Government Climate and Energy Policies Must Target <350 ppm Atmospheric CO_2 by 2100 to Protect Children and Future Generations (March 2021)

INTRODUCTION

Human laws can adapt to nature's laws, but the laws of nature will not bend for human laws. Government climate and energy policies **must** be based on the best available science to protect our climate system and vital natural resources on which human survival and welfare depend, and to ensure the fundamental rights of young people and future generations are protected.

Because carbon dioxide (CO_2) is the primary driver of Earth energy imbalance (EEI), climate destabilization, and ocean warming and acidification, all government policies regarding CO_2 emissions and CO_2 sequestration should be aimed at reducing global CO_2 concentrations **below 350 parts per million (ppm) by 2100**. Global mean atmospheric CO_2 levels, as of 2020, are approximately 412 ppm and rising.[1] With timely action, an emission reductions and sequestration pathway back to <350 ppm could limit peak warming to approximately 1.3°C this century and stabilize long-term heating this century at ~1°C above pre-industrial temperatures with further reductions next century. The temperature of the Earth, much like sea level rise, is a measurable indicator of the CO_2 problem, but it is not a good metric for solving it. EEI and CO_2 levels provide measurable standards, with CO_2 emission reductions and sequestration the measurable means to meet those standards.

As explained in more detail below, there are numerous scientific bases and lines of evidence supporting setting <350 ppm by 2100 as the uppermost safe limit for atmospheric CO_2 concentrations and global warming. Beyond 2100, atmospheric CO_2 may need to return to well below 350 ppm and closer to the preindustrial level of ~280 ppm to prevent the complete melting of Earth's ice sheets and protect coastal cities from sea level rise. Fortunately, it is still not only technically and economically feasible to return to <350 ppm by 2100, but transitioning to clean energy sources will provide significant economic and public health benefits and improve quality-of-life.

WHY GOVERNMENTS MUST AIM FOR <350 PPM AND RESTORING EARTH ENERGY BALANCE

Three lines of robust and conclusive scientific evidence, based on the paleo-climate record and real-world observations, show that above an atmospheric CO_2 concentration of 350 ppm there is: 1) significant Earth energy imbalance; 2) massive ice sheet destabilization and sea level rise; and 3) ocean warming and acidification resulting in the bleaching death of coral reefs and other marine life.

[1] Ed Dlugokencky & Pieter Tans, NOAA/GML, www.esrl.noaa.gov/gmd/ccgg/trends/.

1) Earth Energy Imbalance

Scientists say the "Earth energy imbalance (EEI) is the most critical number defining the prospects for continued global warming and climate change."[2] "Stabilization of climate, the goal of the universally agreed United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Paris Agreement in 2015, requires that EEI be reduced to approximately zero to achieve Earth's system quasi-equilibrium."[3] Earth's energy flow is significantly out of balance. Because of a buildup of CO_2 (and to a lesser extent other greenhouse gases) in our atmosphere, due to human activities, primarily the burning of fossil fuels and deforestation,[4] more solar energy is retained in our atmosphere and less energy is released back into space.[5] (Figure 1.)[6] The measured imbalance from 2010-2018 (0.87±0.12 Wm^{-2}) was approximately double the imbalance from 1971-2018.[7]

Returning CO_2 concentrations to below 350 ppm would restore the energy balance of Earth by allowing as much heat to escape into space as Earth retains, an important historic balance that has kept our planet in the sweet spot for the past 10,000 years, supporting stable sea levels and coastlines, enabling productive agriculture, and allowing humans and other species to thrive.[8] The paleo-climate record shows that CO_2 levels, temperature, and sea level all move together (see Figure 2). Humans have caused CO_2 levels to shoot off the chart (circled in red), rising to levels unprecedented over the past 3 million years, and causing the Earth energy imbalance.[9]

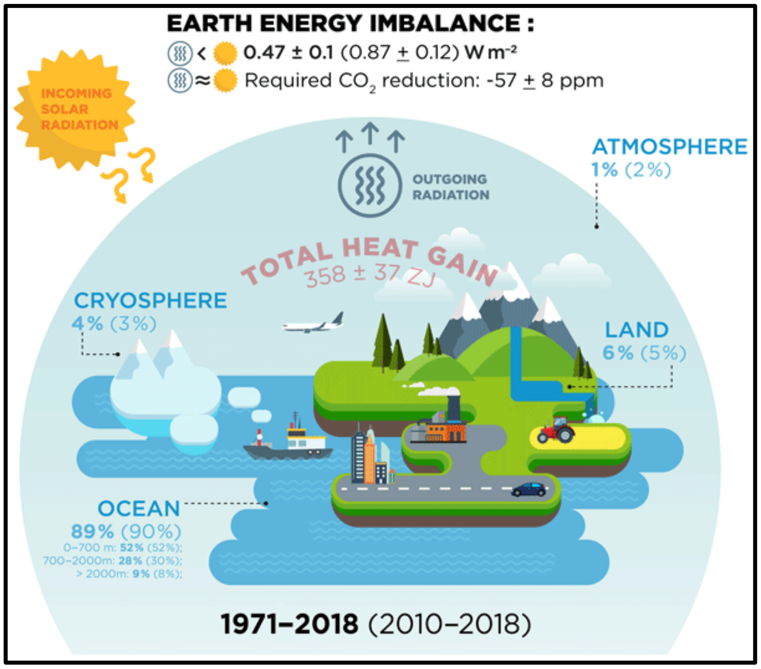

Figure 1: Earth heat inventory for Earth energy imbalance at the top of the atmosphere.

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[2] Karina von Schuckmann et al., *Heat Stored in the Earth System: Where Does the Energy Go?*, 12 Earth Syst. Sci. Data. 2013 (2020) [hereinafter *Heat Stored in the Earth System*] (written by 38 international experts, including lead IPCC authors).

[3] *Id.*

[4] IPCC, *Summary for Policymakers, in* Climate Change 2014: Synthesis Report (2014).

[5] James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE e81648 (2013) [hereinafter *Assessing* "*Dangerous Climate Change*"].

[6] von Schuckmann, *Heat Stored in the Earth System.*

[7] *Id.*

[8] James Hansen, *Storms of My Grandchildren* 166 (2009).

[9] M. Willeit et al., *Mid-Pleistocene Transition in Glacial Cycles Explained by Declining CO_2 and Regolith Removal*, 5 Science Advances eaav7337 (2019).

2) Ice Sheets and Sea Level Rise

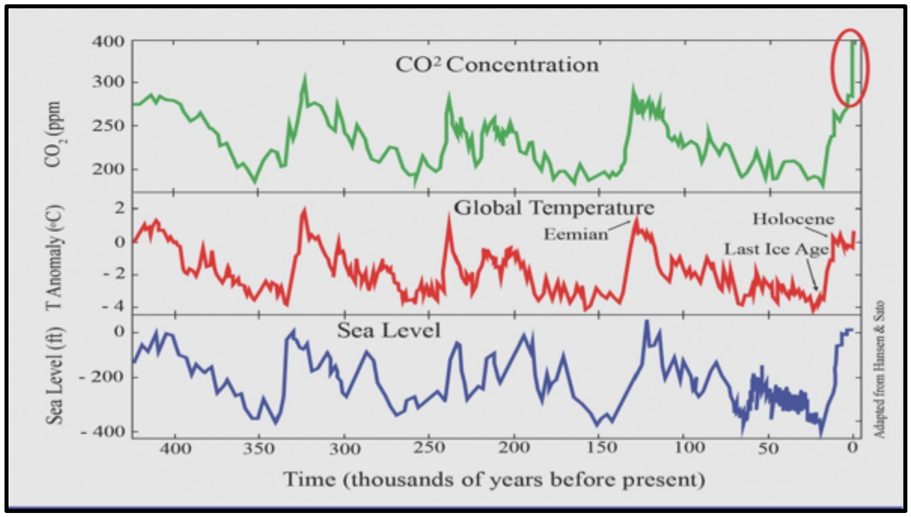

Figure 2: Evidence from the paleo-climate record showing the relationship between CO_2 concentration, global temperature, and sea level.

The last time the ice sheets appeared stable in the modern era was in the 1980s when the atmospheric CO_2 concentration was below 350 ppm. The consequences of >350 ppm and >1°C of warming are already visible, significant, and dangerous for humanity. With just over a global average 1°C of warming, glaciers in all regions of the world are shrinking, and the rate at which they are melting is accelerating.[10] Large parts of the Greenland and Antarctic ice sheets, which required millennia to grow, are teetering on the edge of irreversible disintegration, a point that, if reached, would lock-in major ice sheet mass loss, sea level rise of many meters, and worldwide loss of coastal cities – a consequence that would be irreversible on any timescale relevant to humanity (see Figure 3).[11] Greenland's ice sheet melt is currently occurring faster than anytime during the last three and a half centuries, with a 33% increase alone since the 20th century.[12] From 1994 to 2017, the Earth lost 28 trillion tonnes of ice, with the rate of ice loss increasing by 57% compared to the 1990s.[13] The paleo-climate record shows the last time atmospheric CO_2 levels were over 400 ppm, the seas were **70 feet higher** than they are today and heating consistent with CO_2 concentrations as low as 450 ppm may have been enough to melt almost all of Antarctica.[14] While many experts are predicting multi-meter sea level rise this century, even NOAA's modest estimate of 5-8.2 feet (1.5-2.5 m) global mean rise by 2100[15] would impact millions of Americans (see Figure 4).[16]

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[10] M. Zemp et al., *Global Glacier Mass Changes and their Contributions to Sea-Level Rise from 1961-2016*, 568 Nature 382 (2019); B. Menounos et al., *Heterogeneous Changes in Western North American Glaciers Linked to Decadal Variability in Zonal Wind Strength*, 46 Geophysical Research Letters 200 (2019).

[11] Hansen, *Assessing "Dangerous Climate Change*," at 13; *see also* James 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*, 16 Atmos. Chem. & Phys. 3761 (2016) [hereinafter *Ice Melt, Sea Level Rise and Superstorms*].

[12] L.D. Trusel et al., *Nonlinear Rise in Greenland Runoff in Response to Post-industrial Arctic Warming*, 562 Nature 105 (2018).

[13] T. Slater et al., *Earth's Ice Imbalance*, 15 The Cryosphere 233 (2021).

[14] James E. Hansen, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 6:15-cv-01517-TC, 14 (D. Or. Aug. 12, 2015); IPCC, *Chapter 6.3.2, What Does the Record of the Mid-Pliocene Show?, in* Climate Change 2007: The Physical Science Basis (2007); Dowsett & Cronin, *High Eustatic Sea Level During the Middle Pliocene: Evidence from the Southeastern U.S. Atlantic Coastal Plain*, 18 Geology 435 (1990); N.J. Shackleton et al., *Pliocene Stable Isotope Stratigraphy of Site 846*, 138 Proceedings of the Ocean Drilling Program, Scientific Results 337 (1995).

[15] NOAA, *Global and Regional Sea Level Rise Scenarios for the United States* (2017) (intermediate-high to extreme global mean sea level rise scenarios).

[16] NOAA, Examining Sea Level Rise Exposure for Future Populations, https://coast.noaa.gov/digitalcoast/stories/population-risk.html.

Figure 3: Antarctic melt water from the Nansen ice shelf.

Many climate models represent sea level rise as a gradual linear response to melting ice sheets, but the historic climate record shows something very different. In reality, seas do not rise slowly and predictably but rather in pulses as ice sheets destabilize.[17] Scientists believe we still have a chance to preserve the large ice sheets of Greenland and Antarctica and most of our shorelines and ecosystems if we restore Earth's energy balance and return to below 350 ppm, thereby limiting longer-term warming by the end of the century to no more than 1°C above pre-industrial levels (short-term warming will inevitably exceed 1°C but must not exceed 1°C for more than a short span of years rather than multiple decades or centuries).

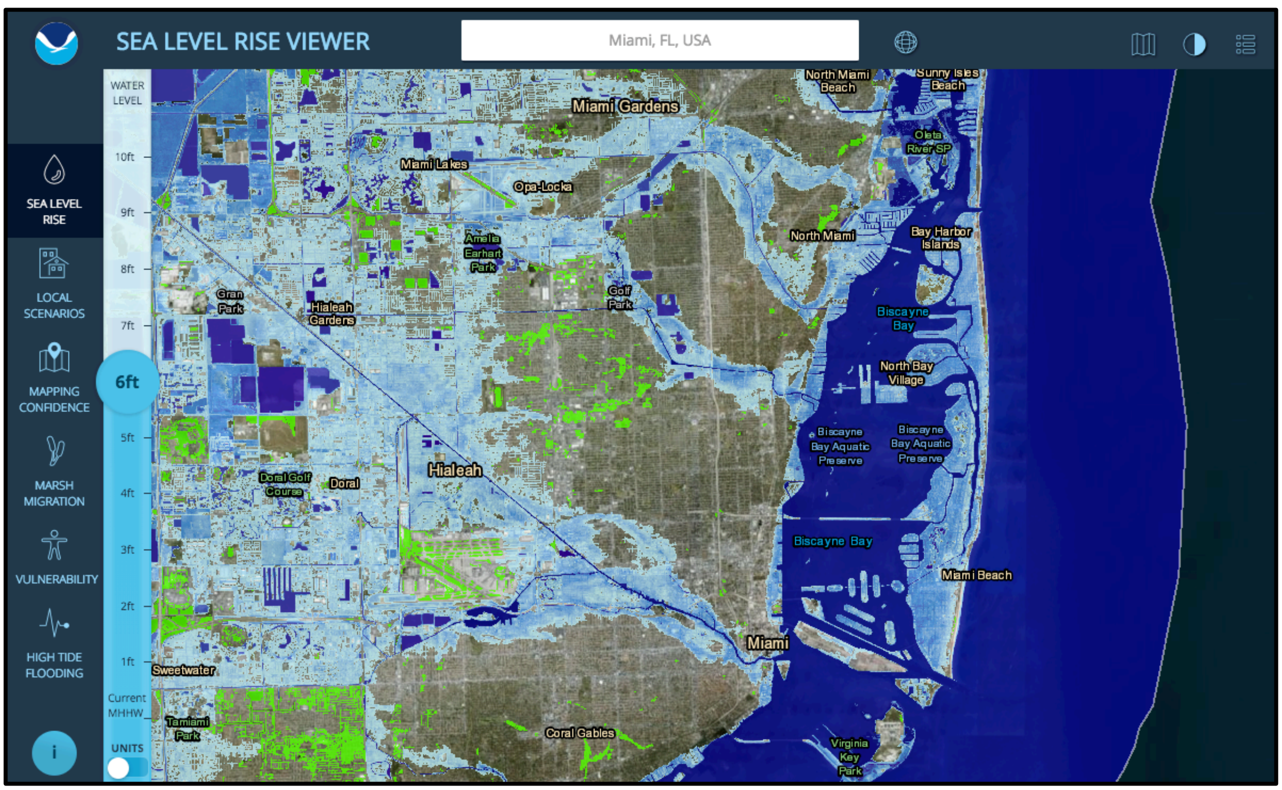

Figure 4: South Florida, including Miami, will face significant inundation with 6 feet of sea level rise.

[17] H.R. Wanless, et al., *Dynamics and Historical Evolution of the Mangrove/Marsh Fringe Belt of Southwest Florida, in Response to Sea-level History, Biogenic Processes, Storm Influences and Climatic Fluctuations*. Semi-annual Research Report (June 1993 to February 1994); Hansen, *Ice Melt, Sea Level Rise and Superstorms*, at 3761; Hansen, *Assessing "Dangerous Climate Change,"* at 20.

3) **Ocean Warming and Acidification**

Less than 350 ppm is the best scientific standard to protect oceans and marine life. Our oceans have absorbed about 90% of the excess heat in the atmosphere trapped by greenhouse gases (see Figure 5) as well as approximately 30% of CO_2 emitted into the atmosphere, causing ocean temperatures to surge and the ocean to become more acidic.[18] Indeed, our oceans are warming much more rapidly than previously-thought.[19] In 2020, the oceans absorbed 20 sextillion joules of heat due to climate change and warmed to record levels. The quantity of warming, 20,000,000,000,000,000,000,000 joules, is equivalent to the amount of energy from 10 Hiroshima atomic bombs being released every second of the year or to heat 1.3 billion kettles of water.[20] Many marine ecosystems, and particularly coral reef ecosystems, cannot tolerate the increased warming and acidity of ocean waters that result from increased CO_2 levels.[21] At today's global mean CO_2 concentration, around 412 ppm, critically important ocean ecosystems, such as coral reefs, are rapidly declining and will be irreversibly damaged from high ocean temperatures and repeated mass bleaching events if we do not quickly curtail emissions (see Figures 6 and 7).[22] According to the Intergovernmental Panel on Climate Change (IPCC), bleaching events are occurring more frequently than the IPCC previously projected and 70-90% of the world's coral reefs could disappear as soon as 2030 (the IPCC also predicts >99% of coral reefs will die with 2°C warming).[23] The 2018 National Climate Assessment acknowledged that coral reefs in Florida, Hawaii, Puerto Rico, and the

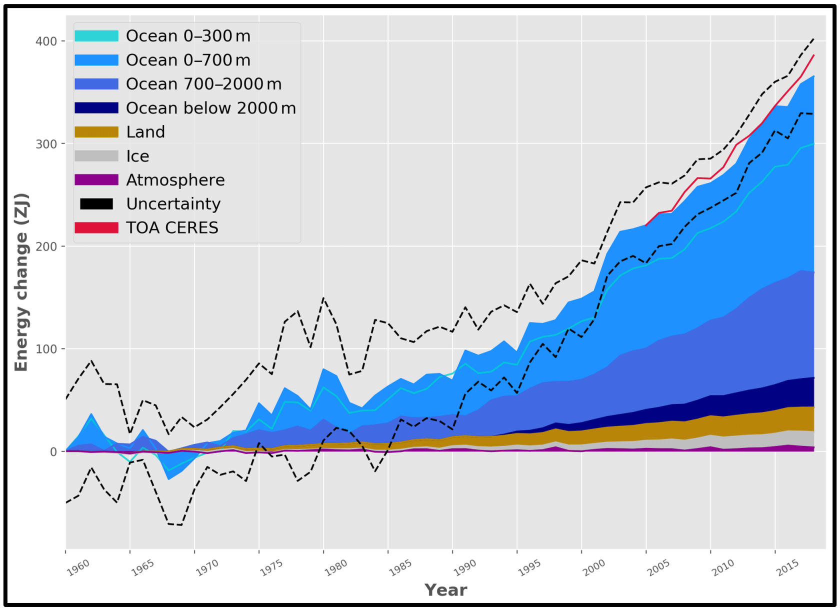

Figure 5 . Earth energy accumulation relative to 1960.

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[18] von Schuckmann, *Heat Stored in the Earth System*; Hansen, *Assessing "Dangerous Climate Change,"* at 1; IPCC, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2013); L. Cheng et al., *How Fast are the Oceans Warming?* 363 Science 128 (2019) (as of 2019, about 93% of the energy balance accumulates in the ocean); NOAA, *What is Ocean Acidification?,* https://oceanservice.noaa.gov/facts/acidification.html.

[19] L. Cheng et al., *How Fast are the Oceans Warming?*, 363 Science 128 (2019).

[20] https://www.abc.net.au/news/2021-01-18/ocean-temperatures-reached-record-high-in-2020-study-finds/13062628; https://www.cambridgenetwork.co.uk/news/world-continued-warm-2020.

[21] T. P. Hughes et al., *Global Warming Impairs Stock-Recruitment Dynamics of Corals*, 568 Nature 387 (2019).

[22] K. Frieler et al., *Limiting Global Warming to 2 ℃ is Unlikely to Save Most Coral Reefs*, 3 Nature Climate Change 165 (2013); J. Veron et al; *The Coral Reef Crisis: The Critical Importance of <350ppm* CO_2, 58 Marine Pollution Bulletin 1428 (2009); T. P. Hughes et al., *Spatial and Temporal Patterns of Mass Bleaching of Corals in the Anthropocene*, 359 Science 80 (2018); T. P. Hughes et al., *Global Warming Impairs Stock–Recruitment Dynamics of Corals*, 568 Nature 387 (2019).

[23] Ove Hoegh-Guldberg et al., *Impacts of 1.5ºC Global Warming on Natural and Human Systems, in* Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, at 225-226 (2018); IPCC, *Summary for Policymakers, in* Global Warming of 1.5°C (2018).

U.S. Virgin Islands have been harmed by mass bleaching and coral diseases and could disappear by mid-century as a result of warming waters.[24] Scientists believe we can protect marine life and prevent massive bleaching and die-off of coral reefs only by rapidly returning CO_2 levels to below 350 ppm.[25]

No scientific institution, including the IPCC, has ever concluded that the Earth energy imbalance, which exists with >350 ppm, and 1.5-2°C warming would be safe for ocean life. According to Dr. Ove Hoegh-Guldberg, one of the world's leading experts on ocean warming and acidification, and a Coordinating Lead Author on the "The Ocean" chapter of the IPCC's Fifth Assessment Report and on the "Impacts of 1.5ºC Global Warming on Natural and Human Systems" of the IPCC's Special Report on Global Warming of 1.5°C:

"Allowing a temperature rise of up to 2°C would seriously jeopardize ocean life, and the income and livelihoods of those who depend on healthy marine ecosystems. Indeed, the best science available suggests that coral dominated reefs will completely disappear if carbon dioxide concentrations exceed much more than today's concentrations. Failing to restrict further increases in atmospheric carbon dioxide will eliminate coral reefs as we know them and will deny future generations of children from enjoying these wonderful ecosystems."[26]

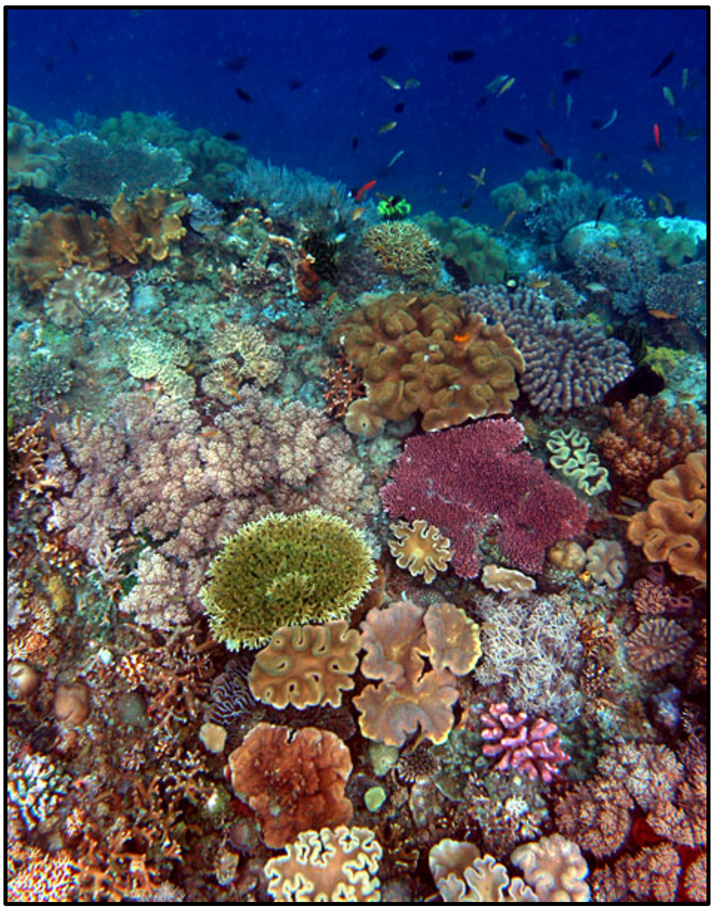

Figure 6: Healthy coral like this are already gravely threatened and will likely die with warming of 1.5°C.

Figure 7: Bleached coral from warmer ocean temperatures.

IPCC's Special Report on Global Warming of 1.5° states that "[w]arming of 1.5ºC is not considered 'safe' for most nations, communities, ecosystems, and sectors and poses significant risks to natural and human systems as compared to current warming of 1°C (*high confidence*)."[27]

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[24] A.J. Pershing et al., *Oceans and Marine Resources, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018).

[25] J. Veron et al., *The Coral Reef Crisis: The Critical Importance of <350 ppm CO_2*, 58 Marine Pollution Bulletin 1428 (2009).

[26] Ove Hoegh-Guldberg, *Declaration in Support of Petitioners, Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA (Wash. Super. Ct. Aug. 24, 2015).

[27] J. Roy et al., *Sustainable Development, Poverty Eradication and Reducing Inequalities, in* Global Warming of 1.5°C,

ADDITIONAL OBSERVATIONS ILLUSTRATE THE DANGERS OF INCREASED WARMING

In addition to the evidence discussed above which illustrates the necessity of ensuring that the atmospheric CO_2 concentration returns to no more than 350 ppm, based on present day observations about climate impacts occurring **now**, it is clear that the present level of 412 ppm and resulting heating of 1.1°C (as of 2020) is already causing significant climate impacts and additional warming will exacerbate these already dangerous impacts. Climate impacts that are already being experienced today include:

- Declining snowpack and rising temperatures are increasing the length and severity of drought conditions, especially in the western United States and Southwest, causing problems for agriculture users, forcing some people to relocate, and leading to water restrictions.[28]
- In the western United States, the wildfire season is now almost three months longer (87 days) than it was in the 1980s.[29] 10.3 million acres burned in 2020, well above the 2011-2020 average of 7.5 million acres.[30]
- Extreme weather events, such as intense rainfall events that cause flooding, are increasing in frequency and severity because a warmer atmosphere holds more moisture.[31] What are supposedly 1-in-1000-year rainfall events are now occurring with alarming frequency – in 2018 there were at least five such events.[32]
- Tropical storms and hurricanes are increasing in frequency and intensity, both in terms of rainfall and windspeed, as warmer oceans provide more energy for the storms (as seen with Hurricanes Harvey, Irma, and Maria in 2017) [33] (Figure 8).
- Terrestrial ecosystems are experiencing compositional and structural changes, with major adverse consequences for ecosystem services.[34]

Figure 8: Flooding in Port Arthur, Texas on August 13, 2018 after Hurricane Harvey.

at 447 (2018).

[28] Steven W. Running, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-12 (9th Cir. Feb. 7, 2019).

[29] *Id.*; A. L. Westerling, *Increasing Western US Forest Wildfire Activity: Sensitivity to Changes in the Timing of Spring*, 371 Phil. Trans. R. Soc. B 20150178 (2016).

[30] Congressional Research Service, *Wildfire Statistics* (updated Jan. 4, 2021).

[31] Kevin E. Trenberth, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-3 (9th Cir. Feb. 7, 2019).

[32] F. Belles, *America's 'One-in-1,000-Year' Rainfall Events in 2018*, The Weather Channel (Sept. 27, 2018).

[33] Kevin E. Trenberth, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-3 (9th Cir. Feb. 7, 2019).

[34] C. Nolan et al., *Past and Future Global Transformation of Terrestrial Ecosystems Under Climate Change*, 361 Science

- Terrestrial, freshwater, and marine species are experiencing a significant decrease in population size and geographic range, with some going extinct and others are facing the very real prospect of extinction – the rapid rate of extinctions has been called the sixth mass extinction.[35]
- Human health and well-being are already being affected by heat waves, floods, droughts, and extreme events; infectious diseases; and quality of air, food, and water.[36] Doctors and leading medical institutions are calling climate change a "health emergency."[37] Children are uniquely vulnerable to climate change health effects due to their higher respiratory rate, lung growth and development, immature immune system, higher metabolic demands, and immature central nervous system.[38]
- In addition to physical harm, climate change is causing mental health impacts, ranging from stress to clinical disorders such as anxiety, depression, and suicidality, due to exposure to climate events, displacement, loss of income, chronic stress, and other impacts of climate change.[39]

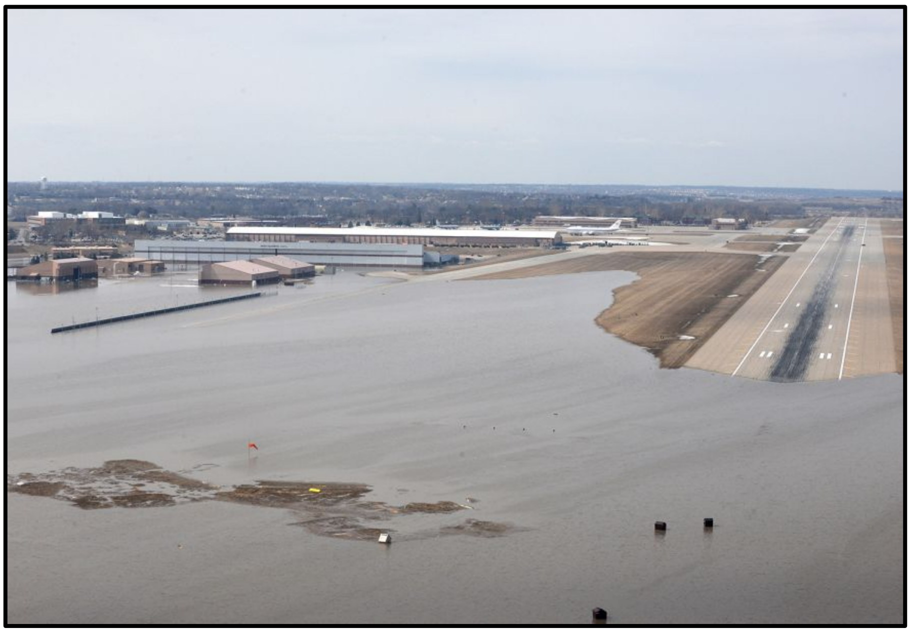

Figure 9: Offutt Air Force Base was impacted by flood waters during flooding in Nebraska during spring 2019.

- As Congress has recognized, "climate change is a direct threat to the national security of the United States and is impacting stability in areas of the world both where the United States Armed Forces are operating today, and where strategic implications for future conflict exist."[40] Senior military leaders have called climate change "*the* most serious national security threat facing our Nation

920 (2018).

[35] G. Ceballos et al., *Accelerated Modern Human–Induced Species Losses: Entering the Sixth Mass Extinction*, 1 Science Advances e1400253 (2015); Steven W. Running, *Expert Report, Juliana v. United States*, No. 6:15-cv-01517-TC, Doc. 264-1 (D. Or. June 28, 2018).

[36] K.L. Ebi et al., *Human Health, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018).

[37] C.G. Solomon & R.C. LaRocque, *Climate Change – A Health Emergency*, 380 N. Engl. J. Med. 209 (2019).

[38] S. Pacheco, *Catastrophic Effects of Climate Change on Children's Health Start before Birth*, 130 Journal of Clinical Investigation 562 (2020); C. May et al., *Northwest, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018); N. Watts et al., *The 2019 Report of The Lancet Countdown on Health and Climate Change: Ensuring that the Health of a Child Born Today is not Defined by a Changing Climate*, 394 The Lancet 1836 (2019); *Brief of Amici Curiae Public Health Experts, Public Health Organizations, and Doctors in Support of Plaintiffs*, No. 18-36082, Doc. 47 (9th Cir. Mar. 1, 2019).

[39] Lise Van Susteren, *Expert Report, Juliana v. United States*, No. 6:15-cv-01517-TC, Doc. 271-1 (D. Or. June 28, 2018). K.L. Ebi et al., *Human Health, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018).

[40] *National Defense Authorization Act for Fiscal Year 2018*, Pub. L. No. 115-91, 131 Stat. 1358.

today,"[41] a conclusion similarly recognized by our Nation's intelligence community.[42] Climate change is increasing food and water shortages, pandemic disease, conflicts over refugees and resources, and destruction to homes, land, infrastructure, and military assets, directly threatening our military personnel and the "Department of Defense's ability to defend the Nation" (see Figure 9).[43]

- Climate change is already causing vast economic harm in the United States. Since 1980 the United States has experienced 285 climate and weather disasters that each caused damages in excess of $1 billion, for a total cost of $1.875 trillion.[44] In 2018 alone, Congress appropriated more than $130 billion for weather and climate related disasters.[45]

These already serious impacts will grow in severity and will impact increasingly large numbers of people and parts of the world if CO_2 concentrations continue to rise. If we want our children and grandchildren to have a safe planet to live on, full of health and biodiversity rather than chaos and conflict, we must follow the best scientific prescription to restore Earth's energy balance and avoid the destruction of our planet's atmosphere, climate, and oceans.

INTERNATIONAL POLITICAL TARGETS OF 1.5°C OR 2°C ARE NOT SCIENCE-BASED AND ARE NOT SAFE

International treaties require the stabilization of the climate system to avoid dangerous anthropogenic climate change. As described above, EEI and CO_2 concentrations should be the measurable scientific metrics, adopted as legal standards, for setting emission reduction and sequestration targets to stabilize our climate, avoid danger, and protect children and future generations. Temperature targets, set higher than today's already-too-hot planet, which would mean an even greater and more dangerous EEI and greater instability, are incompatible with fundamental human rights. International, politically-established temperature targets like 1.5°C or "well below" 2°C – which are commonly associated with long-term atmospheric CO_2 concentrations of 425 and 450 ppm, respectively – have not been and are not presently considered safe or scientifically-sound targets for present or future generations.

Legalizing heating of 1.5°C-2°C legalizes greater dangers than we have already witnessed. It is a death sentence for young people. In fact, Sir David King, former Special Envoy for Climate Change and Chief Scientific Advisor for the United Kingdom, elaborated on the importance of 350 ppm and limiting global heating to 1°C:

> *As a key negotiator for the United Kingdom government during discussions leading up to the Paris Agreement, I advocated that 1.5°C was an acceptable level of global warming. However, I was wrong. In 2020, our planet experienced an average of 1.1°C*

[41] Vice Admiral Lee Gunn, USN (Ret.), *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-17 (9th Cir. Feb. 7, 2019) (emphasis in original); *see also* CNA Military Advisory Board, *National Security and the Accelerating Risks of Climate Change* (2014).
[42] National Intelligence Council, *Implications for US National Security of Anticipated Climate Change* (Sept. 2016).
[43] U.S. Dep't of Defense, *2014 Climate Change Adaptation Roadmap* (2014).
[44] NOAA, *Billion Dollar U.S. Weather/Climate Disasters 1980-2020* (2020), https://www.ncdc.noaa.gov/billions/events.pdf.
[45] U.S. House of Representatives Committee on the Budget, *The Budgetary Impact of Climate Change* 2 (Nov. 27, 2018).

of warming — much higher in some places like the Arctic -- and we experienced catastrophic weather events and climate-related disasters. These will only become more frequent, and more severe, as our emissions continue to rise. We cannot afford to negotiate what we now know is the safest level for stabilizing our climate systems: We must limit warming to less than 1.0°C as fast as possible. The 350 ppm pathways findings in studies by Jim Williams and Evolved Energy Research successfully demonstrate that the United States has clear pathways available to significantly reduce emissions, protecting the health and livelihood of their citizens while also boosting their national economies. This will crucially enable the USA to join leading nations in managing this severe challenge to humanity.[46]

Importantly, the IPCC has never established nor endorsed a target of 1.5°C or 2°C warming as a limit below which the climate system will be stable and the energy balance restored. It is beyond the IPCC's declared mandate to endorse a particular threshold of warming as "safe" or "dangerous." As the IPCC makes clear, "each major IPCC assessment has examined the impacts of [a] multiplicity of temperature changes but has left [it to the] political processes to make decisions on which thresholds may be appropriate."[47]

Neither 1.5°C nor 2°C warming above pre-industrial levels has ever been considered "safe" from either a political or scientific point of view. The 2°C figure was originally adopted in the political arena "from a set of heuristics," and it has retained predominantly political character ever since.[48] The 2°C figure has recently been all-but-abandoned as a credible policy goal, in light of the findings in IPCC's 1.5°C Special Report, and the mounting evidence leading up to its publication, that 2°C would be catastrophic relative to lower, still-achievable levels of warming.[49]

On the other hand, the idea of a 1.5°C target was first raised by the Alliance of Small Island States (AOSIS) in the negotiations leading up to the ill-fated 2009 UNFCCC Conference of Parties in Copenhagen.[50] AOSIS, however, was explicitly advocating a *well below* 1.5°C and *well below* 350 ppm target, on the basis of the research of Dr. James Hansen and his colleagues.[51] Political compromise, including pressure from the fossil fuel industry, on this target then led to the adoption of a goal of "pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" in Article 2 of the Paris Agreement. Yet the 2018 IPCC Special Report on 1.5°C has made clear that allowing a temperature rise of 1.5°C:

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[46] Correspondence from Sir David King to Julia Olson (Jan. 2021) (notes on file with Julia Olson); The Do One Better! Podcast, Interview with Sir David King, https://www.lidji.org/sir-david-king.

[47] IPCC, *Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report* 125 (Cambridge University Press, 2014).

[48] S. Randalls, *History of the 2°C Temperature Target*, 1 WIREs Climate Change 598, 603 (2010); C. Jaeger & J. Jaeger, *Three Views of Two Degrees*, 11 (Suppl 1) Reg. Environ. Change S15 (2011).

[49] IPCC, *Summary for Policymakers, in* Climate Change 2014: Impacts, Adaptation, and Vulnerability, 13-14 (2014); UNFCCC, *Report on the Structured Expert Dialogue on the 2013–2015 Review*, 18 (2015), http://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf; Petra Tschakert, *1.5°C or 2°C: A Conduit's View from the Science-Policy Interface at COP20 in Lima, Peru*, 2 Climate Change Responses 8 (2015); IPCC, *Global Warming of 1.5°C* (2018).

[50] *See* R. Webster, *A Brief History of the 1.5C Target*. Climate Change News (Dec. 10, 2015), http://www.climatechangenews.com/2015/12/10/a-brief-history-of-the-1-5c-target/.

[51] *Submission from Grenada on behalf of AOISIS to the Ad Hoc Working Group on Further Commitments for Annex I Parties Under the Kyoto Protocol*, U.N. Doc. FCCC/KP/AWG/2009/MISC.1/Add.1 (25 March 2009), https://unfccc.int/sites/default/files/resource/docs/2009/awg7/eng/misc01a01.pdf, citing James Hansen et al. *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 The Open Atmospheric Science Journal 217 (2008).

> is **not considered 'safe'** for most nations, communities, ecosystems, and sectors and poses significant risks to natural and human systems as compared to current warming of 1°C (*high confidence*).[52]

Dr. James Hansen warns that "distinctions between pathways aimed at ~1°C and 2°C warming are much greater and more fundamental than the numbers 1°C and 2°C themselves might suggest. These fundamental distinctions make scenarios with 2°C or more global warming far more dangerous; so dangerous, we [James Hansen et al.] suggest, that aiming for the 2°C pathway would be foolhardy."[53] This target is at best the equivalent of "flip[ping] a coin in the hopes that future generations are not left with few choices beyond mere survival. This is not risk management, it is recklessness and we must do better."[54]

Tellingly, more than 80 eminent scientists from over 50 different institutions have been co-authors on publications in peer-reviewed journals finding that the maximum level of atmospheric CO_2 consistent with restoring the EEI, protecting humanity and other species is 350 ppm, and no one, including the IPCC, has published any scientific evidence to counter that 350 ppm is the maximum safe concentration of CO_2.[55]

A 1.5° OR 2°C TARGET RISKS LOCKING-IN DANGEROUS FEEDBACKS

The longer the length of time atmospheric CO_2 concentrations remain at dangerous levels (i.e., above 350 ppm) and there is an Earth energy imbalance, the risk of triggering, and locking-in, dangerous warming-driven feedback loops increases. The 1.5°C or 2°C target (linked to 425-450 ppm) reduces the likelihood that the biosphere will be able to sequester CO_2 due to carbon cycle feedbacks and shifting climate zones.[56] As Earth surface temperatures increase, forests burn and soils warm, releasing their carbon. These natural carbon "sinks" become carbon "sources" and a portion of the natural carbon sequestration necessary to drawdown excess CO_2 simply disappear. Another dangerous feedback includes the release of methane, a potent greenhouse gas, as the global tundra thaws.[57] These feedbacks might show little change in the short-term, but can hit a point of no return, even at a 1.5°C or 2°C temperature increase, which will trigger accelerated heating and sudden *and irreversible* catastrophic impacts. Moreover, an emission reduction target aimed at 2°C would "yield

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[52] J. Roy et al., *Sustainable Development, Poverty Eradication and Reducing Inequalities, in* Global Warming of 1.5°C, at 447 (2018) (emphasis added).
[53] Hansen, *Assessing "Dangerous Climate Change*," at 15.
[54] Matt Vespa, *Why 350? Climate Policy Must Aim to Stabilize Greenhouse Gases at the Level Necessary to Minimize the Risk of Catastrophic Outcomes*, 36 Ecology Law Currents 185, 186 (2009).
[55] James Hansen, et al., *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 The Open Atmospheric Science Journal 217 (2008); Hansen, *Assessing "Dangerous Climate Change"*; Hansen, *Ice Melt, Sea Level Rise and Superstorms*; James Hansen, et al., *Young People's Burden: Requirement of Negative CO_2 Emissions*, 8 Earth Syst. Dynamics 577 (2017); J. Veron, et al., *The Coral Reef Crisis: The Critical Importance of <350 ppm CO_2* 58 Marine Pollution Bulletin 1428 (2009); K. Frieler, et al., *Limiting Global Warming to 2 ℃ is Unlikely to Save Most Coral Reefs* 3 Nature Climate Change 165 (2013); von Schuckmann, *Heat Stored in the Earth System*; Communication from James Hansen, Karina von Shuckmann to Julia Olson (2021) (notes on file with Julia Olson).
[56] Hansen, *Assessing "Dangerous Climate Change,"* at 15, 20.
[57] *Id*.

a larger eventual warming because of slow feedbacks, probably at least 3°C."[58] Once a temperature increase of 2°C is reached, there will already be "additional climate change 'in the pipeline' even without further change of atmospheric composition."[59]

THE BEST AVAILABLE SCIENCE REQUIRES US TO REDUCE CO_2 LEVELS TO <350 PPM BY 2100

There are two steps to reducing CO_2 levels to <350 ppm by the end of the century: 1) reducing CO_2 emissions; and separately 2) sequestering excess CO_2 already in the atmosphere (carbon drawdown). Carbon dioxide emission reductions of approximately 80% by 2030 and close to 100% by 2050 (in addition to the requisite CO_2 sequestration) are necessary to be on track to an atmospheric CO_2 concentration to 350 ppm, restoring energy balance, and keeping long-term warming to below 1°C above preindustrial temperatures. Politically-motivated emission reduction targets that seek to reduce CO_2 emissions by only 80% by 2050 are consistent with an atmospheric CO_2 concentration of 450 ppm and long-term warming of 2°C, which, as described above, would result in catastrophic and irreversible impacts for the climate system and oceans.

IT IS TECHNOLOGICALLY AND ECONOMICALLY FEASIBLE TO REDUCE EMISSIONS IN LINE WITH 350 PPM BY 2100

Importantly, it is economically and technologically feasible to transition the entire U.S. energy system to a zero-CO_2 energy system by 2050 and to drawdown the excess CO_2 in the atmosphere through reforestation and carbon sequestration in soils.[60]

Deep Decarbonization Pathways Project and Evolved Energy Research recently completed research and very sophisticated modeling describing a nearly complete phase out of fossil fuels in the U.S. by 2050.[61] They describe six different technologically feasible pathways to drastically, and quickly, cut our reliance on fossil fuels and achieve the requisite level of emissions reductions in the U.S. while meeting our nation's forecasted energy needs. All of the 350 ppm pathways rely on four pillars of action: a) investment in energy efficiency; b) electrification of everything that can be electrified; c) shifting to very low-carbon and primarily renewable electricity generation; and d) carbon dioxide capture as fossil fuels are phased out. The six scenarios are used to evaluate the ability to meet the targets even absent one key technology. For example, one scenario describes a route to 350 ppm absent construction of new nuclear facilities; another illustrates getting to 350 ppm with extremely limited biomass technology; still another describes a way to 350 ppm without any carbon capture and storage. Even absent a key technology, each of these six routes are viable and cost effective.

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[58] *Id*. at 15.
[59] *Id*. at 19.
[60] *See* Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States,* 8 Energy & Envtl. Sci. 2093 (2015) (for plans on how the United States and over 100 other countries can transition to a 100% renewable energy economy see www.thesolutionsproject.org); *see also* Arjun Makhijani, *Carbon-Free, Nuclear-Free: A Roadmap for U.S. Energy Policy* (2007); B. Haley et al., *350 ppm Pathways for the United States* (2019); James Williams et al., *Carbon-Neutral Pathways for the United States*, 2 AGU Advances e2020AV000284 (2021).
[61] B. Haley et al., *350 ppm Pathways for the United States* (2019).

A related 2021 study concludes that emissions reductions consistent with a 350 ppm trajectory by 2100 can be done at low net cost, substantially lower than estimates for less ambitious 80% by 2050 scenarios a few years ago due to recent declines in solar, wind, and vehicle battery prices.[62] The cost would be well below the 9.5% of GDP spent on the energy system in 2009 (not to mention well below the harm to the economy caused by climate change). (Figure 10)[63] Once the transition is complete, the cost of energy will remain low and stable because we will no longer be dependent on volatile global fossil fuel markets for our energy supplies. As Nobel Laureate Economist Dr. Joseph Stiglitz has stated: "[t]he benefits of making choices today that limit the economic costs of climate change far outweigh any economic costs associated with limiting our use of fossil fuels."[64]

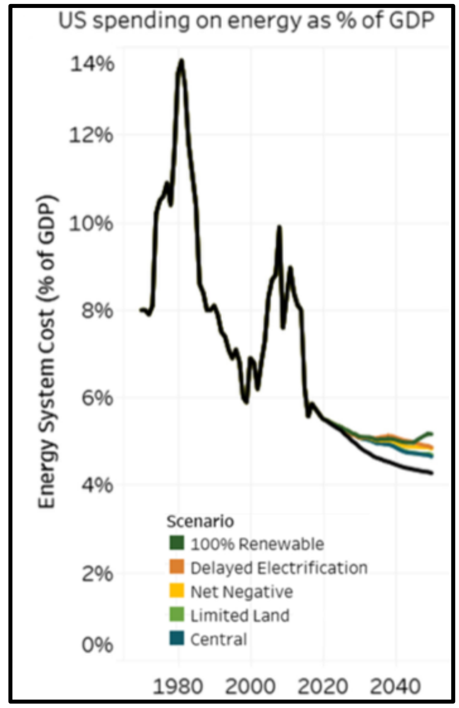

Figure 10: Historic and projected costs of energy in the U.S. as percentage of GDP.

Other experts have already prepared plans for all 50 U.S. states as well as for over 139 countries that demonstrate the technological and economic feasibility of transitioning off of fossil fuels toward 100% of energy, for all energy sectors, from clean and renewable energy sources: wind, water, and sunlight by 2050 (with 80% reductions in fossil fuels by 2030).[65]

Products already exist that enable new construction or retrofits that result in zero greenhouse gas buildings. We have the technology to meet all electricity needs with zero-emission electric generation. We know how to achieve zero-emission transportation, including aviation. These actions result in other benefits, such as improved health, job creation, and savings on energy costs.

The amount of natural carbon sequestration required is also proven to be feasible. Researchers have evaluated the potential to drawdown excess carbon dioxide in the atmosphere by increasing the carbon

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[62] James Williams et al., *Carbon-Neutral Pathways for the United States*, 2 AGU Advances e2020AV000284 (2021).
[63] *Id*., Ben Haley et al., *350 ppm Pathways for Florida, Technical Supplement* (2020).
[64] Joseph E. Stiglitz, Ph.D., *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-14 (9th Cir. Feb. 7, 2019).
[65] Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States,* 8 Energy & Envtl. Sci. 2093 (2015). For a graphic depicting the overview of the plan for the United States see: https://thesolutionsproject.org/why-clean-energy/#/map/countries/location/USA.

stored in forests, soils, and wetlands, and have found significant potential for these natural systems to support a return to 350 ppm by the end of the century.[66] We know the agricultural, rangeland, wetland, and forest management practices that decrease greenhouse gas emissions and increase sequestration.

There is no scientific, technological, or economic reason to *not* adopt a <350 ppm and 1°C by 2100 target. There are abundant reasons for doing so, not the least of which is to do our best through human laws to respect the laws of nature and create a safe and healthy world for children and future generations.

A NOTE ON "NET ZERO"

The politically popular concept of "net zero" allows governments to zero out a percentage of ongoing fossil fuel emissions by counting them as "sequestered" through removal processes, such as biogenic or natural sequestration in carbon sinks, leaving a smaller amount of source "net emissions" to be reduced. However, in order to align emissions and sequestration with a <350 ppm standard, carbon removed through natural sequestration in sinks must be used to draw down the excess CO_2 already in the atmosphere from cumulative historic emissions, not to provide a negative credit or offset for ongoing emissions. Emissions and sequestration must be accounted and inventoried separately with separate standards for each category.[67] A "net zero" emissions target is a shell game with little accountability, detached from a precise standard for protection of fundamental rights and restoration of Earth's energy balance.

[66] Benson W. Griscom et al., *Natural Climate Solutions,* 114 Proceedings of the National Academies of Sciences 11645 (2017); Joseph E. Fargione et al., *Natural Climate Solutions for the United States,* 4 Science Advances eaat1869 (2018).
[67] D. McLaren et al., *Beyond "Net-Zero": A Case for Separate Targets for Emissions Reduction and Negative Emissions*, Front. Clim. (2019).