be adjusted for the level of permanency and risk inhering in such projects.

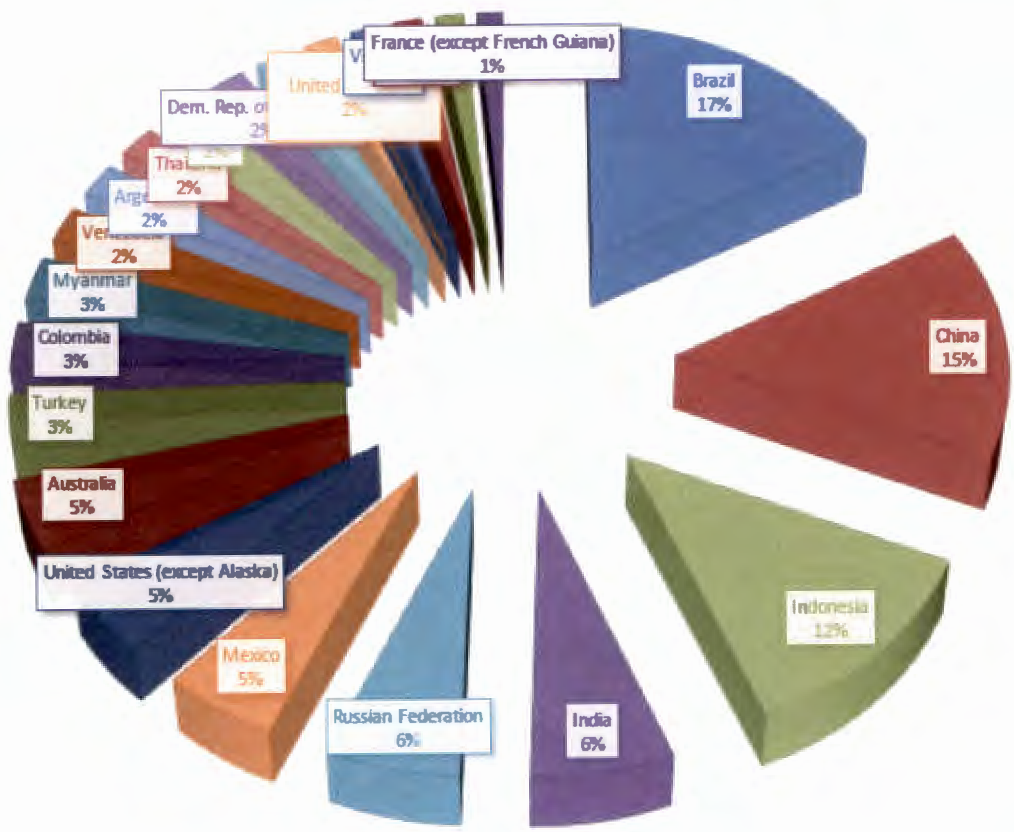

Fig. 19: Calculations and graphics by the Law Office of Daniel M Galpern.

213 Griscom et al., *Natural Climate Solutions*, PSAS (2017) at www.pnas.org/content/114/44/11645.

A recent article in *Science Advances*[214] quantified the potential of natural climate solutions to increase carbon storage and avoid GHG emissions in the United States. They found a maximum potential of 1.2 (0.9 to 1.6) Gt CO_2 eq y^{-1}, the equivalent of 21% of current net annual emissions of the United States. At current carbon market prices (US $10 per Mg CO_2 eq), 0.3 Gt CO_2 eq y^{-1} could be achieved. NCS would also provide air and water filtration, flood control, soil health, wildlife habitat, and climate resilience benefits.

Although cost-effective strategies to reduce CO_2 and CH_4 emissions are available, existing controls have not reduced CO_2 and CH_4 emissions sufficiently to protect against environmental harm. For example, most natural gas power plants have *never* exceeded the agency's recently proposed emissions limit, thus indicating that existing and newly constructed facilities could easily satisfy a more stringent standard.[215] Because energy-related CO_2 and CH_4 pollution accounts for more than eighty percent of U.S. GHG production, readily achievable reductions in this sector would significantly benefit the environment.[216] Similarly, the pulp and paper industry ranks among the largest consumers of energy,[217] and emitted nearly 58 million metric tons of CO_2 equivalent gases in 2004.[218]

Moreover, market incentives and regulatory controls are effective in increasing the rate of innovation for technologies that can reduce CO_2 and CH_4 emissions. Federal programs aimed at consumers also can reduce CO_2 and CH_4 emissions. For example, EPA's Energy Star program has prevented 1.8 Gt of GHG emissions by providing information that helps customers select energy efficient devices. Sequestration of CO_2 in products, infrastructure, and waste management are among numerous methods that could be cost-effective to mitigate CO_2 and CH_4 pollution. Providing solar cooking ovens or stoves to replace coal burning ones in countries where this is a predominate cooking "appliance" would substantially reduce emissions. Reducing coal use and achieving the health, albedo and other benefits of reducing black carbon would also be useful.

If a chemical presenting an unreasonable risk to health and the environment has already been distributed, EPA may prescribe procedures by which relevant manufacturers and purchasers must replace or repurchase that chemical.[219] In addition, EPA is authorized to prohibit or otherwise restrict any continuing disposal of CO_2 and CH_4 by its manufacturer, processor or other person.[220] In the present situation, we urge the agency to exercise its authority to remediate existing harm by requiring that responsible parties either remove residual or legacy CO_2 and CH_4 emissions or pay into a carbon removal fund sufficient for that to be done.

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214 Fargione, Joseph E., et al. "Natural climate solutions for the United States." *Science Advances* 4.11 (2018): eaat1869.

215 Ctr. for Biological Diversity, Comments on Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units (Proposed Rule) Docket No. EPA-HQ-OAR-2013-0495 at 1314 (May 9, 2014).

216 U.S. Dept. of State, U.S. Climate Action Report at 16 (2010).

217 *See* U.S. Energy Information Administration, First Use of Energy for All Purposes (Fuel and Nonfuel), 2010 (Mar. 2013), http://www.eia.gov/consumption/manufacturing/data/2010/#r1.

218 EPA, Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Industry at 7 (2010).

219 15 U.S.C. § 2605(a)(7)(C).

220 15 U.S.C. § 2605(a)(6)(A).

There are numerous approaches to sequestering CO_2 and CH_4. Effective land use and agricultural practices can significantly reduce CO_2 and CH_4 emissions and sequester CO_2, as mentioned above with respect to our discussion of natural climate solutions to sequester CO_2.

As for methane, near-source destruction methods may be employed to destroy fugitive methane from the fossil fuel industry, such as aggregating and destroying fugitive emissions from coal mines.[221] Methods of destroying less concentrated methane are also being researched and developed. Promising methane removal methods that, at least in "[d]esk and laboratory studies," appear to mimic natural removal processes, may prove to be viable – for example, iron salt aerosols employed to enhance natural sinks and remove CH_4 as well as CO_2.[222] If trials and subsequent assessments of methane removal prove its feasibility,[223] then EPA could require oil, gas, and coal producers to pay for their utilization to remove excess atmospheric methane, as well as its CO_2 remainder.

Methods of removing ambient CO_2 also are being researched and developed, including with the Agency's support. Petitioners deem it critical that the Agency evaluate progress in this area continuously to discern the efficiency and effectiveness of methods. Particularly in light of the long atmospheric residence time of CO_2, as discussed *supra*, [224] the full potential "to remove CO_2 from the atmosphere and durably store it in reservoirs" must be pursued in order to "compensate for residual emissions [and] if implemented at a scale where anthropogenic removals exceed anthropogenic emissions, to lower surface temperature."[225]

However, while "[t]he cooling (or avoided warming) due to CDR might be proportional to the cumulative amount of CO_2 removed from the atmosphere by CDR,"[226] CO_2 emissions and removal efforts are not perfectly symmetric. This is so, according to the IPCC, because "the fraction of CO_2 remaining in the atmosphere after an emission is larger than the fraction of CO_2 remaining out of the atmosphere after a removal."[227] This implies that, all other things being equal, it is preferable to avoid an emission than to remove it later. For this and other reasons, Petitioners strongly endorse a recent admonition from the Department of Energy's Office of Fossil Energy and Carbon Management, namely that "it is imperative that Carbon Capture and Storage and Carbon Dioxide Removal technologies are not used as mechanisms to continue

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221 https://verra.org/methodology/vm0014-interception-and-destruction-of-fugitive-methane-from-coal-bed-methane-cbm-seeps-v1-0/

222 Ming, Tingzhen, et al. "A nature-based negative emissions technology able to remove atmospheric methane and other greenhouse gases." *Atmospheric Pollution Research* (2021).

223 In its recently-released AR6 Working Group I report, the IPCC stated, "Methane removal is, however, still in its infancy and the available literature is insufficient for an assessment." We note, however, that "the cut-off date for scientific literature to be included in the contribution to the Sixth Assessment Report (AR6) of Working Group I" was January 31, 2021. *See* https://www.ipcc.ch/2020/05/29/ipcc-extends-working-group-i-literature-cut-off-date-postpones-final-lead-author-meeting/. At minimum, a number of leading scientists have since that time attempted to forge a research agenda aimed at systematically assessing the potential for promising atmospheric methane removal. *See* Jackson RB et al. 2021 Atmospheric methane removal: a research agenda. Phil. Trans. R. Soc. A 379: 20200454 (May 20, 2021) available at https://doi.org/10.1098/rsta.2020.0454.

224 *Op-cit* nte 68.

225 IPCC AR6, SPM-39.

226 *Id.*

227 *Id.* at §5.6.2.1.4.

burning fossil fuels, but instead as tools in an overall strategy to achieve deep decarbonization."[228]

The IPCC recently reviewed the effects of specific CDR methods on biogeochemical cycles and climate.[229] The methods include "afforestation, soil carbon sequestration, bioenergy with carbon capture and storage, wetland restoration, ocean fertilization, ocean alkalinization, enhanced terrestrial weathering and direct air capture and storage."[230] In its March 2022 report on Mitigation of Climate Change, the IPCC's Working Group III evaluated and discussed the potential of different CDR options in terms of the amount of CO_2 removed per year from the atmosphere, costs, risks and impacts, tradeoffs, and potential role in various mitigation pathways. Petitioners here reprint that report's Table TS.7, in which the IPCC neatly summarizes its most current assessment of CDR methods.[231]

Table TS.7: Summary of status, costs, potentials, risk and impacts, co-benefits, trade-offs and spill over effects and the role in mitigation pathways for CDR methods {12.3.2, 7.4} <u>TRL = Technology Readiness Level</u>

CDR option	Status (TRL)	Cost (USD tCO_2^{-1})	Mitigation Potential ($GtCO_2$ yr^{-1})	Risk and Impacts	Co-benefits	Trade-offs and spill over effects	Role in mitigation pathways	Section
Afforestation/Reforestation	(8-9)	0-240	0.5-10	Reversal of carbon removal through wildfire, disease, pests may occur. Reduced catchment water yield and lower groundwater level if species and biome are inappropriate.	Enhanced employment and local livelihoods, improved biodiversity, improved renewable wood products provision, soil carbon and nutrient cycling. Possibly less pressure on primary forest.	Inappropriate deployment at large scale can lead to competition for land with biodiversity conservation and food production.	Substantial contribution in IAMs and also in bottom-up sectoral studies.	{7.4}
Soil Carbon Sequestration in croplands and grasslands	(8-9)	45-100	0.6-9.3	Risk of increased nitrous oxide emissions due to higher levels of organic nitrogen in the soil; risk of reversal of carbon sequestration	Improved soil quality, resilience and agricultural productivity.	Attempts to increase carbon sequestration potential at the expense of production. Net addition per hectare is very small; hard to monitor.	In development - not yet in global mitigation pathways simulated by IAMs in bottom-up studies: with medium contribution.	{7.4}
Peatland and coastal wetland restoration	(8-9)	Insufficient data	0.5-2.1	Reversal of carbon removal in drought or future disturbance. Risk of increased CH_4 emissions.	Enhanced employment and local livelihoods, increased productivity of fisheries, improved biodiversity, soil carbon and nutrient cycling.	Competition for land for food production on some peatlands used for food production.	Not in IAMs but some bottom-up studies with medium contribution.	{7.4}
Agroforestry	(8-9)	Insufficient data	0.3-9.4	Risk that some land area lost from food production; requires very high skills.	Enhanced employment and local livelihoods, variety of products improved soil quality, more resilient systems.	Some trade off with agricultural crop production, but enhanced biodiversity, and resilience of system.	No data from IAMs, but in bottom-up sectoral studies with medium contribution.	{7.4}
Improved Forest management	(8-9)	Insufficient data	0.1-2.1	If improved management is understood as merely intensification involving increased fertiliser use and introduced species, then it could reduce biodiversity and increase eutrophication.	In case of sustainable forest management, it leads to enhanced employment and local livelihoods, enhanced biodiversity, improved productivity.	If it involves increased fertiliser use and introduced species it could reduce biodiversity and increase eutrophication and upstream GHG emissions.	No data from IAMs, but in bottom-up sectoral studies with medium contribution.	{7.4}
Biochar	(6-7)	10-345	0.3-6.6	Particulate and GHG emissions from production; biodiversity and carbon stock loss from unsustainable biomass harvest.	Increased crop yields and reduced non-CO_2 emissions from soil; and resilience to drought.	Environmental impacts associated particulate matter; competition for biomass resource.	In development – not yet in global mitigation pathways simulated by IAMs.	{7.4}
DACCS	6	100-300 (84-386)	5-40	Increased energy and water use	Water produced (solid sorbent DAC designs only).	Potentially increased emissions from water supply and energy generation.	In a few IAMs; DACCS complements other CDR methods.	{12.3}
BECCS	(5-6)	15-400	0.5-11	Inappropriate deployment at very large- scale leads to additional land and water use to grow biomass feedstock. Biodiversity and carbon stock loss if from unsustainable biomass harvest.	Reduction of air pollutants; fuel security, optimal use of residues, additional income, health benefits and if implemented well can enhance biodiversity.	Competition for land with biodiversity conservation and food production.	Substantial contribution in IAMs and bottom -up sectoral studies. Note- mitigation through avoided GHG emissions resulting from the bioenergy use is of the same magnitude as	{7.4}

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[228] Office of Fossil Energy and Carbon Management, *DOE's Office of Fossil Energy and Carbon Management Makes Historic Shift to Center Work on Climate Change* (Dec. 6, 2021) available at https://www.energy.gov/fecm/articles/does-office-fossil-energy-and-carbon-management-makes-historic-shift-center-work

[229] IPCC AR6 WGI Report: Physical Science Basis, at §5.6.2.2.

[230] *Id.* at §4.6.3.2 and §5.6.2.2.

[231] As the diagonal watermark denotes, this displayed table and other sections of the IPCC WGIII report (outside of its Summary for Policymakers) have been accepted for publication but, at this writing, May 26, 2022, remain "subject to final edits."

CDR option	Status (TRL)	Cost (USD tCO_2^{-1})	Mitigation Potential ($GtCO_2$ yr^{-1})	Risk and Impacts	Co-benefits	Trade-offs and spill over effects	Role in mitigation pathways	Section
							the mitigation from CDR (TS.5.6).	
Enhanced weathering	3-4	50-200 (24-578)	2-4 (<1-95)	Mining impacts; air quality impacts of rock dust when spreading on soil.	Enhanced plant growth, reduced erosion, enhanced soil carbon, reduced pH, soil water retention.	Potentially increased emissions from water supply and energy generation.	In a few IAMs; EW complements other CDR methods	{12.3}
"Blue carbon" in coastal wetlands	2-3	Insufficient data	<1	If degraded or lost, coastal blue carbon ecosystems are expected to release most of their carbon back to the atmosphere; potential for sediment contaminants, toxicity, bioaccumulation and biomagnification in organisms, issues related to altering degradability of coastal plants; use of subtidal areas for tidal wetland carbon removal; effect of shoreline modifications on sediment redeposition and natural marsh accretion; abusive use of coastal blue carbon as means to reclaim land for purposes that degrade capacity for carbon removal.	Provide many non-climatic benefits and can contribute to ecosystem-based adaptation, coastal protection, increased biodiversity, reduced upper ocean acidification; could potentially benefit human nutrition or produce fertiliser for terrestrial agriculture, anti-methanogenic feed additive, or as an industrial or materials feedstock.		Not incorporated in IAMs, but in some bottom-up studies: small contribution.	{7.4, 12.3.1}
Ocean fertilisation	1-2	50-500	1-3	Nutrient redistribution, restructuring of the ecosystem, enhanced oxygen consumption and acidification in deeper waters, potential for decadal-to-millennial-scale return to the atmosphere of nearly all the extra carbon removed, risks of unintended side effects.	Increased productivity and fisheries, reduced upper ocean acidification.	Subsurface ocean acidification, deoxygenation; altered meridional supply of macro-nutrients as they are utilised in the iron-fertilised region and become unavailable for transport to, and utilisation in other regions, fundamental alteration of food webs, biodiversity.	No data.	{12.3.1}
Ocean alkalinity enhancement	1-2	40–260	1–100	Increased seawater pH and saturation states and may impact marine biota. Possible release of nutritive or toxic elements and compounds. Mining impacts.	Limiting ocean acidification.	Potentially increased emissions of CO_2 and dust from mining, transport and deployment operations.	No data	{12.3.1}

Range based on authors' estimates (as assessed from literature) are shown, with full literature ranges shown in brackets

Petitioners suggest that in addition to any missing and necessary information concerning the science of ocean warming, deoxygenation and acidification, the Agency must work together with the Department of Energy and others to undertake any required additional testing of emissions reduction and sequestration processes and technologies. If information on the efficacy of removal and sequestration technologies is inadequate, Petitioners recommend that the Agency utilize its authorities under TSCA §4, 15 USC §2603. The Agency has in the past required TSCA test rules for many chemicals already released and in the environment in high volumes (such as dyes, plasticizers, flame retardants) to determine if treatment/mitigation methods (for example aerobic digestion) are sufficient to reduce the risk to human health and the environment to a reasonable level. [232] Treatment/mitigation methods to control CO_2 and CH_4 after release are analogous to those test rules. Any such Agency assessment should evaluate the efficiency and cost of sequestration technology and methods to treat/mitigate released CO_2 and CH_4. Costs for any such testing (and for remedies under §§ 2605 or 2608) should be apportioned among CO_2 and CH_4 emission contributors according to the cumulative CO_2 emission inventory information the Agency has collected. This could be structured in a manner similar to the sponsorship format used in TSCA's High Production Volume (HPV) Program (a more complex format than for GHGs, the Program covered thousands of chemicals and thousands of tests from both foreign and domestic sources).

Since any carbon emissions that result from sequestration actions must be subtracted to calculate net carbon sequestration, the Agency should in particular examine options that rely (completely or substantially) on non-fossil fuel energy, such as biosequestration relying on solar, wind, geothermal and nuclear power.

In the view of Petitioners, CDR methods that offer substantial ecological or agricultural co-benefits merit the Agency's special attention. By increasing their process area, volume, or efficiency, naturally occurring processes may sequester gigatons of carbon. For example, grass pastures can build soil carbon slowly through microbial processes. Legume-based pastures that

[232] See, for example: Certain Polybrominated Diphenylethers; Federal Register / Vol. 77, No. 63 / Monday, April 2, 2012 / Proposed Rules

fix nitrogen and drive higher biomass production of associated grasses may ensure a more rapid carbon accretion.[233] Marginal lands may be managed to trap a ton of carbon per hectare a year with proper management.[234] Enhanced soil carbon is beneficial not only for its increased productivity, but also because it enables greater infiltration and retention of rainfall, and this compensates for expected increases in temperature and more uncertain rainfall. In the oceans, microalgae can be fertilized to sequester carbon, and then removed/ harvested for products. For example, the nutritional value of micro algae,[235] and its potential as a biodiesel source,[236] have been extensively researched. Petitioners suggest that ancillary benefits like these should be accounted for in assessing net sequestration benefits, as is required to provide a complete analysis by OMB and Agency economic and regulatory guidelines.

Recently, the World Bank investigated the capacity of different agricultural land use management practices to sequester carbon. Biomass, especially in soils, sequesters atmospheric carbon, and this role as a carbon sink and carbon store can be strategically optimized through proven farming techniques and methods that simultaneously reduce emissions. These technical elements of climate-smart agriculture are well understood, and in addition to their technical feasibility they can be highly productive and profitable. In its report, the World Bank authors estimated there to be an enormous capacity of agriculture to sequester carbon and in turn provide markets to repurchase legacy carbon, yielding negative emissions options. Looking at different scenarios that are based on different levels of international integration and ecological concern, the employment of land use and management techniques in Asia, Africa and Latin America could sequester between 12 and 18 Gt of carbon, with net positive welfare benefits of between 1.4 and 1.6 trillion dollars by 2030.[237] Lal et al.[238] in particular have estimated that soil carbon has the potential to offset fossil-fuel emissions by 0.4 to 1.2 Gt C/ year, or 5 to 15% of the global emissions. Soil organic carbon is an extremely valuable natural resource and has many ancillary benefits including food security and watershed protection. These benefits should be considered in any carbon management regulatory option that includes trading soil C. This is another option for legacy carbon emission buy-back.

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233 Dalal, RC, Strong, WM, Weston, EJ, Cooper, JE, Lehane, KJ, King, AJ, Chicken, CJ (1995). Australian Journal of Experimental Agriculture, **35**

234 Project Drawdown estimates Carbon sequestration rates of 1.3 tons per hectare per year, based on meta-analysis of 31 data points from four sources.

235 FAO Fisheries Technical Paper 361

236 NREL/TP-580-24190

237 Carbon Sequestration in Agricultural Soils, The World Bank, REPORT NO. 67395-GLB, 2012

238 Lal, Rattan. "Soil carbon sequestration impacts on global climate change and food security." science 304.5677 (2004): 1623-1627.

More aggressively, it has been proposed that lignin rich crops, which sequester carbon refractorially, might be used directly as a soil amendment to enrich and provide carbon to desertified or otherwise depleted lands, enabling the growth of more lignin crops to produce additional fertile soils, geometrically amplifying the sequestration.[239] Climate change may worsen desertification because of temporal changes in radiation, wind, temperature, rainfall and other parameters driven by the increased energy in the atmosphere,[240] making soil management all that more important.

Globally, human land use has resulted in an estimated 74 Mha of salinized agricultural land[241] – 43 Mha is irrigated land and 31 Mha is secondary salinization of nonirrigated land. There are ecosystem and economic benefits, in addition to carbon sequestration, to reclaiming desertified or salinized land, and studies have identified suitable tree species for reclamation of saline farmland,[242] and the use of salinized lands for fuel-wood production.[243] Of potential halophytic shrubs, saltbush (*Atriplex* spp.) has been the most extensively examined due to its salt tolerance and its nutritional potential as an alternative fodder for livestock.[244]

Studies have shown that another economically beneficial use for tree litter and other forestry and agricultural high lignin sources (>15%) would be for erosion control necessitated by the expected increase in rainfall in many areas from the rising temperatures.[245]

Sustainable biochar has both an energy and a sequestration component, so that it can be used to produce fuels while the char itself can be used to increase soil fertility, thus enabling greater sequestration of carbon. Researchers estimate that up to 12% of anthropogenic emissions could be offset by biochar application to soils.[246]

Reforestation and reducing deforestation can also play enormous roles. Reforestation to combat desertification is underway, e.g., in Mongolia by the Mongolian and South Korean governments.[247, 248] estimated that by halting deforestation, allowing forests to regrow, and leaving mature forests undisturbed, tropical forests alone could capture 25–35% of anthropogenic carbon emissions. Of course, the sequestration potential of forestration "varies depending on the scenario-assumptions of available land and of background climate. . . Afforestation of native grasslands, savannas, and open-canopy woodlands leads to the undesireable loss of unique natural ecosysems with risk biodiversity, carbon storage and other

239 Viviani, Bioenergy and Biobased Products, DOE National Bioenergy Center Strategic Partnerships Workshop, April 11-12, 2001, at 150-168. https://www.nrel.gov/docs/gen/fy01/30304.pdf

240 World Meterological Organization, Climate_Change Desertification, 2007.

241 Dregne, Harold E., and Nan-Ting Chou. "Global desertification dimensions and costs." Degradation and restoration of arid lands (1992): 73-92.

242 Marcar et al., 1995; Benyon et al., 1999; Niknam & McComb, 2000.

243 E.g. El-Lakany, 1986.

244 Norman et al., 2004.

245 Trees, Crops, and Soil Fertility: Concepts and Research Methods edited by G. Schroth, Fergus L. Sinclair

246 Nature Communications 1: 56 doi:10.1038/ncomms1053

247 Min-Kyung Kang et al, Jour. Korean For. Soc. Vol. 99 No. 5, pp 655-663 (2010)

248 Rosa C. Goodman and Martin Herold. 2014. "Why Maintaining Tropical Forests Is Essential and Urgent for a Stable Climate." CGD Working Paper 385. Washington, DC: Center for Global Development.

ecosystem services." Further, account needs to be taken of feedbacks which are "highly region dependent. For instance, afforestation at high latitudes would decrease albedo and increase local warming. . . ."[249][250]

X. Need for Regulations for GHG Emission Reductions and Sequestration

Given the magnitude of the climate change problem, the mitigation prescription must also be adequate to the purpose. In the absence of human activities, nature maintains carbon dioxide atmospheric concentrations within a narrow band by balancing emissions with sequestration. Nature efficiently removes atmospheric carbon by transforming it into biomass and minerals, or "storing" it in the oceans (the source of the ocean acidification problem). Unlike the natural cycle, which is in dynamic equilibrium, the anthropogenic carbon cycle is unbalanced.

The economics of the anthropogenic carbon cycle still do not take into account the externalities of climate change or ocean warming and acidification; accordingly, the economic carbon cycle is skewed towards emissions and away from removal and secure sequestration. While the amount of the imbalance is relatively small when compared to the annual amount of carbon nature moves into and out of the atmosphere, it is consistently biased in one direction and over the years has almost doubled the baseline atmospheric carbon.

We thus confront a two-fold market failure[251] as the environmental cost of emissions are not included in the price of fossil fuel energy and the environmental benefits of removal and sequestration of CO_2 (or oxidation of methane) similarly are not valued by the market. OMB's "best practices" [252] for preparing the economic analysis of a significant regulatory action, called for by Executive Order 12866,[253] include determining whether there exists a market failure that is likely to be significant. Fossil fuel GHG emissions-imposed global warming and associated atmospheric, land and oceans impacts clearly meet OMB's definition of an externality.[254] "Once a significant market failure has been identified, the analysis should show how adequately the regulatory alternatives to be considered address the specified market failure."[255] Of course, these are best practices for regulatory agencies, not Petitioners, and Petitioner here recommend that the Agency include all reasonable options in its cost analysis to comply with the OMB best practices.

The Council of Economic Advisers have pointed out that "the emission of greenhouse gases such as carbon dioxide (CO_2) harms others in a way that is not reflected in the price of carbon-based energy, i.e., CO_2 emissions create a negative externality. Because the price of carbon-based energy does not reflect the full cost or economic damages, market forces result in a level of CO_2 emissions that is far too high. Public policies are thus needed to reduce CO_2 emissions and thereby limit the damage to economies and the natural world from further climate

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249 IPCC AR6, WGI, §5.6.2.2.1.

250 Petitioners add here that the selection of appropriate regulatory emission and sequestration remedies is a policy judgement for the Agency but, as noted *supra*, where promising options require further testing those could be required under TSCA §4.

251 The Cost of Delaying Action to Stem Climate Change, US Council of Economic Advisors, EOP, 2014

252 OMB: https://www.whitehouse.gov/omb/inforeg_riaguide last accessed 8/17/16

253 Executive Order 12866, "Regulatory Planning and Review"

254 OMB: https://www.whitehouse.gov/omb/inforeg_riaguide last accessed 8/17/16

255 *Id.*

change."[256] Some of these harms have been identified herein, including severe heat, wildfire, extreme weather, degraded air quality, ocean warming, deoxygenation, and acidification. TSCA provides a vehicle for implementing the public policy called for by the Council necessary to rectify the market failure.

The largest benefits and perhaps the most powerful argument for action may be the possibility of catastrophic effects from continued emissions. These include the possibility of amplified climate change stemming from feedback physical and chemical processes. Most of these positive feedbacks are anticipated from the simple physics of the situation, including loss of arctic ice-albedo[257, 258] (more summer ice melt means warmer water, warmer water means less winter ice formation, gradually decreasing each year's arctic ice coverage) and the release of soil carbon as frozen soil warms.[259] These effects are occurring now, and there are many others,[260] including potential collapse of the marine food web; impacts to cloud albedo[261]; alterations in ocean circulation[262]; rapid sea-level rise driven by West Antarctic Ice Sheet collapse or other sources; shifts in weather patterns like the Indian Summer Monsoon or the West African Monsoon[263]; ecological regime shifts in the Amazon or the Sahel; and the potential for massive release of carbon from seafloor methane hydrates.[264] Modeling studies have revealed the potential for an atmospheric super rotation threshold that rapidly increases climate sensitivity by changing planetary cloudiness[265] or an abrupt decline in the volume of snow on the Tibetan Plateau.[266] Some of these potential tipping elements may be realized by 2100 or earlier under current trajectories, others are likely not to materialize this century. In any case, both near and long-term tipping points need to be included so that significant costs and benefits of regulatory alternatives may be considered by decision makers.

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256 The Cost of Delaying Action to Stem Climate Change, CEA, July 2014.

257 Pistone et al http://www.pnas.org/content/111/9/3322.short

258 Vihma, T. Surv Geophys (2014) 35: 1175. https://doi.org/10.1007/s10712-014-9284-0

259 Shuur et al, The effect of permafrost thaw on old carbon release and net carbon exchange from tundra, Nature 459, 556-559 (28 May 2009).

260 Price, James. "Climate Tipping Points." (2012).

261 Six K.D., Kloster S., Ilyina T., Archer S.D., Zhang.K, Maier-Reimer,E., Global warming amplified by reduced sulphur fluxes as a result of ocean acidification. Nature Climate Change

262 Rahmstorf, S., Box, J., Feulner, G., Mann, M., Robinson, A., Rutherford, S., Schaffernicht, E. (2015): Evidence for an exceptional 20th-Century slowdown in Atlantic Ocean overturning. Nature Climate Change (online)

263 Nordhaus, William D., and Joseph Boyer. "Warming the world." (2000).

264 Schellnhuber, Hans Joachim. "Tipping elements in the Earth System." Proceedings of the National Academy of Sciences 106.49 (2009): 20561-20563.

265 Caballero, Rodrigo, and Matthew Huber. "Spontaneous transition to superrotation in warm climates simulated by CAM3." Geophysical Research Letters 37.11 (2010).

266 Drijfhout, Sybren, et al. "Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models." Proceedings of the National Academy of Sciences 112.43 (2015): E5777-E5786.

As Petitioners discussed *supra*, Executive Order 12866[267] clearly requires accounting of low probability, high impact events in EPA's risk and benefit analysis. There is research[268] that indicates that probabilities, at least for extreme weather events, are consistently undervalued. Such mistakes must be avoided by the Agency in its evaluation of a rule that aims to ensure that fossil fuel and other GHG emissions, both new and legacy, are phased out and removed so as to eliminate their present and anticipated injury to public health and the environment.

XI. Risk Reduction Costs and Benefits

As discussed earlier, while the Agency's §21 guidance[269] stated that petitioners are *encouraged* to provide cost and benefit information, the plain language of TSCA section 2605 (b) (4) (A), as amended in 2016 – and thus, *after* the denial of Petitioner Viviani's 2015 petition -- now makes it clear that it is the Administrator's responsibility to conduct the risk evaluation to determine if a risk is unreasonable without consideration of cost and other nonrisk factors. That is:

> *The Administrator shall conduct risk evaluations pursuant to this paragraph to determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other nonrisk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator, under the conditions of use.*

As noted, *supra*, resolving the myriad widespread and severe threats to health and the environment arising from fossil fuel GHG emissions, in particular but not limited to CO_2 and CH_4 – including Earth's energy imbalance, global warming, increasing drought, wildfire, and extreme weather, ecosystem degradation, species loss,[270] ice melt and sea level rise, ocean acidification, ocean warming, ocean detoxification, and the threat to the food web – **all** require a phaseout of those emissions and removal of a significant share of their atmospheric excess.[271]

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267 https://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo12866_10041993.pdf

268 Mann, Michael E., Elisabeth A. Lloyd, and Naomi Oreskes. "Assessing climate change impacts on extreme weather events: the case for an alternative (Bayesian) approach." Climatic Change (2017): 1-12.

269 FR Doc. 85-26938.

270 A far more substantial review is warranted of the threat to land-based ecosystems and species from business-as-usual GHG pollution than is provided herein. Accordingly, Petitioners intend to supplement by way of letter upon EPA's opening of a docket governing the subject matter of this Petition. For now, we cite the recent IPCC AR6 WG3 technical report that stated, in relevant part, that, "[c]limate change has altered marine, terrestrial and freshwater ecosystems all around the world (very high confidence). Effects have been experienced earlier, are more widespread and with further reaching consequences than anticipated (medium confidence). Biological responses including changes in physiology, growth, abundances, geographic placement and shifting seasonal timing are often not sufficient to cope with recent climate change (very high confidence). Climate change has caused local species losses, increases in disease (high confidence), mass mortality events of plants and animals (very high confidence), resulting in the first climate driven extinctions (medium confidence), ecosystem restructuring, increases in areas burned by wildfire (high confidence), and declines in key ecosystem services (high confidence)." *See* also, IUCN Issue Brief, Species and Climate Change ("Species are already being impacted by anthropogenic climate change, and its rapid onset is limiting the ability of many species to adapt to their environments. Climate change currently affects at least 10,967 species on the IUCN Red List of Threatened Species™, increasing the likelihood of their extinction.").

271 IBGP, IOC & SCOR, 2013. Ocean Acidification Summary for Policymakers – Third Symposium on the Ocean in a High- CO_2 World.

The information provided herein suffices for the Agency to determine that the present surfeit of these chemicals presents an imminent, widespread, severe and unreasonable risk of injury to health or the environment, so that EPA should initiate a civil action against fossil fuel companies to phase out production, release and the continuing disposal of these substances.

Further, Petitioners assert that the present concentrations of atmospheric CO_2 and CH_4 and ocean CO_2, combined with the certainty of worse to come absent emissions phaseout and removal, amply meets the TSCA unreasonable risk standard. Moreover, there is strong evidence that the benefits of strong action to reduce CO_2 and CH_4 concentrations outweigh the costs,[272, 273] i.e., the benefits based on the risk avoided and economic payback derived from increased reliance on clean energy and removal of excess atmospheric concentrations of CO_2 and CH_4 are calculated in the trillions of dollars. Global, country, and industry-wide analyses estimate a positive balance of benefit over cost for various mitigation options the Agency could select, and numerous analyses show that even with uneven initial participation by some countries, the goal of keeping or returning warming to below 1.5°C still may be attained. These facts alone, given the enormity of the existential risk from global warming and ocean impacts, and the dire consequences of not acting quickly, require the Agency to initiate rule making under TSCA.

Petitioners herein present data on (a) the socio-economic costs of CO_2 and CH_4 pollution, (b) the feasibility of controls on CO_2 and CH_4, and (c) the social cost of carbon including the costs of delaying action to reduce and mitigate CO_2 and CH_4 pollution. Ultimately it is the responsibility of the Agency to gather all the necessary information, develop robust options and decide how to proceed, in order to comply with the intent of Congress, i.e., that the Administrator shall carry out this chapter in a reasonable and prudent manner, considering the environmental, economic, and social impact of any action the Administrator takes or proposes.[274]

(a) Socioeconomic Costs, and Benefits

The release of CO_2 and CH_4 into the environment is already imposing substantial social and economic impacts, and these will become ever more damaging upon additional loading of the atmosphere with these dangerous gases. Primary economic concerns include the lost functionality of coastal cities and regions, agricultural degradation and collapse, lost worker productivity, loss of life from migration-related civil unrest and war, and loss of fisheries and increased food insecurity.

1. US economic risks from unabated climate change

Volume II of the Fourth National Climate Assessment (NCA4) (2018) focuses on "the human welfare, societal, and environmental elements of climate change and variability for 10 regions and 18 national topics, with particular attention paid to observed and projected risks, impacts, consideration of risk reduction, and implications under different mitigation pathways."[275] The Environmental Protection Agency is one of 13 federal agencies comprising

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272 https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30029-9/fulltext

273 https://www.tandfonline.com/doi/full/10.1080/14693062.2020.1724070

274 TSCA §2601. Findings, policy, and intent.

275 *See* https://nca2018.globalchange.gov/chapter/front-matter-about/

"the Subcommittee on Global Change Research of the Committee on Environment within the National Science and Technology Council,"[276] that helped to provide "several rounds of technical and policy review" of that volume.[277] In the light of its high-quality, we directly incorporate and cite relevant portions of that volume's summary chapter (Chapter 1) in the duration of this sub-section, while omitting internal references for ease of reading.[278]

> Without more significant global greenhouse gas mitigation and regional adaptation efforts, climate change is expected to cause substantial losses to infrastructure and property and impede the rate of economic growth over this century. Regional economies and industries that depend on natural resources and favorable climate conditions, such as agriculture, tourism, and fisheries, are increasingly vulnerable to impacts driven by climate change. Reliable and affordable energy supplies, which underpin virtually every sector of the economy, are increasingly at risk from climate change and weather extremes. The impacts of climate change beyond our borders are expected to increasingly affect our trade and economy, including import and export prices and U.S. businesses with overseas operation and supply chains). Some aspects of our economy may see slight improvements in a modestly warmer world. However, the continued warming that is projected to occur without significant reductions in global greenhouse gas emissions is expected to cause substantial net damage to the U.S. economy, especially in the absence of increased adaptation efforts. The potential for losses in some sectors could reach hundreds of billions of dollars per year by the end of this century.
>
> Existing water, transportation, and energy infrastructure already face challenges from heavy rainfall, inland and coastal flooding, landslides, drought, wildfire, heat waves, and other weather and climate. Many extreme weather and climate-related events are expected to become more frequent and more intense in a warmer world, creating greater risks of infrastructure disruption and failure that can cascade across economic sectors. For example, more frequent and severe heat waves and other extreme events in many parts of the United States are expected to increase stresses on the energy system, amplifying the risk of more frequent and longer-lasting power outages and fuel shortages that could affect other critical sectors and systems, such as access to medical. Current infrastructure is typically designed for historical climate conditions and development patterns—for instance, coastal land use—generally do not account for a changing climate, resulting in increasing vulnerability to future risks from weather extremes and climate. Infrastructure age and deterioration make failure or interrupted service from extreme weather even more likely. Climate change is expected to increase the costs of maintaining, repairing, and replacing infrastructure, with differences across regions.
>
> Recent extreme events demonstrate the vulnerabilities of interconnected economic sectors to increasing risks from climate change. In 2017, Hurricane Harvey dumped an unprecedented amount of rainfall over the greater Houston area, some of which

[276] https://www.globalchange.gov/agencies

[277] https://nca2018.globalchange.gov/chapter/front-matter-about/

[278] Petitioners direct the reader to https://nca2018.globalchange.gov/chapter/1/ for such further detail.

has been attributed to human-induced climate change. Resulting power outages had cascading effects on critical infrastructure facilities such as hospitals and water and wastewater treatment plants. Reduced oil production and refining capacity in the Gulf of Mexico caused price spikes regionally and nationally from actual and anticipated gasoline shortages. In the U.S. Caribbean, Hurricanes Irma and Maria caused catastrophic damage to infrastructure, including the complete failure of Puerto Rico's power grid and the loss of power throughout the U.S. Virgin Islands, as well as extensive damage to the region's agricultural industry. The death toll in Puerto Rico grew in the three months following Maria's landfall on the island due in part to the lack of electricity and potable water as well as access to medical facilities and medical care.

Climate-related risks to infrastructure, property, and the economy vary across regions. Along the U.S. coastline, public infrastructure and $1 trillion in national wealth held in coastal real estate are threatened by rising sea levels, higher storm surges, and the ongoing increase in high tide flooding. Coastal infrastructure provides critical lifelines to the rest of the country, including energy supplies and access to goods and services from overseas trade; increased damage to coastal facilities is expected to result in cascading costs and national impacts. High tide flooding is projected to become more disruptive and costlier as its frequency, depth, and inland extent grow in the coming decades. Without significant adaptation measures, many coastal cities in the Southeast are expected to experience daily high tide flooding by the end of the century. Higher sea levels will also cause storm surge from tropical storms to travel farther inland than in the past, impacting more coastal properties and infrastructure. Oil, natural gas, and electrical infrastructure located along the coasts of the Atlantic Ocean and Gulf of Mexico are at increased risk of damage from rising sea levels and stronger hurricanes; regional disruptions are expected to have national implications. Hawai'i and the U.S.-Affiliated Pacific Islands and the U.S. Caribbean also face high risks to critical infrastructure from coastal flooding, erosion, and storm surge.

In the western United States, increasing wildfire is damaging ranches and rangelands as well as property in cities near the wildland–urban interface. Drier conditions are projected to increase the risk of wildfires and damage to property and infrastructure, including energy production and generation assets and the power grid. In Alaska, thawing of permafrost is responsible for severe damage to roads, buildings, and pipelines that will be costly to replace, especially in remote parts of Alaska. Alaska oil and gas operations are vulnerable to thawing permafrost, sea level rise, and increased coastal exposure due to declining sea ice; however, a longer ice-free season may enhance offshore energy operations and transport. These impacts are expected to grow with continued warming.

U.S. agriculture and the communities it supports are threatened by increases in temperatures, drought, heavy precipitation events, and wildfire on rangelands. Yields of major U.S. crops (such as corn, soybeans, wheat, rice, sorghum, and cotton) are expected to decline over this century as a consequence of increases in temperatures and possibly changes in water availability and disease and pest outbreaks. Increases in growing season temperatures in the Midwest are projected to be the largest contributing factor to declines in U.S. agricultural. Climate change is also expected to lead to large-scale shifts in the availability and prices of many agricultural products across the world, with corresponding impacts on U.S. agricultural producers and the U.S. economy.

Extreme heat poses a significant risk to human health and labor productivity in the agricultural, construction, and other outdoor sectors. Under a higher scenario (RCP8.5), almost two billion labor hours are projected to be lost annually by 2090 from the impacts of temperature extremes, costing an estimated $160 billion in lost wages. States within the Southeast and Southern Great Plains regions are projected to experience some of the greatest impacts.

2. A closer look at ocean-based economic risks from unabated climate change

a. Sea-level rise economic risks

According to a recent Center on Public Integrity study – one that employed highly conservative assumptions – the United States faces more than $400 billion in costs over the next 20 years to defend coastal communities from unavoidable sea-level rise – requiring the construction of more than 50,000 miles of coastal barriers in 22 states.[279] More than 130 counties face at least $1 billion in costs, and 14 states will see expenses of $10 billion or greater between now and 2040. These costs reflect the bare minimum coastal defenses that communities need to build to hold back rising seas and prevent chronic flooding and inundation over the next 20 years. Unless action begins now to hold temperature rise to 1.5 ºC, costs for adaptation and public health impacts,[280] including increases in water-borne diseases[281] and other morbidities,[282] will greatly increase.

A 2018 analysis[283] using a multi-model approach estimated the different impacts in terms of sea level rise for a temperature increase of 1.5 ºC and 2.0 ºC by 2100. Authors found a difference of 11 cm global sea level rise in 2100 between the two temperatures and estimated potential additional losses of $1.4 trillion per year (0.25% of global GDP) if no additional adaptation is assumed from the modelled adaptation in the base year. The study used the NOAA-funded, Coupled Model Intercomparison Project (CMIP5).[284] This coupled model combines data from three types of models – Atmosphere–Ocean, General Circulation, and Earth System – and simulated both long and short-term data sets.

If the current emissions trajectory isn't changed, the human impact and the costs will become far more extreme. The UK National Oceanographic Centre found flooding from rising

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279 Center for Climate Integrity, High Tide Tax: The Price to Protect Coastal Communities from Rising Seas (2019) at https://www.climatecosts2040.org/files/ClimateCosts2040_Report.pdf.

280 Allen, Thomas R., et al. "Linking water infrastructure, public health, and sea level rise: integrated assessment of flood resilience in coastal cities." *Public Works Management & Policy* 24.1 (2019): 110-139.

281 Dvorak, Ana C., et al. "Possible impacts of sea level rise on disease transmission and potential adaptation strategies, a review." *Journal of environmental management* 217 (2018): 951-968.

282 Vineis, Paolo, Queenie Chan, and Aneire Khan. "Climate change impacts on water salinity and health." *Journal of Epidemiology and Global Health* 1.1 (2011): 5-10.

283 Jevrejeva, Svetlana, et al. "Flood damage costs under the sea level rise with warming of 1.5 C and 2 C." *Environmental Research Letters* 13.7 (2018): 074014.

284 Taylor, Karl E., Ronald J. Stouffer, and Gerald A. Meehl. "An overview of CMIP5 and the experiment design." *Bulletin of the American meteorological Society* 93.4 (2012): 485-498

sea levels could cost more than $14 trillion worldwide *annually* by 2100, if global warming reaches 2 ºC above pre-industrial levels.[285]

A higher-end projection of 184 cm and a 95% quantile of 292 cm by 2100[286] was estimated by Le Bars et al, using a probabilistic process-based method. Uncertainties in the projections increase when including the temperature dependence of Antarctic mass loss and the uncertainty in the Coupled Model Intercomparison Project Phase 5 (CMIP5) model ensemble.

The costs required to respond to sea level rise are high and rising sharply. Sugiyama et al.[287] looked at four kinds of cost: protection cost; dryland/capital loss; wetland loss; and wetland gain. They found that, under an assumption of linear sea level rise, net wetland loss (wetland loss offset by gain) dominated costs, estimating that the cost of sea level rise[288] was $1,182B for global cost and loss.[289] As well, using purchasing power parity (PPP), they estimate $1,991B for global cost and loss (and $317B for the US).

A 2018 study[290] estimated global and coastal sea level projections with warming of 1.5 °C and 2 °C by 2100 and compared the costs associated with RCP8.5 business as usual temperature rise. They projected global sea-flood costs of $10.2 trillion per year (1.8% of GDP) without additional adaptation for sea level projections with warming of 1.5 °C by 2100. With adaptation they estimated costs could decrease to $1.1 trillion per year (0.2% GDP) for the same 1.5 °C scenario in 2100. If warming is not mitigated and follows the RCP8.5 scenario, global mean sea level could rise to 86 cm (median) or even 180 cm (95th percentile) by 2100. This could result in annual sea-flood costs of US$ 14 trillion per year and US$ 27 trillion per year, respectively, if no further adaptation were undertaken.[291]

Meeting the Paris Accord limits[292] could restrict sea level rise to about half of what it would be under the IPCC business as usual projections (RCP8.5). This would provide for a significant difference in risk, as "[t]he median global mean sea-level rise by 2100 is projected as 35 cm for RCP2.6 and 74 cm for RCP8.5"; and "under constant protection 0.2–2.9% of the global population is expected to be flooded annually in the year 2100 under RCP2.6 and 0.5–4.6% under RCP8.5."[293] Starting in about 20 years, the damage patterns from sea level rise-

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[285] Zhongming, Zhu, et al. "Rising sea levels could cost the world $14 trillion a year by 2100." UK NOC (2018).

[286] Le Bars, Dewi, Sybren Drijfhout, and Hylke de Vries. "A high-end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss." *Environmental Research Letters* 12.4 (2017): 044013.

[287] Sugiyama, Masahiro, Robert J. Nicholls, and Athanasios Vafeidis. Estimating the economic cost of sea-level rise. MIT Joint Program on the Science and Policy of Global Change, 2008.

[288] All in 1995 dollars.

[289] "Cost and loss" refers to protection cost, capital loss and wetland loss (net wetlands loss being the largest contributor).

[290] Jevrejeva, Svetlana, et al. "Flood damage costs under the sea level rise with warming of 1.5 C and 2 C." *Environmental Research Letters* 13.7 (2018): 074014

[291] The latter would equate to 2.7% of global GDP.

[292] This is ~ RCP2.6, which is includes atmospheric CO_2 eq peaking at 490ppm and then declining.

[293] Hinkel, Jochen, et al. "Coastal flood damage and adaptation costs under 21st century sea-level rise." *Proceedings of the National Academy of Sciences* 111.9 (2014): 3292-3297. In the constant protection strategy, dikes are maintained at their height, but not raised, so flood risk increases with time as relative sea level rises. In the enhanced protection strategy, dikes are raised following both relative sea-level rise and socioeconomic development (i.e., dikes are raised as the demand for safety increases with growing affluence and increasing population density) Dike costs comprise annual investment cost (for building and upgrading dikes) and the cost of maintaining the additional dike

induced flooding under different emissions scenarios begins to diverge sharply, so that the higher fossil fuel GHG emissions will impose trillions of additional costs on impacted communities.

The IPCC also found a doubling of sea level rise from RCP2.6 to RCP8.5.[294] In its Special Report on the impacts of global warming of 1.5°C , the IPCC projected that risks to global aggregated economic growth due to climate change impacts "would be lower at 1.5°C than at 2°C ," particularly "in the tropics and Southern Hemisphere subtropics."[295] The IPCC estimated that future rise in global mean sea level (GMSL) caused by thermal expansion, melting of glaciers and ice sheets and land water storage changes, will rise between 0.43 m (0.29–0.59 m, *likely* range; RCP2.6) and 0.84 m (0.61–1.10 m, *likely* range; RCP8.5) by 2100 relative to 1986–2005. Beyond 2100, sea level will continue to rise for centuries due to continuing deep ocean heat uptake and mass loss of the GIS and AIS and will remain elevated for thousands of years (*high confidence*). Under RCP8.5, estimates for 2100 are higher and the uncertainty range larger than in AR5. Antarctica could contribute up to 28 cm of SLR (RCP8.5, upper end of *likely* range) by the end of the century.[296] Keeping temperature rise to 1.5°C (versus 2°C) will reduce GMSL by about 100 cm.[297] Following the current business as usual, Zillow data indicates almost 1.9 million homes (or roughly 2 percent of all U.S. homes) – worth a combined $882 billion – are at risk of being underwater by 2100.[298]

b. Acidification-based economic risks

According to the Secretariat of the U.N. Convention on Biological Diversity, ocean acidification and warming will induce a loss of more than $1 trillion *annually* in marine food resources by disrupting marine communities, promoting harmful algal blooms and the spread of some diseases, and increasing contaminants in fish and shellfish[299]

The United Nations Environment Programme has also reported that ocean acidification's impact on marine organisms is a threat to food security,[300] posing a threat to fisheries resources and the billions of people that rely on a marine-based diet.[301] Seafood consumption has been

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stock built since the base year of 1995. In 2100, these costs range from US$ 12–31 billion under RCP2.6 to US$ 27–71 billion under RCP8.5.

[294] 2013: Sea Level Change. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[295] IPCC Special Report on 1.5°C , SPM-B.5.5. Similarly, *see* Kopp, Robert E., et al. "Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites." Earth's Future 2.8 (2014): 383-406.

[296] *See also*, Church, J.A., Clark, P.U., Cazenave, A., Gregory, J.M., Jevrejeva, S., Levermann, A., Merrifield, M.A., Milne, G.A., Nerem, R.S., Nunn, P.D. and Payne, A.J., 2013. Sea level change. PM Cambridge University Press.

[297] IPCC special report on the impacts of global warming of 1.5°C

[298] Rao, K., 2017. Climate Change and Housing: Will a Rising Tide Sink All Homes? https://www.zillow.com/research/climate-change-underwater-homes-12890/.

[299] Tirado, M.C. et al., 2010. Climate change and food safety: A review. Food Research International, 43(7), pp.1745–1765.

[300] UNEP, 2010. The Emissions Gap Report: Are the Copenhagen Accord pledges sufficient to limit global warming to 2°C or 1.5°C ?

[301] United Nations Environment Programme, 2010. Environmental consequences of ocean acidification: A threat to food security.

shown to prevent hundreds of thousands of premature deaths, as well as significantly reducing infant morbidity, so that a decline of seafood availability will increase deaths. Additionally, entire populations, including subsistence fishing populations and poor communities that depend on seafood, will suffer from the loss of this critical food source. For example, 95% of Alaskan households do some sort of subsistence fishing, and 17% of the state's population, 120,000 people, depend on subsistence fishing.[302] Many subsistence fishers also have cultural ties that are threatened by ocean acidification. Accordingly, CO_2 and CH_4 implicate severe social and environmental justice concerns.[303]

Not only will ocean acidification affect global food webs and ecosystems, it also will have a direct effect on the global economy. The U.S. economy is highly dependent on the health of the ocean. In 2009, the ocean economy contributed over US$ 223 billion annually to the U.S. gross domestic product and provided more than 2.6 million jobs.[304] In Washington State alone, the seafood industry generates $1.7 billion for gross state product and employs 42,000 people.[305] Already, shellfish hatchery failures in Washington have caused an economic stir and caused some hatcheries to relocate. Alaska's commercial fishing industry is valued at over $4 billion a year and supports 90,000 jobs; recreational fishing and fishing tourism add even more value.[306]

Tropical coral reefs provide ecosystem services, such as habitat and nursery functions for commercial and recreational fisheries and coastal protection. As reefs decline in warming and increasingly acidified waters, there will be an ecological shift to a new ecosystem state dominated by less commercially valuable species. Brander et al.[307] estimated the annual economic damage of ocean acidification-induced coral reef loss will escalate rapidly over time, reaching $870 billion by 2100. In an updated review, Brander et al.[308] estimated the annual anticipated loss of ecosystem services from coral loss to be $1 trillion. Shoreline protection afforded by coral reefs and the services they provide by preventing loss of life, property damage and erosion are also reduced by legacy and continuing CO_2 and CH_4 emissions.

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302 Mathis, J.T. et al., 2014. Ocean acidification risk assessment for Alaska's fishery sector. Progress in Oceanography.

303 Convention on Biological Diversity, 2014. An Updated Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity.

304 NOAA, http://oceanservice.noaa.gov/facts/oceaneconomy.html. *See also*, Cooley, Sarah R., and Scott C. Doney. "Anticipating ocean acidification's economic consequences for commercial fisheries." Environmental Research Letters 4.2 (2009): 024007.

305 Washington State Blue Ribbon Panel, 2012. Ocean Acidification : From Knowledge to Action, Washington State's Strategic Response.

306 Mathis, J. T., et al. "Ocean acidification risk assessment for Alaska's fishery sector." Progress in Oceanography 136 (2015): 71-91. Alaska is ranked among the most vulnerable areas to acidification.

307 Brander, Luke M., et al. "The economic impact of ocean acidification on coral reefs." Climate Change Economics 3.01 (2012): 1250002.

308 Brander, Luke M., et al. "The economic impacts of ocean acidification." Handbook on the Economics of Ecosystem Services and Biodiversity (2014): 78-92. *See also*, Lane, Diana, et al. "Climate change impacts on freshwater fish, coral reefs, and related ecosystem services in the United States." Climatic Change 131.1 (2015): 143-157 (modeling three major U.S. locations for shallow water reefs – South Florida, Puerto Rico, and Hawai'i – to project future reef cover and associated economic values to inform a GHG emissions mitigation scenario compared to a business as usual to estimate, for example, that reducing emissions would result in an "avoided loss" in Hawai'i of approximately $10.6 billion in recreational use).

Acidification impacts are so fundamental to the overall structure and function of marine ecosystems that any significant changes could have far-reaching consequences for the oceans of the future and the hundreds of millions of people that depend on its food and other resources for their livelihoods.[309] There is also a significant cost to delaying action. According to a recent report by the Council of Economic Advisers, delaying the implementation of policies to mitigate climate change could significantly increase economic damages, in addition to worsening environmental harm.[310]

While there are still large unknowns on the biological consequences of ocean acidification, the science we have is clear: from shellfish to corals, and from pteropods to fish, our marine resources are threatened by the acidification of our ocean waters, and these risks are amplified by synergistic effects from warming and deoxygenating oceans.[311]

A recent study estimated that the damage our oceans will face from emissions-related problems will amount to $428 billion a year by 2050 and nearly $2 trillion per year by the century's end.[312]

As was also mentioned *supra*, a recent study[313] of emissions traced to just 88 investor- and state-owned fossil fuel producers establishes their responsibility for half of the historical (1880–2015) decline in surface ocean pH. The research is critical to an assignment of associated damages and the cost of removing excess atmospheric CO_2 and CH_4.

3. A closer look at economic risks of climate extremes

As referenced earlier, some model estimates do not take full account of low probability or difficult-to-quantify effects that amplify and accelerate warming, such as unstable methane deposit releases from permafrost and the sea floor,[314] impacts to cloud albedo,[315] the observed effects on the ocean carbon pump, or the very likely and perhaps inevitable (absent swift action) collapse of major ice sheets.[316] Petitioners do not accept that all of these are low probability

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309 Doney, S.C. et al., 2009. Ocean acidification: the other CO2 problem. Annual Review of Marine Science, 1, pp.169–192.

310 Executive Office of the President of the United States, The Cost of Delaying Action to Stem Climate Change at 1 (July 2014).

311 *See also*, Hoagland P, Scatasta S. 2006. The economic effects of harmful algal blooms. In E Graneli and J Turner, eds., Ecology of Harmful Algae. Ecology Studies Series. Chap. 29 (discussing toxicity of harmful algal bloom increases under conditions of ocean acidification, which not only poison marine mammals but also cause paralytic shellfish poisoning in people. Scientists hypothesize that some of the increases in red tides off the coast of Southern California may be related to ocean acidification, though this has yet to be confirmed).

312 Noone, K., Sumaila, R. & Diaz, R., 2012. *Valuing the Ocean*: Draft Executive Summary, Stockholm Environment Institute.

313 Licker, Rachel, et al. "Attributing ocean acidification to major carbon producers." *Environmental Research Letters* 14.12 (2019).

314 Schaefer, K., T. Zhang, L. Bruhwiler, and A. P. Barrett (2011), Amount and timing of permafrost carbon release in response to climate warming, Tellus Series B: Chem. Phys. Met., DOI: 10.1111/j.1600-0889.2011.00527.x.; oven teal, Analysis of Permafrost Thermal Dynamics and Response to Climate Change in the CMIP5 Earth System Models, JOURNAL OF CLIMATE 2013

315Six K.D., Kloster S., Ilyina T., Archer S.D., Zhang.K, Maier-Reimer,E., Global warming amplified by reduced sulphur fluxes as a result of ocean acidification. Nature Climate Change

316 Pycroft, Jonathan, Lucia Vergano, and Chris Hope. "The economic impact of extreme sea-level rise: Ice sheet vulnerability and the social cost of carbon dioxide." Global environmental change 24 (2014): 99-107. *See also* discussion, *op cit*, of *Ice Melt* study by Petitioner Hansen et al.

events in the case of continued high emissions. But even for those that may be denominated as relatively low probability, because of their fateful consequences they must be accounted for by EPA either as a deterministic estimate or, as suggested by Weitzman,[317] as a probability density function. Otherwise, the Agency's rulemaking will not be based on a true representation of all critical potential costs and benefits.

Pycroft *et al.*[318] looked at the importance for the social cost of carbon to incorporate the possibility of extreme sea-level rise. They incorporated three types of "fat tails" associated with the effect of elevated temperature on sea level rise allowing for, and representing in the damage function, the possibility that the physical consequences of greenhouse gases and/or the consequent economic damages might be very high. They found that incorporating the possible collapse of ice sheets "by adding thin, medium or fat tails to the climate sensitivity and damage exponents" raises the mean value for the social cost of carbon dioxide. When tails for the two parameters are normally distributed, the mean value of the social cost of carbon dioxide rises to \$135/t CO_2 (33% above the standard model), when using lognormal distributions the mean value is \$147/t CO_2 (44% above), and when using Pareto distributions the mean is \$218/tCO_2 109% above).

The effects on the social cost of carbon dioxide range show a consistent asymmetry. As expected, the 5th and 50th percentile values do not change significantly, while a more substantial increase is registered for the 95th and 99th percentiles. The 95th percentile for the social cost of carbon dioxide is \$489/ tCO_2 with the tails normally distributed and \$839/t CO_2 with the Pareto distribution (112% and 263% above the standard values). It should be noted here that EPA often has credited 95th[319] or higher percentile[320] impacts in one or more aspects of each risk assessment, e.g., for exposure or effect. But none of such previous uses of the 95th or higher percentile presented an equivalently devastating magnitude or potential risk as is presented by the over-concentration of CO_2 and CH_4 – including, e.g., from the potential of ice sheet collapse.

Executive Order 12866[321] clearly requires accounting of low probability high impact events in EPA's risk and benefit analysis. As was observed by a group convened by OMB to describe "best practices" for preparing the economic analysis of any significant regulatory action pursuant to E.O 12866, "risk assessments should be conducted in a way that permits their use in a more general benefit-cost framework," so that they characterize, in part, "the probabilities of

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317 Weitzman, Martin L. "On modeling and interpreting the economics of catastrophic climate change." The Review of Economics and Statistics 91.1 (2009): 1-19.

318 *Id.*

319 e.g., the U.S. Ambient Water Quality Criteria for Protection of Aquatic Life are based on Species Sensitivity Distributions (SSDs), with the criteria set at the fifth percentile, they can be interpreted as protecting at least 95% of the species in a community.

320 We note, for instance, that EPA uses the 99.9 percentile for exposure in regulating pesticide food tolerance, when determining the threshold of concern for pesticide consumption. A lower percentile may be used if the risk assessment contains a number of "conservative" assumptions that might result in overestimates of risk at the 99.9th percentile. However, as noted in this petition, because many potential climate amplifying effects are ignored, the warming, acidification and other deleterious effect estimates cannot be characterized as at all conservative.

321 *See* https://www.reginfo.gov/public/jsp/Utilities/EO_12866.pdf.

occurrence of outcomes of interest" and provide "a valuation of the levels and changes in risk experienced by affected populations as a result of the regulation."[322]

Petitioners note that, according to the U.S. Global Change Research Program, in the period January 1980 through December 2020, the U.S. experienced 290 weather and climate disasters with damage costs reaching or exceeding $1 billion[323] for each individual event. The cumulative costs for these 290 events exceed $1.9 trillion. Figure 20 depicts these events; the trend is clear enough.

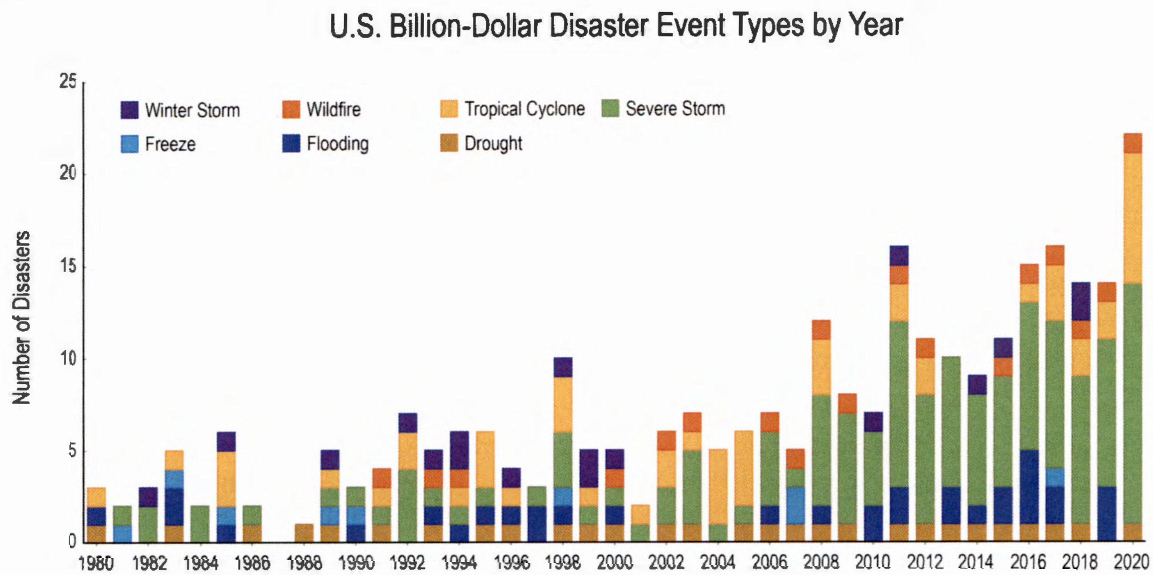

Fig. 20: Billion-dollar disaster events. Research and graphic from the U.S. Global Change Research Program

4. Accounting for climate action co-benefits

Local air quality co-benefits[324] amplify the beneficial impact of climate action, including by reducing premature deaths from air pollution. Vandyke et al,[325] showed that the transformation of the energy system implied by the emission reduction pledges of the Paris Agreement on climate change substantially reduces local air pollution across the globe. The Nationally Determined Contributions (NDCs), if achieved, could avoid between 71 and 99 thousand premature deaths annually in 2030 compared to a reference case, depending on the stringency of direct air pollution controls. The same study determined that if NDCs were strengthened so that they were actually consistent with Paris Agreement requirements (itself a wholly-inadequate target in light of the impacts of that level of warming on human and natural

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322 Economic Analysis of Federal Regulations Under Executive Order 12866, OMB, 1996, available at https://georgewbush-whitehouse.archives.gov/omb/inforeg/riaguide.html#iii.

323 https://www.globalchange.gov/browse/indicators/billion-dollar-disasters

324 Aldy, Joseph E., et al. Co-Benefits and Regulatory Impact Analysis: Theory and Evidence from Federal Air Quality Regulations. No. w27603. National Bureau of Economic Research, 2020.

325 Vandyck, Toon, et al. "Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges." *Nature communications* 9.1 (2018): 1-11.

systems) then substantially more premature deaths from air pollution would be avoided –between 178–346 thousand annually in 2030, and up to 0.7–1.5 million in the year 2050. Air quality co-benefits on morbidity, mortality, and agriculture could globally offset the costs of climate policy.

McCollum et al.,[326] using a single integrated assessment model, assessed just the benefits from energy security improvement, climate change mitigation, and the reduction of air pollution and its human health impacts accrued by keeping warming under 2°C . They found that total cost savings were between 0.1 % and 0.7 % of globally-aggregated GDP in 2030. While the steps taken in their analysis add to energy system expenditures, the analysis showed that these costs will be substantially compensated for by the corresponding reductions of air pollution control and energy security expenditures.

Petitioners are aware that while the impact of non-fossil fuel energy is complicated for pollutants such as NO_x and SO_2 that are already subject to emissions cap and trade programs, there are many pollutants other than CO_2 that pose serious adverse health and environmental impacts, including fine particulate matter, volatile organic compounds, and trace heavy metals *not* currently subject to emissions trading requirements. Emissions of these pollutants will be reduced when fossil fuel generation is reduced, and the health and environmental benefit from reduction of these pollutants need to be accounted for as benefits, to the extent each regulatory option considered includes them.

In particular, exposure to ambient fine particulate matter (PM) air pollution from fossil fuels is a major risk for premature death. Warmer temperatures speed up these reactions. When we breathe, particulate matter is pulled into our nose and lungs. Its presence in our bodies triggers inflammation. Many diseases and conditions are linked to inflammation – and by extension therefore are linked to polluted air. Particulate matter comes in many sizes – with the largest particles not making it much past our noses – because of a primary filtration process that takes place. With smaller particles it's a different story. The smaller the particle, the better it is at escaping our body's defenses. Ultrafine particulate matter is especially dangerous because it can cross directly from lung tissue into the bloodstream where it is then carried throughout the body, as illustrated in Figure 21. Research, already confirmed in nonhuman primates, suggests that in humans ultra-fine particulate matter also crosses the nasal mucosa to pass directly into the brain – transported via nerve endings.[327] These smaller particles, e.g., PM1 and PM0.1, present a greater risk because they penetrate further into the body. PM 0.1 indeed presents the most grievous risk as it readily crosses the alveoli into the blood stream, and then cross the blood brain barrier—inducing inflammation in the brain as well as other organs.

326 McCollum et al, Climatic Change (2013) 119:479–494.

327 Obederdöster, G., Elder, A., & Rinderknecht, A. (2009). Nanoparticles and the brain: Cause for concern? *Journal of Nanoscience and Nanotechnology, 9*, 4996–5007.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3804071/pdf/nihms-507989.pdf

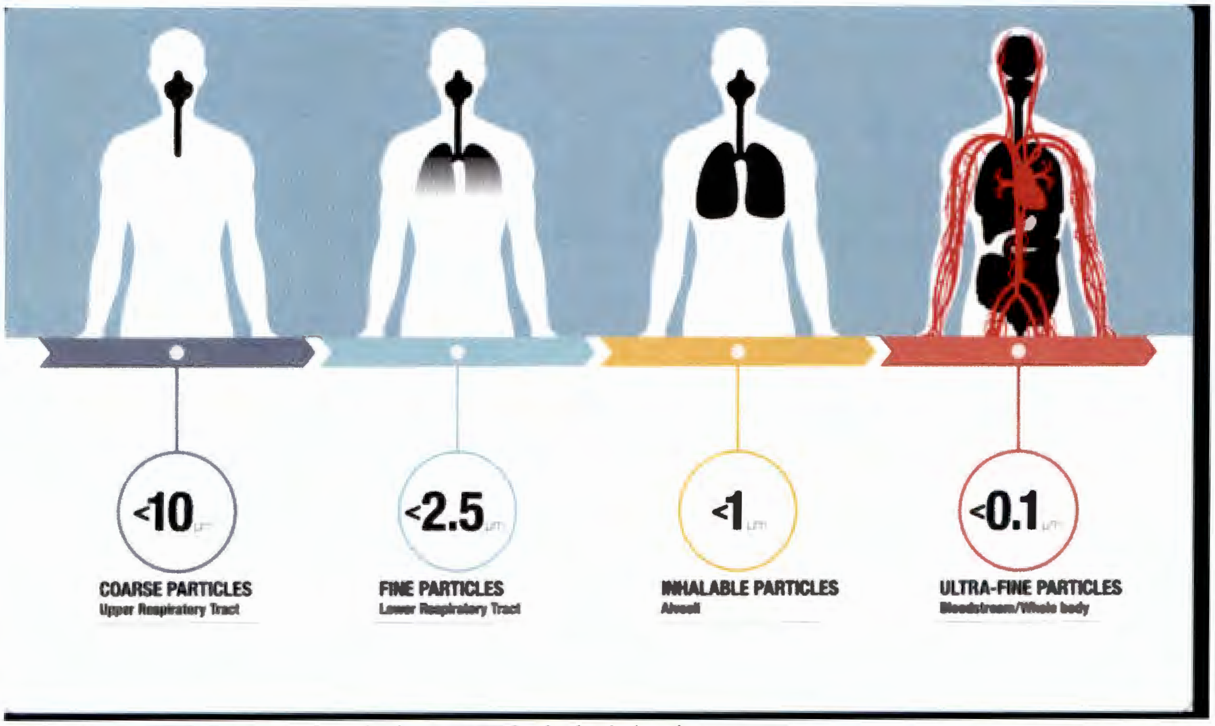

Figure 21: Transport of particulate matter in the body by size

Evidence is mounting that inflammation of brain tissue from air pollution is linked to dementia, including Alzheimer's type; to being a comorbidity factor in the development and exacerbation of symptoms of Parkinson's disease, and to amyotrophic lateral sclerosis (ALS).[328] Even intermittent exposure to exhaust PM air pollution cause both a decline in neurogenesis in some areas of the brain and an increase in other parts, and is accompanied by inflammation.[329] Reducing fossil fuel combustion will decrease this risk.[330]

Evidence supports a link between the role of neuro-inflammation in classic psychiatric illness and major depressive disorders, bipolar disorder, schizophrenia, and obsessive-compulsive disorders (Souhel, Pearlman, Alper, Najjar, & Devinsky, 2013[331]). Air pollution is

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[328] Calderón-Garcidueñas, L., & Villareal-Ríos, R. (2017). Living close to heavy traffic roads, air pollution, and dementia. *The Lancet, 389*, 675–677; Chen, C.-Y., Hung, H.-J., Chang, K.-H., Chung, Y. H., Muo, C.-H., Tsai, C.-H., et al. (2017). Long-term exposure to air pollution and the incidence of Parkinson's disease: A nested case-control study. *PLoS One, 12*(8), e0182834; Seelen, M., Toro Campos, R. A., Veldink, J. H., Visser, A. E., Hoek, G., Brunekreef, B., van der Kooi, A. J., de Visser, M., Raaphorst, J., van den Berg, L. H., & Vermeulen, R. C. (2017). Long-term air pollution exposure and amyotrophic lateral sclerosis in Netherlands: A population-based case-control study. *Environmental Health Perspectives, 125*, 097023.

[329] Rivas-Arancibia, Selva, et al. "Oxidative stress caused by ozone exposure induces loss of brain repair in the hippocampus of adult rats." *Toxicological Sciences* 113.1 (2010): 187-197.

[330] *See* World Health Organization, COP26 Special Report on Climate Change and Health

The Health Argument for Climate Action, October 2021 at https://www.who.int/publications/i/item/cop26-special-report.

[331] Souhel, N., Pearlman, D., Alper, K., Najjar, A., & Devinsky, O. (2013). Neuroinflammation and psychiatric illness. *Journal of Neuroinflammation, 10*, 43.

also associated with increased psychosis in adolescents.[332] Even *low levels of pollution*—primarily from traffic—are associated with an increased risk of mental illness in children.[333] The American Psychological Association reported that children exposed to particulate matter were more likely to have "brain and damaged tissue in the prefrontal cortex," as well as lower test scores with respect to "memory, cognition and intelligence."[334] Researchers have also established a statistically-significant association between emergency room visits for anxiety—including panic attacks and threats to commit suicide—and air pollution.[335]

Petitioners anticipate that the incidence of these diseases and impacts will rise; they already bring an economic burden in the hundreds of billions of dollars. The cost in human suffering alone amplifies the case that continued use of fossil fuels threatens public health.[336, 337, 338]

While particulate matter is formed by a range of anthropogenic activities, fossil fuel combustion is the primary source. *See* Figure 22.[339] Wildfire smoke and dust, the major natural sources, are also increased by global warming. Accordingly, addressing warming by phasing out fossil fuels, reducing other GHG sources, and removing excess atmospheric CO_2 and methane—with the attendant resulting temperature moderation – accordingly will reduce the sources of fine and superfine PM in the troposphere.

Using data from the Global Burden of Disease project and actuarial standard life table methods, Apte et al[340] estimated global and national decrements in life expectancy that can be attributed to ambient PM2.5 for 185 countries. In 2016, PM2.5 exposure reduced average global life expectancy at birth by ~1 year with reductions of ~1.2−1.9 years in polluted countries of Asia and Africa. While more polluted countries would have greater increases in life expectancy from reduced air pollution and reduced particulate matter, countries at all levels of economic

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332 Newbury, J. B., Arseneault, L., Beevers, S., et al. (2019). Association of air pollution exposure with psychotic experiences during adolescence. *JAMA Psychiatry, 76*, 614–623.

333 Oudin, A., Bråbäck, L., Åström, D. O., Strömgren, M., & Forsberg, B. (2016). Association between neighbourhood air pollution concentrations and dispensed medication for psychiatric disorders in a large longitudinal cohort of Swedish children and adolescents. *BMJ Open 6*:e010004.

334 Weir, K. (2012). Smog in our brains: Researchers are identifying startling connections between air pollution and decreased cognition and well-being. *American Psychological Association, 43*, 32. https://www.apa.org/monitor/2012/07-08/smog

335 Szyszkowicz, M., Willey, J. B., Grafstein, E., Rowe, B., & Colman, I. (2010). Air pollution and emergency department visits for suicide attempts in Vancouver, Canada. *Environmental Health Insights, 4*, 79–86.

336 Gladman, M., & Zinman, L. (2015). *The economic impact of amyotrophic lateral sclerosis: A systematic review.* National Center for Biotechnology Information, U.S. National Library of Medicine.

337 Kirson, N., Desai, U., Ristovska, L., Cummings, A. K., Birnbaum, H., Ye, W., et al. (2016). Assessing the economic burden of Alzheimer's disease patients first diagnosed by specialists. *BMC Geriatrics, 16*, 138.

338 Kowal, S.L., Dall, T. M., Chakrabarti, R., Storm, M.V., & Jain, A. (2013). *The current and projected economic burden of Parkinson's disease in the United States.* Movement Disorders Society. US National Library of Medicine National Institutes of Health.

339 Karagulian, Federico, et al. "Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level." *Atmospheric environment* 120 (2015): 475-483.

340 Joshua S. Apte, Michael Brauer, Aaron J. Cohen, Majid Ezzati, and C. Arden Pope, *Environmental Science & Technology Letters* **2018** *5* (9), 546-551

development could experience gains in life expectancy on par with reducing other well recognized threats to public health.

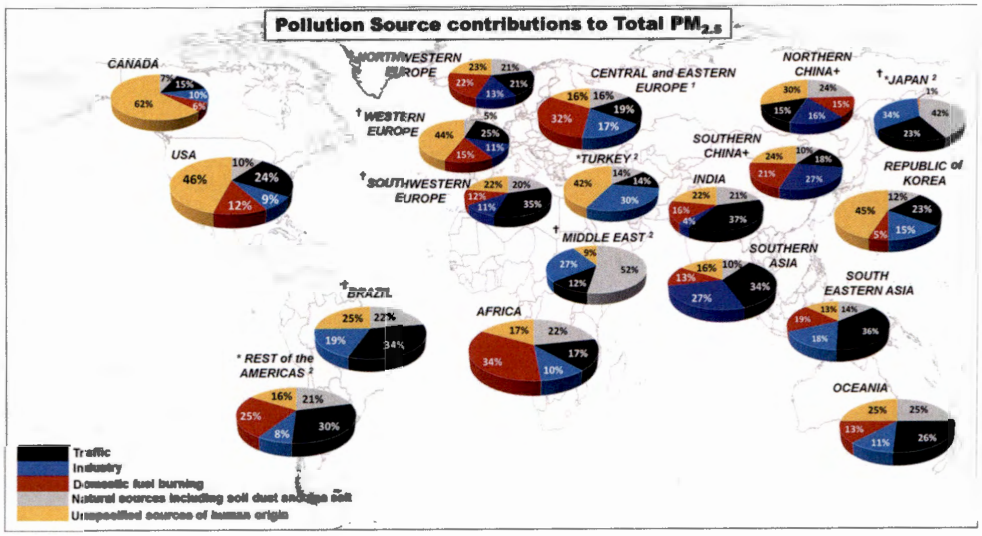

Figure 22: PM2.5 Sources by area[341]

Yang et al.[342] used the Environmental Benefits Mapping and Analysis Program to estimate the health and economic impacts of projected changes in O_3 and PM2.5 in the U.S. in a future (2046–2055) decade relative to the current (2001–2010) decade under the Representative Concentration Pathway (RCP) 4.5 and 8.5 climate scenarios. This petition asks that carbon emissions be held significantly under what these pathways estimate. The instant petition asks for CO_2 to be stabilized by 2100 at a little more than half of the RCP 4.5 and a quarter or the RCP 8.5 scenarios. Accordingly, the estimate by the aforementioned authors greatly underestimates the actual benefits in mortality and morbidity.

Even so, the benefits calculated for the US are highly significant. Comparing the decades 2001-10 with 2045-55 for the US, they estimated over 38,000 deaths avoided in the decades 2046-55 and $55,354 million in additional costs due to projected higher O_3 under RCP8.5 relative to RCP4.5. (Again, the benefits anticipated under the instant petition would be much larger.)

A recent *Lancet* study[343] used an additive model to examine the relationship between long-term exposure to the combustion products fine particulate matter <PM$_{2.}$, and tropospheric ozone, and hospital admissions among Medicare patients (2000-2016). The study looked at cardiovascular and respiratory outcomes (myocardial infarction, ischemic stroke, atrial fibrillation and flutter, and pneumonia). They found that "[l]ong-term exposure to air pollutants

341 Karagulian, Federico, et al. "Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level." *Atmospheric environment* 120 (2015): 475-483.

342 Yang, Peilin, et al. "Health impacts and cost-benefit analyses of surface O3 and PM2. 5 over the US under future climate and emission scenarios." *Environmental research* 178 (2019): 108687.

343 Danesh Yazdi, Mahdieh, et al. "Long-Term Association of Air Pollution and Hospital Admissions Among Medicare Participants Using a Doubly Robust Additive Model." *Circulation* 143.16 (2021): 1584-1596.

poses a significant risk to cardiovascular and respiratory health among the elderly population in the United States, with the greatest increase in the association per unit of exposure occurring at lower concentrations." In particular, they found that each 1 μg/m³ increase in annual $PM_{2.5}$ increased absolute annual risk of death by 0.073% (95% CI 0.071–0.076) and each 1 ppb increase in summer O_3 concentrations increased the annual risk of death by 0.081% (0.080–0.083). These translated to approximately 11,540 attributable deaths (95% CI 11,087–11,992) for $PM_{2.5}$, and 15,115 attributable deaths (14,896–15,333) for O_3 per year for each unit increase in pollution concentrations. The effects were higher in certain subgroups, including individuals living in areas of low socioeconomic status. These considerations are relevant here, since TSCA directs EPA to identify and protect "potentially exposed or susceptible sub-populations,"[344] which would include individuals living in areas of low socioeconomic status.

Lelieveld et al[345] estimated that globally, fossil-fuel-related emissions account for about 65% of the excess mortality imposed by air pollution. They relied upon Atmospheric Chemistry – Climate (EMAC)[346] model to estimate the climate and health outcomes attributable to fossil fuel use, indicating the potential benefits of a phaseout and estimated 3.61 (2.96–4.21) million deaths per year could be avoided worldwide by reducing and, for some uses, eliminating combustion of fossil fuels. This could be up to 5.55 (4.52–6.52) million per year by additionally controlling non fossil anthropogenic sources.

Peters et al.[347] found, in a systematic review of literature,[348] that greater exposure to airborne pollutants, particularly PM, is associated with increased risk of dementia. Because many of the studies used quantiles and/or different statistical methods, no meta-analysis was done.

TSCA provides regulatory and incentivized pathways to reduce particulate matter and ozone. Making combustion less competitive through fees targeting market failures, or emission limits, would ensure a market for non- and less polluting alternatives and encourage their development. Germany, e.g., has increased its green energy profile from less than 3%[349] to about

344 The term "potentially exposed or susceptible subpopulation" means a group of individuals within the general population identified by the Administrator who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, low-wage workers, the elderly, or persons with pre-existing respiratory disease.

345 Lelieveld, J., et al. "Effects of fossil fuel and total anthropogenic emission removal on public health and climate." *Proceedings of the National Academy of Sciences* 116.15 (2019): 7192-7197. The authors attempted to take into account the global temperature and potential hydrologic impacts from removing fossil fuel aerosol pollution. They suggest that such aerosol pollution, if removed, could help restore rainfall patterns (ameliorating long-term drought) in Asia, the Sahel, and elsewhere, but at the cost of "liberating," that is, unlocking considerable additional warming. The study authors recommend, therefore, that "to reverse the major impacts on public health, regional climate, water supply, and food production," a phaseout of other anthropogenic emissions sources of CH4 and black carbon should be pursued in conjunction with a phaseout of fossil fuels.

346 EMAC comprehensively simulates atmospheric chemical and meteorological processes and interactions with the oceans and the biosphere.

347 Peters, Ruth, et al. "Air pollution and dementia: a systematic review." *Journal of Alzheimer's Disease* 70.s1 (2019): S145-S163.

348 Medline, Embase, and PsychINFO® were searched from their inception to September 2018, for publications reporting on longitudinal studies of exposure to air pollution and incident dementia or cognitive decline in adults

349 Wüstenhagen, Rolf, and Michael Bilharz. "Green energy market development in Germany: effective public policy and emerging customer demand." *Energy policy* 34.13 (2006): 1681-1696.

46% in 2020,[350] using a combination of subsidies, incentives and encouragement of consumer demand.[351]

TSCA §§ 2605 and 2606 can be used to reduce the emission of CO_2, through limits and fees, and thereby also limit the formation of much particulate matter. There is considerable literature on the ability of both Market Pull policies or Technology Push policies to increase the rate of innovation.[352] While not all of these sequestration technologies/methods are available at the current time to provide significant mitigation, they could be in the near future given proper market incentives and rules. In any case, the Agency has a successful history of setting regulatory "reach" targets (e.g., CAFE standards).

Under TSCA §2608, the Administrator would also be encouraged to fully use CAA authority to lower CAFE standards, while under section TSCA §§ 2611, 2612 and 2614, EPA can seize and/or impose fees on imports and exports that in their manufacture fail to meet the requirements of section 2605.

XII. In Conclusion

The evidence adduced in this Part amply establishesvthat the manufacture, distribution, use and disposal of the subject chemical substances and mixtures present an unreasonable risk to both health and the environment.

The Agency should act without delay to grant the petition. It should then proceed to render the TSCA determination and commence rulemaking to fashion and impose a set of requirements pursuant to TSCA §6, 15 USC §2605. The aim must be to place our nation on a secure path to achieve net-zero emissions, or better, well prior to 2050.

Securing that path is necessary not merely to honor our recent international commitments, but to reclaim a leadership position among nations with respect to the crisis.

Petitioners have demonstrated herein, including in Part I, that existing law suffices to commence a full decarbonization program in the United States. Indeed, TSCA provides both on-point and ample authority to the President and the Agency.

Petitioners and their Counsel stand ready to respond to any requests for clarification by the Agency and others on the President's climate team. There can be no doubt: we face an existential threat, as the President has observed. And so there is work to be done to contain that threat, and thus to secure a viable future for our children and future generations. Together, in reason, on the basis of the relevant evidence, and with all deliberate speed, we can work to avert added injury by protecting and restoring a functioning, habitable climate system.

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[350] BMW1, 8th Monitoring Report on the Energy Transition (2021)

[351] Sunstein, Cass R., and Lucia A. Reisch. "Automatically green: Behavioral economics and environmental protection." *Harv. Envtl. L. Rev.* 38 (2014): 127. *See also*, Fischedick, Manfred. "German energy transition: targets, current status, chances and challenges of an ambitious pathway." (2019).

[352] "Impact of Renewable Energy Policy and Use on Innovation, A Literature Review," Felix Groba and Barbara Breitschopf 2013, Deutsches Institut für Wirtschaftsforschung.