THE COSTS OF DELAY

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The physics of Earth harbor a frightening punch line for the climate change story: Even though the consequences of climate change persist for the very long term, the time to avoid those consequences is very short. A delay — of even a decade — in reducing carbon dioxide (CO_2) emissions will lock in large-scale, irreversible change. Delay also increases the risk that the whole climate system will spin out of control.

If we start immediately and make steady progress, we can convert to near-zero energy sources. But if we wait even a decade, the accelerated transition will create a global economic shock. We used the Energy Policy Simulator to model two illustrative U.S. climate policy scenarios reaching net zero cumulative emissions abatement by 2050, one starting climate action in 2021 and the second delaying climate action until 2030.

The resulting differences in costs and required deployment are striking. The net present value of the 2030 Scenario changes in cumulative capital, operational, and fuel expenditures are 72 percent more than the 2021 Scenario. Delaying also requires astounding clean energy deployment — business-as-usual wind and solar deployment is projected to be roughly 20 gigawatts at the end of this decade, but the 2030 Scenario would require six times that amount by 2030 and nine times that by the mid-2030s. Delayed action also means additional polluting power plants, factories, and equipment continue coming online for the next decade, but then making a fast clean energy transition will require expensive retirement of all that polluting equipment before the end of its functional life.

This message may be alarming, but it is not alarmism; it's physics. And Earth's climate physics have serious implications for political action and technological innovation in the coming decade.

Addressing climate change is like turning an ocean liner: Changing course takes time, and no amount of rudder, applied too late, can hit the mark. The world must start to reduce emissions now, or it will not reach any meaningful CO_2 concentration target. The upshot is that the next decade is critical.

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Stabilizing at *any* CO_2 concentration requires very low emissions

CO_2 emissions from the world's economic activities occur on top of a background of finely tuned natural carbon flows. CO_2 is constantly being introduced to, and then absorbed from, the atmosphere through natural processes such as plant growth, animal respiration, and soil erosion.

For millions of years prior to the industrial era, these emission and absorption activities offset each other. But the burning of fossil fuels has introduced as much CO_2 in the past 50 years as had been sequestered over millions of years. This relatively recent increase in emissions has thrown off the natural balance, and atmospheric CO_2 concentrations have been on the rise since the industrial revolution.[1] Today's level is almost 50 percent higher than the preindustrial level.

We can think of our CO_2 system as a giant bathtub: The open tap represents emissions, and the drain represents natural carbon absorbers. Because the faucet is running faster than the drain, the water level — which represents CO_2 concentration — is rising. The current emissions rate is around double what the system can absorb, so even if we stop the *growth* in emissions, the CO_2 level will continue to rise. Only when we reduce emissions to what the natural systems can absorb will CO_2 concentrations start to stabilize.

Once emitted, a significant portion of CO_2 remains in the atmosphere for centuries, or even millennia.[2] Every ton of CO_2 introduced into the atmosphere is therefore cumulative, and the resulting increases in concentration will persist in the atmosphere for thousands of years — regardless of whether emissions are reduced tomorrow.[3] That means that stabilizing CO_2 concentrations at any level, even those far higher than scientists think is safe, ultimately requires emissions close to zero.

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[1] Pieter Tans and Ralph Keeling, "Trends in Atmospheric Carbon Dioxide," Earth Systems Research Laboratory, National Oceanic and Atmospheric Administration. https://www.esrl.noaa.gov/gmd/ccgg/trends/weekly.html

[2] Alan Buis, "The Atmosphere: Getting a "Handle on Carbon Dioxide," NASA's Jet Propulsion Laboratory, October 9, 2019. https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/

[3] U.S. Environmental Protection Agency, "Atmospheric Lifetime and Global Warming Potential Defined." https://www.epa.gov/climateleadership/atmospheric-lifetime-and-global-warming-potential-defined

FIGURE 1: CO$_2$e EMISSIONS

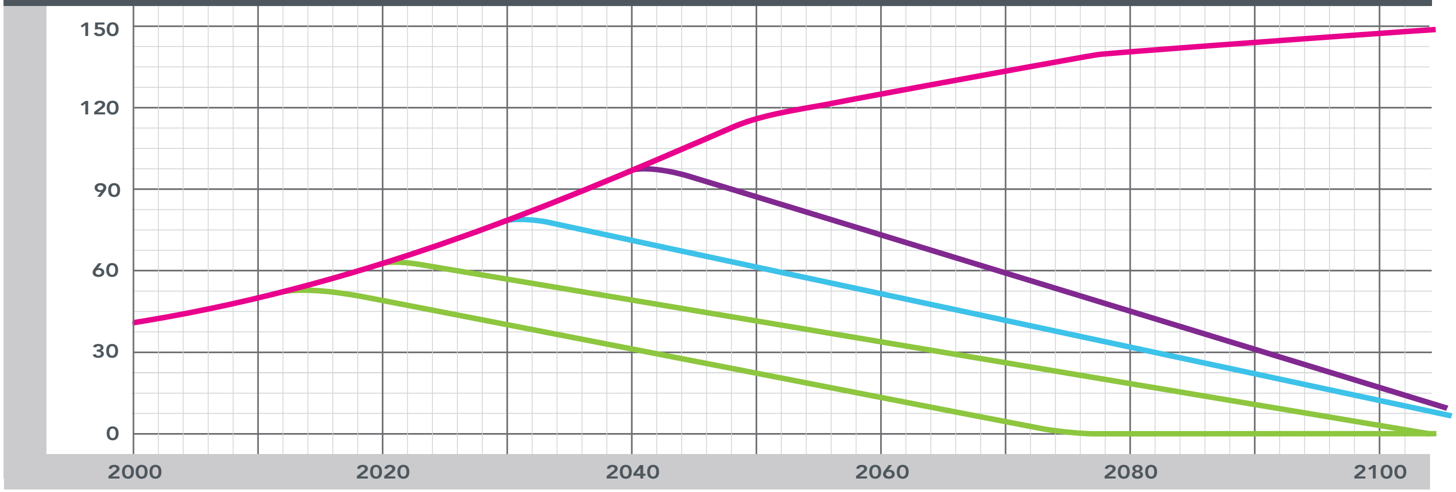
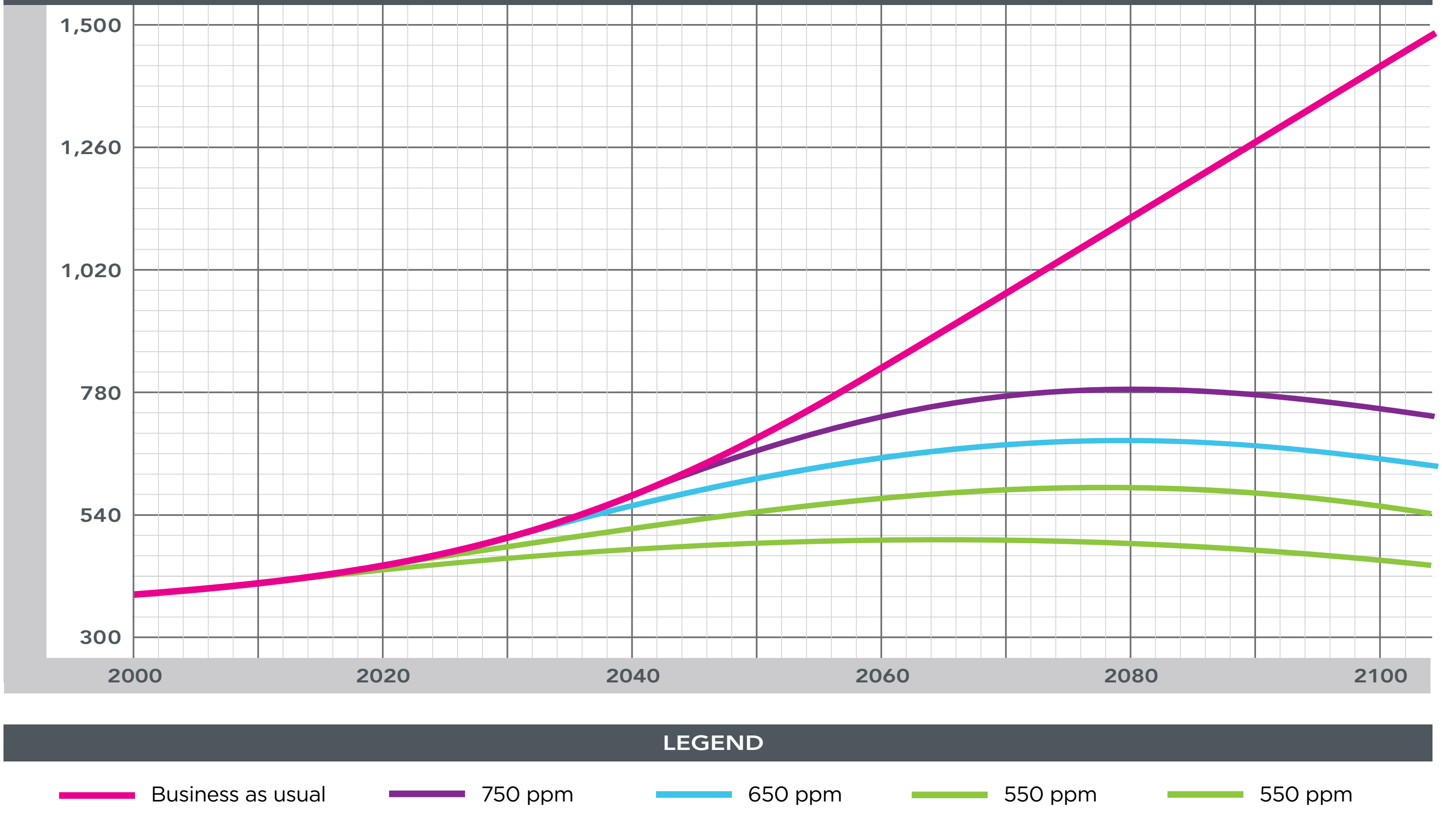


FIGURE 2: CO$_2$e CONCENTRATIONS



The relationship between CO$_2$ emissions and concentrations: *These graphs show different carbon dioxide equivalent (CO$_2$e) emission scenarios (Figure 1) that result in different concentrations (Figure 2). The pink line represents business as usual; the red one shows 450 parts per million (ppm) of CO$_2$e, a level that many scientists agree should provide a "guard rail" against catastrophic climate change. Preindustrial atmospheric CO$_2$e was approximately 280 ppm — well below even the lowest trajectory above.*

Source: Climate Interactive, C-Learn v38a, www.climateinteractive.org/simulations/C-ROADS/overview

2

Carbon “sinks” are disappearing

Until recently, natural carbon “sinks,” primarily oceans and plants, absorbed much of the CO_2 emitted into the atmosphere. Historically, about 25 percent of the CO_2 dumped into the atmosphere each year is absorbed by the oceans (although this has the nasty effect of making the oceans more acidic, potentially devastating marine life) and approximately another quarter by plants.[4] Without these carbon sinks, atmospheric CO_2 levels would rise almost twice as fast as they have since the dawn of the industrial era. But as the world emits more CO_2, these sinks are becoming saturated. This means that even if CO_2 emissions remain constant, the growth rate of CO_2 concentrations in the atmosphere will continue to rise.

As the seas warm, their ability to sequester carbon dioxide decreases; in addition, the more CO_2 they absorb, the more acidic they become, further reducing their ability to absorb carbon.[5] Meanwhile, changing land-use patterns and deforestation are reducing the ability of plants and soil — Earth’s other main carbon sinks — to absorb CO_2.[6]

In essence, these natural sinks have masked the impact of much of our CO_2 emissions. When that physical forgiveness gives out, we will be in deep trouble. Over the next several decades, emissions must be reduced to very low levels to stabilize CO_2 in the atmosphere at any concentration.

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[4] National Oceanic and Atmospheric Administration (NOAA), “Ocean-Atmosphere CO2 Exchange.” https://sos.noaa.gov/datasets/ocean-atmosphere-co2-exchange/; and NOAA, “Ocean Acidification: Saturation State.” https://sos.noaa.gov/datasets/ocean-acidification-saturation-state/

[5] Chris M. Marsay et al, “Attenuation of sinking particulate organic carbon flux through the mesopelagic ocean,” *Proceedings of the National Academy of Sciences*, 2015. https://www.pnas.org/content/early/2015/01/02/1415311112; and Union of Concerned Scientists, “CO2 and Ocean Acidification: Causes, Impacts, Solutions,” January 30, 2019. https://www.ucsusa.org/resources/co2-and-ocean-acidification

[6] Li Lai et al, “Carbon emissions from land-use change and management in China between 1990 and 2010,” *Science Advances*, 2016. https://advances.sciencemag.org/content/2/11/e1601063; and Lei Deng et al, “Global patterns of the effects of land-use changes on soil carbon stocks,” *Global Ecology and Conservation*, January 2016. https://www.sciencedirect.com/science/article/pii/S2351989415300226

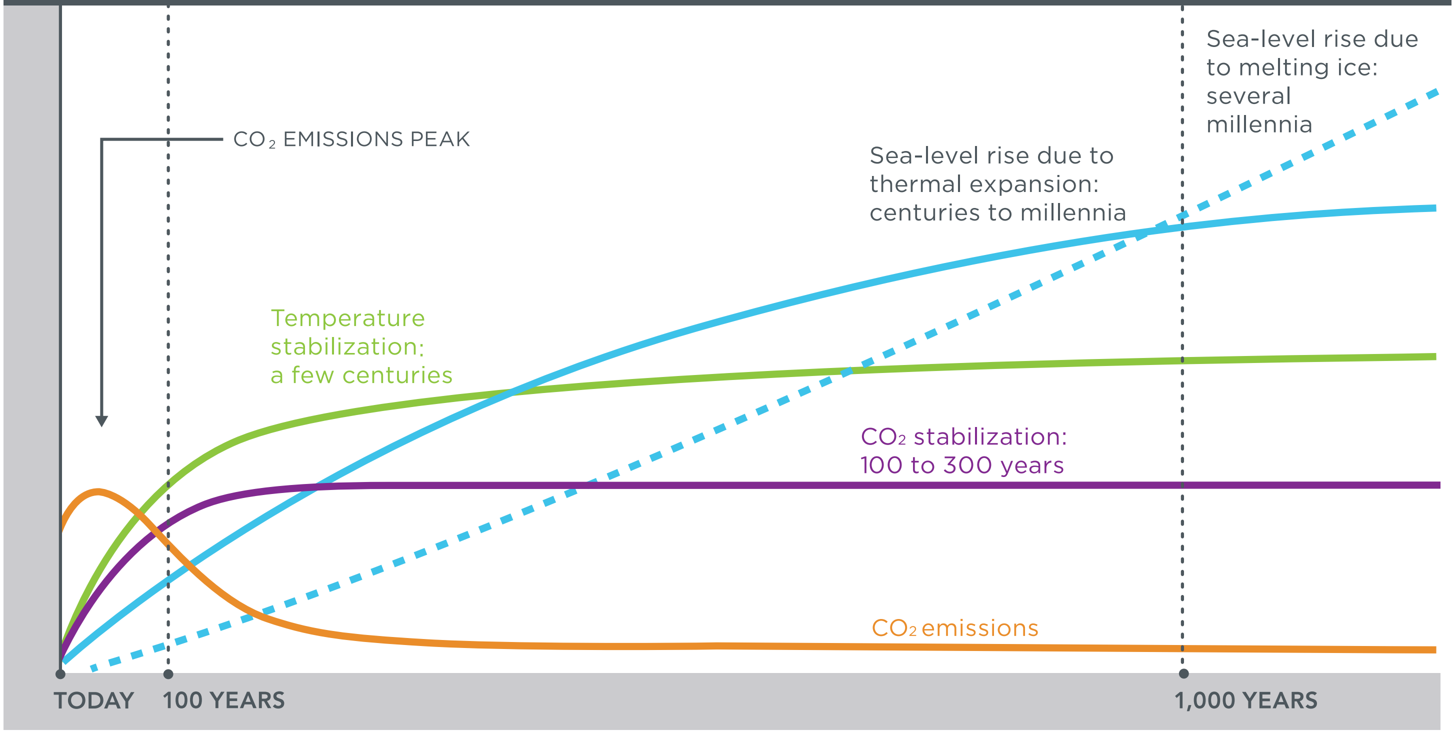
3

Many impacts of climate change are irreversible

Due to time lags inherent in Earth's physical systems, climate changes caused by CO_2 emissions will persist — and even grow — for centuries, even after emissions are halted. We are already seeing some effects of increased greenhouse gas levels, but we have yet to witness the full impact of the current accumulation in the atmosphere.

As shown in Figure 3, even if CO_2 emissions are reduced substantially (orange line), and atmospheric concentrations subsequently stabilize (purple line), the average surface air temperature will continue to rise for at least a century, and sea level will continue to rise for several millennia.

FIGURE 3: TIME REQUIRED TO REACH EQUILIBRIUM



CO_2 concentration, temperature, and sea level continue to rise long after emissions are reduced.

Source: Intergovernmental Panel on Climate Change, Climate Change 2001: Synthesis Report—Summary for Policymakers. www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

This is because Earth's surface temperature does not react instantaneously to rising carbon dioxide levels. Much of this lag, called "thermal inertia," is attributable to the slow warming of the oceans, which have tremendous heat-absorption capacity.

These changes do not reverse, even as emissions drop. And they can have serious consequences. A warmer climate is likely to permanently alter ecosystems, spur a wave of extinctions, and significantly reduce crop yields because of more frequent heat waves and drier soil.[7]

A business-as-usual trajectory threatens one in six species with extinction due to ecosystem alteration and loss. More worrisome estimates show that up to 23 percent of species will vanish.[8] Even the low estimate would rank among the greatest waves of extinction in all history. Early action is crucial — and delays will lead to irreversible loss.

A WARMER CLIMATE IS LIKELY TO PERMANENTLY ALTER ECOSYSTEMS, SPUR A WAVE OF EXTINCTIONS, AND SIGNIFICANTLY REDUCE CROP YIELDS.

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[7] Chuang Zhao et al, "Temperature increase reduces global yields of major crops in four independent estimates," *Proceedings of the National Academy of Sciences*, 2017. https://www.pnas.org/content/114/35/9326

[8] Mark C. Urban, "Accelerating extinction risk from climate change," *Science*, 2015. https://science.sciencemag.org/content/348/6234/571

4

The system can spin out of control

There is a linear relationship between CO_2 emissions, which we can control, and CO_2 concentration. But Earth's reactions to changing CO_2 concentrations — altered global weather patterns, ocean temperature and acidity, and ecosystems, to name a few — are not linear. They can snowball, unleashing a vicious cycle or a huge new force that accelerates warming — at which point we could lose our ability to influence the outcome.

For example, warmer temperatures are melting sea ice and reducing the snow cover in the Arctic tundra. The darker surfaces of the now-exposed ocean and land absorb more solar heat than the light-colored ice and snow that once covered them. This amplifies warming, and that further reduces the snow cover.

Another nonlinear response occurs when one form of warming triggers another force. For instance, rich concentrations of methane, a powerful greenhouse gas, have been locked as slush or ice in the Arctic Ocean floor by low temperatures and high subsea pressure. But an international team of researchers recently confirmed that this lock is breaking: The permafrost under the East Siberian Arctic Shelf is starting to leak large amounts of methane — four to eight times what would normally be expected in the region — into the atmosphere.[9] Release of even a fraction of the methane stored in the shelf could trigger abrupt climate warming — and there is no practical way to contain it.

How bad could this be? No one knows. Two great methane "burps" have occurred in geological history: one about 55 million years ago that caused rapid warming and massive die-offs, disrupting the climate for more than 100,000 years, and another 251 million years ago, when a series of methane emissions came close to wiping out all life on Earth. It took more than 100 million years for some ecosystems to reach their former healthy diversity.[10]

No one is currently predicting this level of catastrophe. But continued warming will release more methane, and methane creates more warming. The implications are clear: If such a nonlinear response begins, we cannot control or reverse it. To reduce the risk of such runaway feedback loops, we need to rapidly reduce greenhouse gas emissions.

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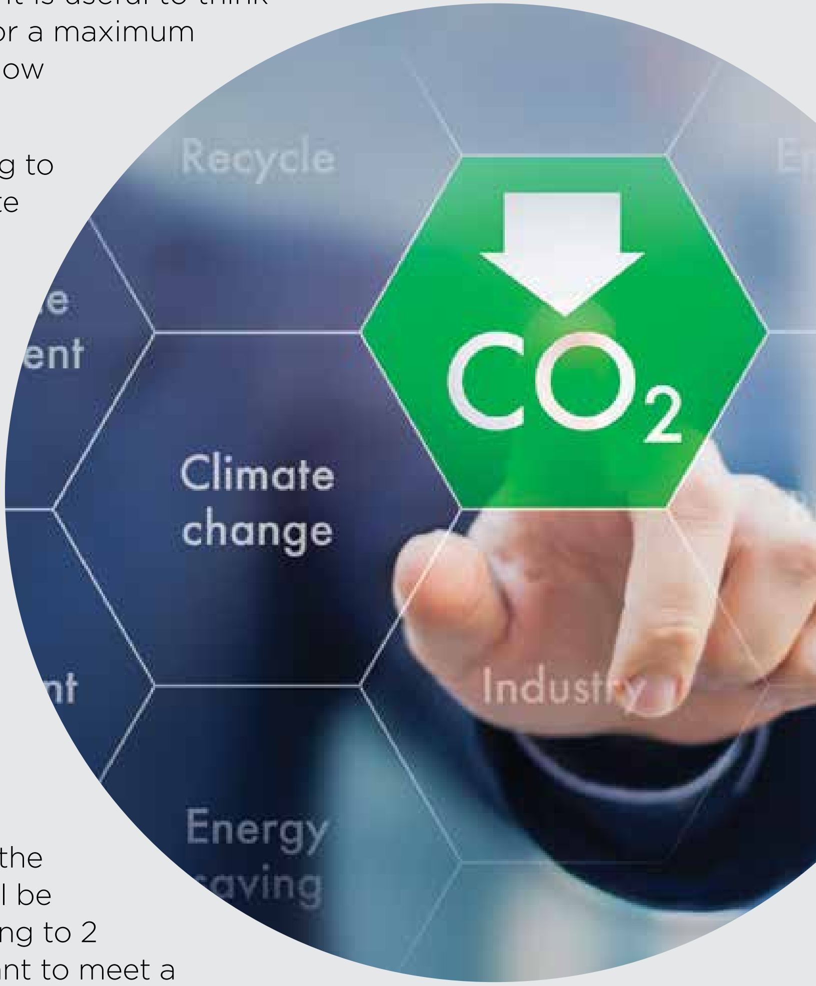
[9] Jonathan Watts, "Arctic methane deposits 'starting to release', scientists say," *The Guardian*, October 27, 2020. https://www.theguardian.com/science/2020/oct/27/sleeping-giant-arctic-methane-deposits-starting-to-release-scientists-find

[10] John Atcheson, "Methane Burps: Ticking Time Bomb," *Common Dreams*, December 15, 2004. https://www.commondreams.org/views/2004/12/15/methane-burps-ticking-time-bomb-arctic-tundra

THE EARTH'S CARBON BUDGET

Given CO_2's persistence in the atmosphere, it is useful to think of emissions in terms of a carbon budget, or a maximum volume of cumulative emissions that will allow atmospheric concentrations to stabilize.



For instance, to limit average global warming to 2 degrees Celsius — a threshold most climate scientists describe as a dangerous tipping point — the world will need to stabilize atmospheric CO_2 at about 450 ppm.[11] This corresponds to a remaining carbon budget of about 1,500 billion tons of emissions starting in 2018.[12] However, scientists have recently shifted their focus to a more stringent 1.5 degrees C limit on warming to avoid the dangerous implications of 2 degrees C warming. This gives the world a much smaller remaining carbon budget of 580 billion tons starting in 2018.[13]

The longer the world emits at current (or growing) levels, the faster we'll use up our carbon budget. The world currently emits about 40 billion tons of CO_2e, each year. At the current rate of emissions, the full budget will be depleted in 35 years if we are to limit warming to 2 degrees C, and in less than 12 years if we want to meet a safer 1.5 degrees C goal.[14, 15]

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[11] This is the level that offers a 50 percent probability of a 2 degrees C (almost 4 degrees F) rise in global average temperatures. The 450-ppm goal can be compared with a preindustrial baseline of about 280 ppm. Intergovernmental Panel on Climate Change (IPCC), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2014. https://www.ipcc.ch/assessment-report/ar5/

[12] IPCC, Global Warming of 1.5° C.An IPCC Special Report on the impacts of global warming of 1.5 degrees 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, 2018. https://www.ipcc.ch/sr15/

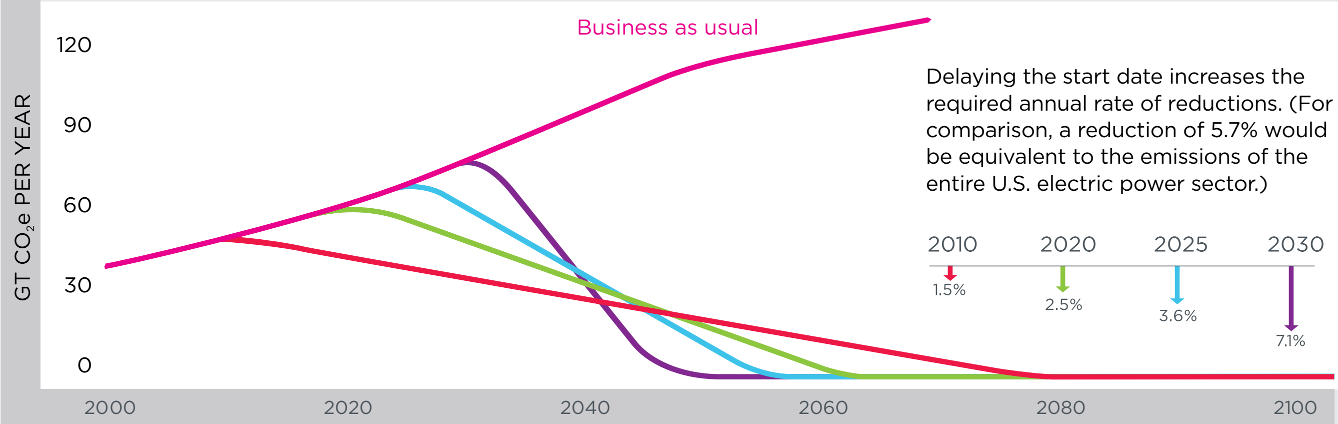
[13] IPCC, Global Warming of 1.5° C.An IPCC Special Report on the impacts of global warming of 1.5 degrees C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, 2018. https://www.ipcc.ch/sr15/

[14] The math for 2 degrees C: 1,500 Gt budget – 40 × 3 Gt emitted through 2020 = 1380 Gt; 1380 ÷ 40 Gt emissions per year = 34.5 years. For 1.5 degrees C: 580 Gt budget – 40 × 3 Gt emitted through 2020 = 460 ÷ 40 Gt emissions per year = 11.5 years

[15] Recent research that better incorporates Earth's feedback loops suggests that we may already have more than 2 degrees C of eventual warming "committed" in the climate system. We can still control the timeline over which warming occurs though. Steady action towards net zero carbon emissions now can slow the rate of warming and give society more time to adapt. Chen Zhou et al, "Greater committed warming after accounting for the pattern effect," *Nature Climate Change*, 2021. https://www.nature.com/articles/s41558-020-00955-x

This concept of a carbon budget is illustrated in Figure 4 as the area under a series of curves, which show total greenhouse gas emissions over time.

FIGURE 4: DIFFERENT PATHWAYS TO 450 PPM



Delaying the start date increases the required annual rate of reductions. (For comparison, a reduction of 5.7% would be equivalent to the emissions of the entire U.S. electric power sector.)

The longer we wait to reduce emissions, the more quickly the reductions will need to happen.

Source: Climate Interactive, C-Learn v38a, www.climateinteractive.org/simulations/C-ROADS/overview

The area under each curve corresponds to atmospheric CO_2 concentrations. In this simulation, they are all set equally, at a 450-ppm goal. For a given ultimate concentration, the shape of each curve is determined by the date when emissions peak.

This shape matters: The carbon budget shows that the later the peak in global emissions, the more drastic the emissions reductions required to meet the 450-ppm goal. Steep declines represent economic and social trauma, as high-emitting industries and individual activities would need to be summarily shut down to achieve the needed reductions.[16]

After a certain point, a reasonable CO_2 target level becomes impossible. Had serious climate action begun in 2010, the global emissions reductions required per year to meet the emissions level in 2030 consistent with a 1.5 degrees C warming scenario would only be 3.3 percent.[17] Since this did not happen, getting back on track to 1.5 degrees C now requires a 6 percent cut in global emissions every year until 2030. The longer we delay action, the harder it will become.[18]

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16 These curves are physical models, not political projections. They show that to land at a reasonable level of CO_2 concentrations, the reductions must start right away.

17 United Nations Environment Programme (UNEP), Emissions Gap Report 2019, 2019. https://www.unenvironment.org/resources/emissions-gap-report-2019

18 UNEP, Emissions Gap Report 2020, 2020. https://www.unenvironment.org/emissions-gap-report-2020

5

Acting now saves money

Most energy-consuming assets — such as homes, offices, power plants, and industrial facilities — have long lives that lock in their energy use patterns for decades.

The cheapest way to reduce CO_2 emissions is to ensure that all new capital equipment — factories, buildings, power plants, and cities — is very efficient and is powered by low-carbon sources. It will be enormously costly if the world misses this opportunity, builds inefficient infrastructure, and then has to renovate it.

It is not difficult to halve the energy consumed in most sectors. For example, a house built with thick insulation, high-performance windows, and an efficient furnace uses very little energy, year after year—and costs only nominally more to build than an inefficient home. In contrast, fixing up a leaky house is much more expensive — and less effective.

MITIGATION VERSUS ADAPTATION

The longer we delay, the more likely we are to face irreversible impacts and therefore be forced to make far costlier investments in human relocation and adaptation. The *Stern Review*, for example, estimated that mitigation would cost 1 percent of GDP, whereas the cost of dealing with unabated climate change could reach 20 percent or more of GDP.[19] Several subsequent studies indicate that the costs of adaptation will be substantially higher.[20]

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[19] *Stern Review on the Economics of Climate Change*, October 2006. http://webarchive.nationalarchives.gov.uk/+/http:/www.hm-treasury.gov.uk/sternreview_index.htm

[20] International Monetary Fund, *Finance and Development: The Economics of Climate*, December 2019. https://www.imf.org/external/pubs/ft/fandd/2019/12/pdf/fd1219.pdf; and Kahn et al, "Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis," 2019. https://www.imf.org/en/Publications/WP/Issues/2019/10/11/Long-Term-Macroeconomic-Effects-of-Climate-Change-A-Cross-Country-Analysis-48691

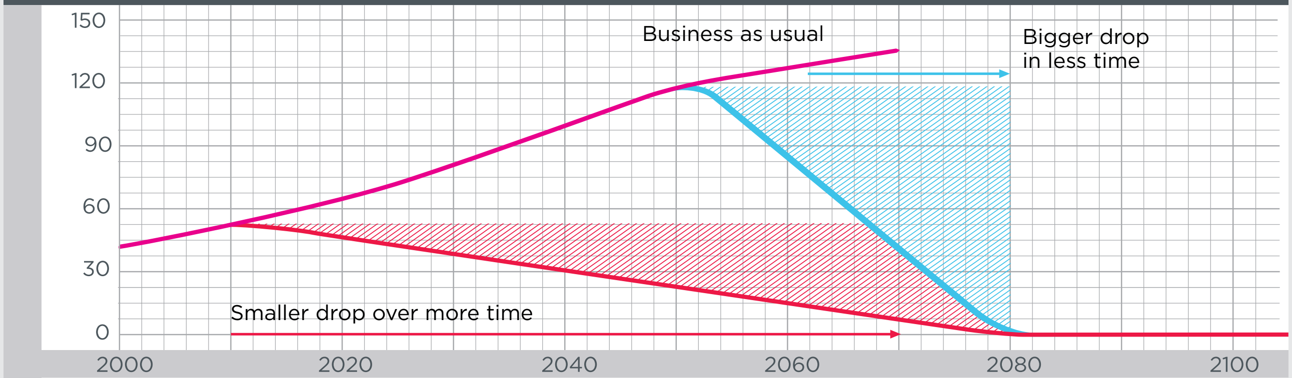
To ensure that houses, cars, equipment, and factories are designed to save energy, nations need to have energy efficiency policies — such as fuel efficiency standards and building codes — in place now, not later. And to drive clean technologies and get the rest of the way to zero emissions, governments must invest substantially in deployment of zero-carbon power plants, factories, and equipment as well as R&D today. If we start immediately and make steady improvement over the next 30 years, we can convert our energy supplies to near-zero sources. If we wait even a decade, the accelerated transition will shock the global economy.

WHY 650 PPM ISN'T EASIER THAN 450 PPM

An often-cited goal for controlling climate change is to stabilize CO_2 concentrations at 450 ppm. Many people assume that a less-stringent target — such as 650 ppm — would be easier to meet. But under most realistic scenarios, this is not true.

This counterintuitive story is shown in Figure 5. If the world delays action to reduce emissions, we will continue along the business-as-usual curve, emitting more greenhouse gases each year and accumulating higher concentrations of CO_2 in the atmosphere. But, as we know, to stabilize CO_2 in the atmosphere at any concentration, we still need to reduce emissions to nearly zero.

FIGURE 5: A HIGHER TARGET ISN'T EASIER



LEGEND

→ **Speed of drop.** Whereas a slow reduction in emissions can be coordinated with ordinary capital stock turnover, a fast drop would likely require scrapping equipment early in its operating life—a much more expensive scenario.

▨ **Size of drop.** Total size of the required drop. A larger total reduction requires more capital.

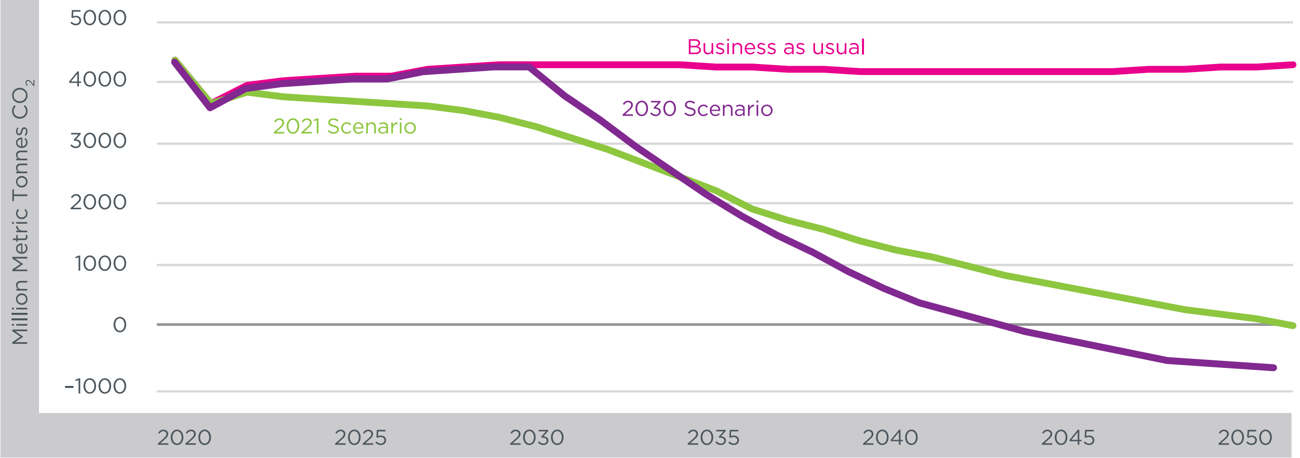
Source: Climate Interactive, C-Learn v38a, www.climateinteractive.org/simulations/C-ROADS/overview

The longer we delay, then, the greater the adjustments we'll have to make to get to zero — and the more likely we are to face irreversible impacts. The steeper the decline, and the greater the reductions required, the more expensive the changes will be.

We can compare these effects to driving on an icy road. It's easier to slow to 20 miles per hour when you're motoring along at 40 mph than when you're doing 60. By the same token, if we wait to reduce emissions, it will be harder to achieve a 650-ppm equilibrium than if we start now and aim for 450 ppm.

To put some numbers behind this concept, we modeled two illustrative scenarios with the United States Energy Policy Simulator,[21] a free, open-source, peer-reviewed model that allows users to estimate the impacts of climate and energy policies. Figure 6 shows a business-as-usual trajectory for the United States, along with two climate policy scenarios achieving approximately the same cumulative emissions abatement. However, the first scenario starts climate action in 2021, whereas the second scenario delays climate action until 2030.

FIGURE 6: UNITED STATES CO_2 EMISSIONS



Source: The Energy Policy Simulator, Energy Innovation

The first scenario reaches net zero CO_2 by 2050, in line with recommendations in the Intergovernmental Panel on Climate Change *Special Report on Global Warming of 1.5° C.*[22] This "2021 Scenario" requires broad action across the economy starting today, with a 90 percent clean electricity standard by 2035 ramping up to 100 percent by 2050, strong electric vehicle and building component sales standards, industrial fuel switching, and efficiency standards across all sectors.[23] The illustrative 2021 Scenario also includes some carbon capture and sequestration to address a portion of remaining industrial emissions. The "2030 Scenario" necessarily requires steeper emissions reductions to achieve the same cumulative abatement. With a tighter window for climate action, it requires additional policies and clean energy deployment, adding additional efficiency and electric sales standards for non-road vehicles, a building retrofit push, additional industrial fuel switching, and significantly more carbon capture and sequestration (including direct air capture to bring emissions below zero before 2050). It also accelerates decarbonization timelines in the power sector, retiring the entire coal fleet between 2030 and 2035 and requiring 100 percent clean electricity by 2040.

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[21] The Energy Policy Simulator, Energy Innovation. https://www.energypolicy.solutions/

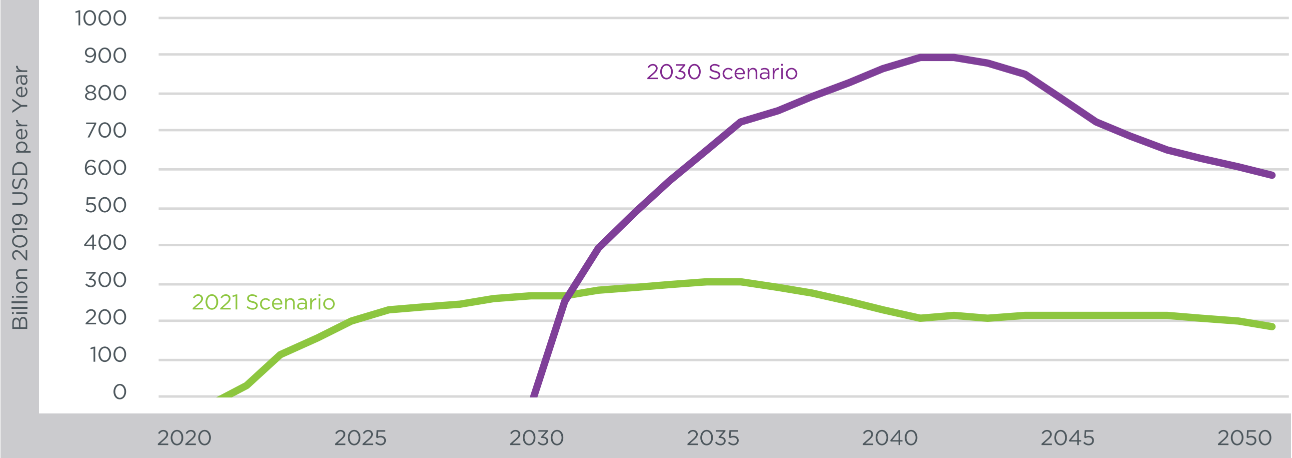
[22] IPCC, Global Warming of 1.5 degrees C.An IPCC Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, 2018. https://www.ipcc.ch/sr15/

[23] See Appendix for policy settings.

The resulting differences in costs are striking. The net present value of the 2030 Scenario changes in cumulative capital, operational, and fuel expenditures are 72 percent more than in the 2021 Scenario.[24] While the 2021 Scenario shows changes in annual expenditures reaching a maximum of roughly $320 billion in 2035, the 2030 Scenario sees annual expenditures ballooning to nearly $750 billion in the first five years before growing to a maximum of more than $900 billion. In addition to accumulating higher costs, delaying climate action requires astounding rates of clean energy deployment and buildout of manufacturing capacity.

For example, business-as-usual wind and solar deployment is projected to be roughly 20 gigawatts (GW) at the end of this decade, but the 2030 Scenario would require six times that amount by the end of this decade and nine times that amount by the mid-2030s. These solar and wind deployment rates could be doable, but the delayed action in the 2030 Scenario would also result in a great deal of stranded assets — if we continue to buy and build polluting power plants, factories, and equipment for the next decade, and then decide we must make the clean energy transition fast to avoid climate damages, we will need to retire much more polluting equipment before the end of its functional life. And that isn't cheap.

FIGURE 7: CHANGE IN CAPITAL, OPERATIONAL, AND FUEL EXPENDITURES



Source: The Energy Policy Simulator, Energy Innovation

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[24] Assuming a 3 percent discount rate.

Putting it all together

The consequences of a delay in reducing carbon emissions are insidious and inescapable. To recap: The math of historical CO_2 accumulation gives us no choice but to slash emissions to very low levels. Earth's natural carbon sinks are becoming saturated, so our safety valve is slowly closing; our planet's ecosystems face irreversible damage such as widespread extinctions; and these changes are pushing our climate system toward tipping points beyond which the domino effects could be devastating. Because many effects lag emissions, we have yet to experience the full impact of historical emissions.

The longer we wait, the more drastic the cuts — and associated costs — will be. If we delay action for even a decade, CO_2 concentrations will likely blow right past 450 ppm and unleash the dangers of nonlinear ecological and geophysical responses. If, instead, we step up to the challenge and pass strong energy policies and invest aggressively in clean energy R&D, we have a fighting chance of containing CO_2 concentrations at 450 ppm — and averting a climate catastrophe.

Appendix

Policy	2021 Scenario Settings	2030 Scenario Settings
Transportation Fuel Economy Standards	50% improvement over business-as-usual (BAU) standards by 2050 for onroad vehicles	50% improvement over BAU standards by 2050 for on-road vehicles; 25% improvement over BAU standards for nonroad vehicles by 2050
Electric Vehicle Sales Standards	100% by 2035 for light-duty vehicles; 100% by 2045 for heavy-duty vehicles	100% by 2035 for light-duty vehicles; 100% by 2045 for heavy-duty vehicles and rail
Clean Electricity Standard	90% by 2035; 100% by 2050	100% by 2040
Additional Battery Storage Deployment	100% of potential by 2050	100% of potential by 2050
Additional Demand Response	100% of potential by 2050	100% of potential by 2050
Transmission Buildout	100% expansion by 2050	100% expansion by 2050
Early Coal Retirements	N/A	Retire all coal by 2035
Building Efficiency Standards	Efficiency improvements ranging from 11%-40% by 2050, depending on the building component	Efficiency improvements ranging from 11%-40% by 2050, depending on the building component
Electric Building Component Sales Standard	100% by 2035 for all building components	100% by 2035 for all building components
Building Retrofits	N/A	Retrofit 37% of preexisting residential and commercial buildings by 2050
Industrial Efficiency Standards	25% efficiency improvement by 2050	25% efficiency improvement by 2050
Industrial Fuel Switching	80% of industrial fuel use shifted to electricity or hydrogen by 2050, with a slower ramp-in through 2040	100% of industrial fuel use shifted to electricity or hydrogen by 2050
Industrial CCS	30% of remaining industrial CO_2 emissions captured	100% of remaining industrial CO_2 emissions captured
Direct Air Capture	N/A	100% of potential by 2050

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