THE NET ZERO FALLACY

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Abstract

Most government, corporate, and institutional plans to achieve far lower carbon emissions than today are based on the false promise of nature-based carbon sinks or miracle technologies designed to draw carbon dioxide out of the atmosphere. To rely on either is scientifically unsound at best, incredibly expensive even if they work, and often major distortions of the truth by governments to avoid making the tough choices they need to make.

How Greenhouse Gas Emissions Could Impact Climate Change in 2100

While there are still some holdouts who think the climate crisis is not real, multiple sources are now projecting that unless some radical reductions in human carbon emissions the planet could heat up by as much 6° C (10.8° F) by the end of this century.

For those who continue to hear the UN Climate Change Paris Accords target of 1.5° C as within reach as opposed to something that has already been passed by, seeing a number almost four times that high as the likely outcome at the end of the century is a shock.

One form of that analysis comes in a recent article from the OSS Foundation[1]. In that reference, it considers a variety of radiative forcing components, including long-lived greenhouse gases such as CH_4 (Methane), CO_2, Nitrous Oxide, and Halocarbons; ozone as propagated in the stratosphere and troposphere; stratospheric water vapor tied to methane emissions; aerosol components in the atmosphere; and direct impacts of changes in surface albedo on the planet. That, along with further data provided by NASA Goddard Space Flight Center's parallel analysis of climate forcing concludes that average temperatures could increase by up to 6° C (10.8° F) by 2100.[2]

To reach this conclusion, most researchers begin with a classic graph showing the relentless increase in carbon emissions concentrations in the atmosphere for many decades. The most cited of those comes from NASA's atmospheric samplings at the top of Mauna Loa observatory in Hawaii and is shown in Figure 1. The reason this data is so commonly used is it represents the longest-running greenhouse gas emission data set continuously monitored by a similar set of apparatus in the world.

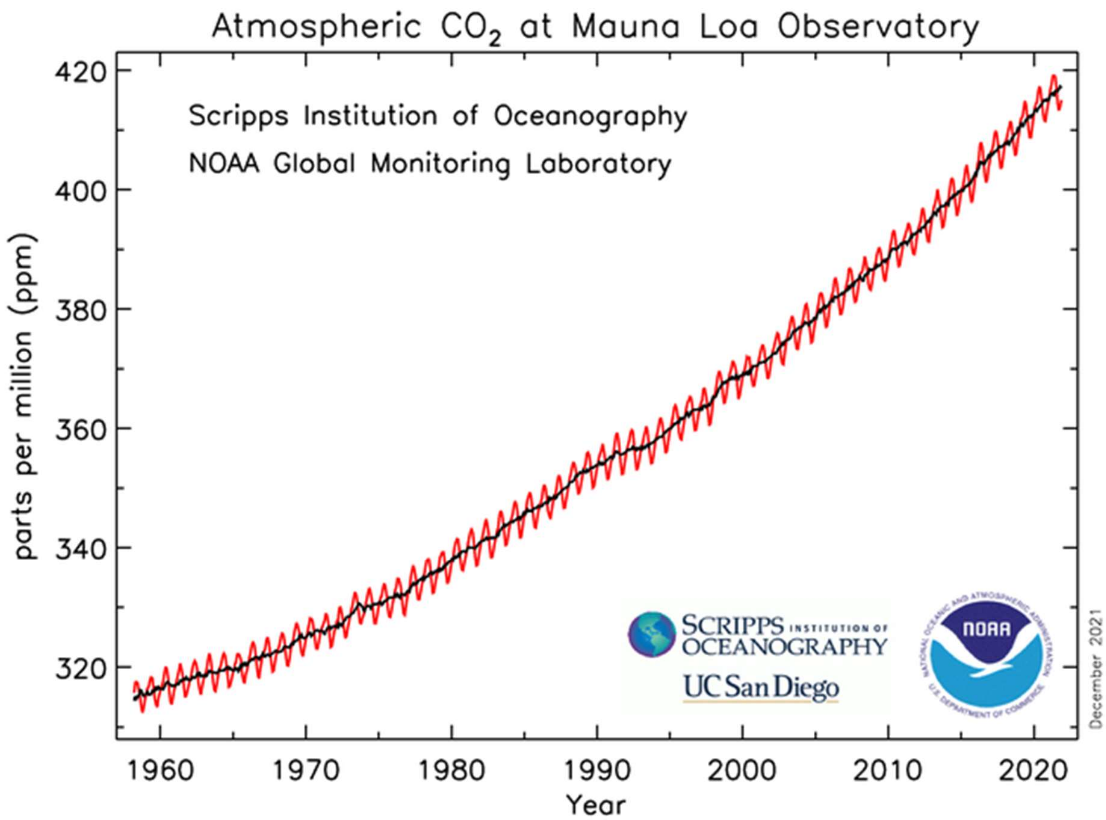

Figure 1. Monthly mean carbon dioxide concentrations as measured at the Mauna Loa Observatory in Hawaii.[3]

As is well known at this point, when solar energy passes through the atmosphere, some significant amount of that solar energy stays trapped close to the Earth's surface, either to be absorbed by the air, the ground, or the oceans below. As a result, there is a strong correlation between the mean temperature of the planet and the concentration of greenhouse gases in the atmosphere.

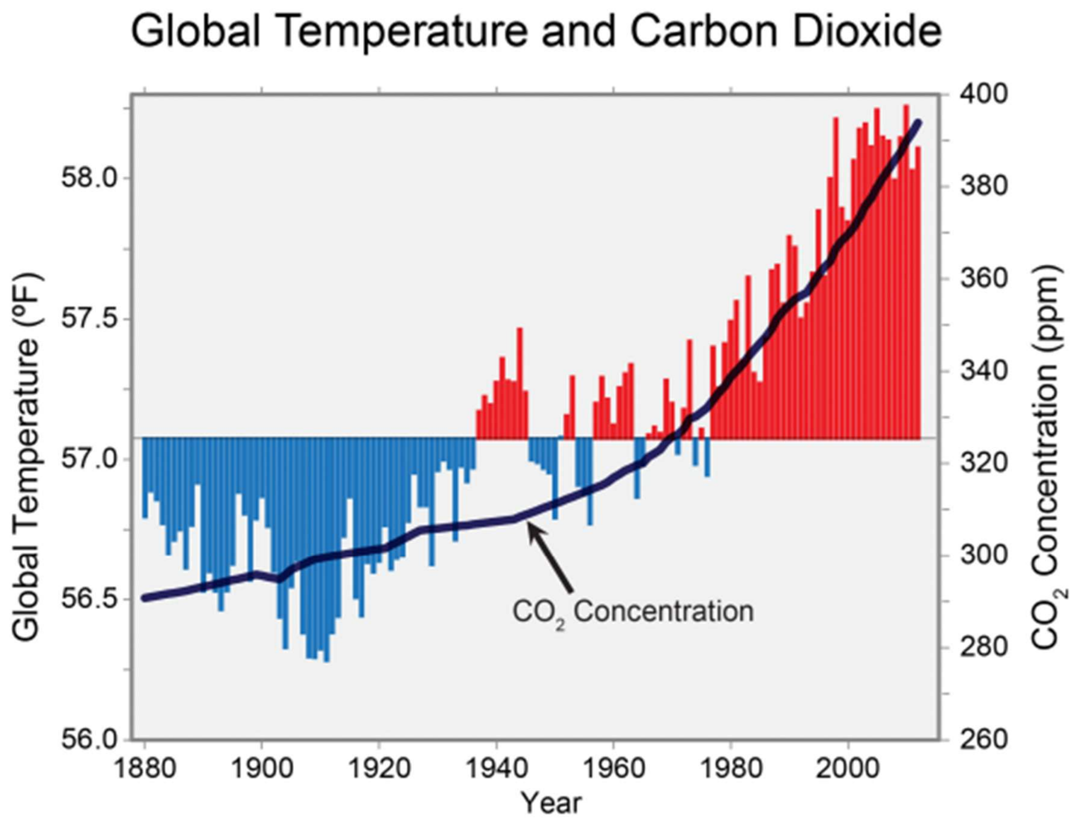

Figure 2. Comparison of the global annual mean temperature since 1880 and carbon dioxide concentrations. The graph begins shortly after the beginning of the industrial revolution when human-driven fossil fuel burning "took off," noting the strong relationship between the mean temperature as measured over both land and oceans and mean CO2 atmospheric levels through 2012.[4]

As noted in the original source of the data for this second graph, temperatures sometimes are up relative to a perfect correlation graph and other times are down relative to the same curve. As the reference notes, those "year-to-year fluctuations are due to natural processes, such as the effects of El Niños, La Niñas, and volcanic eruptions." Yet in the end the conclusion is clear: human fossil fuel carbon dioxide emissions, from burning of fossil fuels for all needs, whether energy production, heating, or transportation, have a direct and predictable effect on global heating.

A third point to note here is the rapid accumulation of all greenhouse gases in the atmosphere just in the last few decades. As noted in Figure 3 below, since 1990 there has just under a 50% increase the total accumulation of carbon dioxide, methane, nitrous oxide, and fluorocarbons, each of which has a differing impact on the total amount of solar energy they prevent from reflecting out into space after striking the planet.

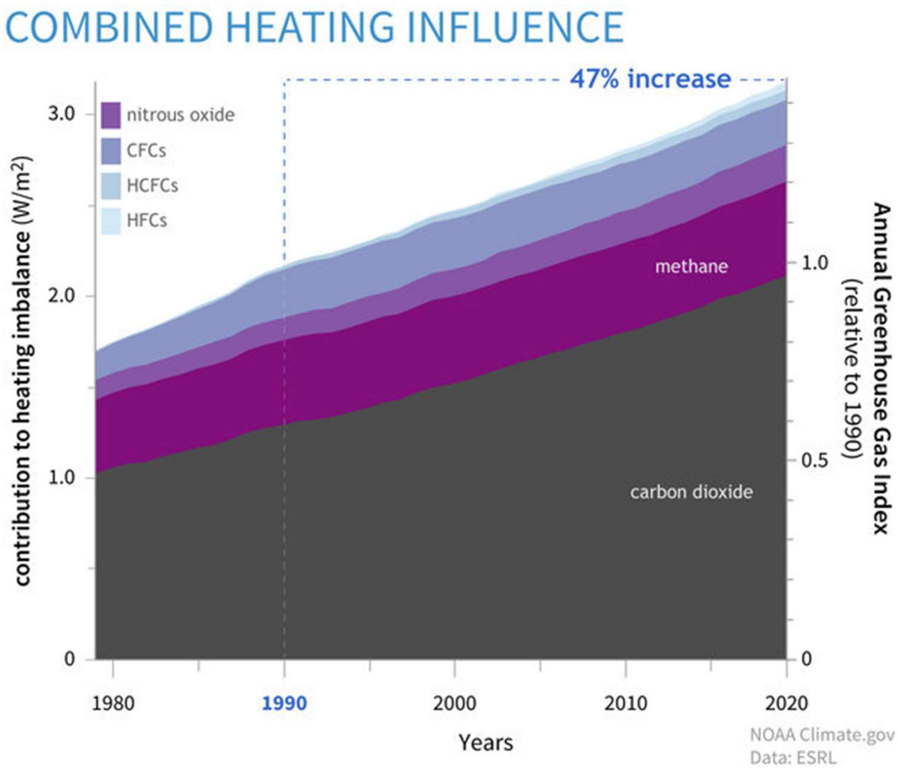

Figure 3. A graph of the heating imbalance caused by each of the most dominant greenhouse gases we human beings produced. Thanks to the combined presence of these gases, the atmosphere we live within today absorbs over 3 excess watts of energy per square meter of the Earth's surface, compared to what it used to absorb in 1750.[5]

These parameters are backed up by further studies which build on what is known as the so-called "worst case" "RCP 8.5 Scenario" for carbon emissions releases on the planet, so named because it describes a model under which radiative forcing has increased to 8.5 W/m^2 by the end of the century. In one of the more comprehensive explanations of what assumptions are built into the RCP 8.5 model,[6] a combination of forces such as increases in global population by a factor of three by 80 years from now, and increased per capita energy consumption pushing power needs to five times what they are now in the same time period, in part driven by increased use of air conditioning as the planet grows hotter, could increase net emissions by a factor of four from current levels.

RCP 8.5 basically boils down to a scenario under which little climate mitigation happens fast enough to matter this century, resulting in – as show in the graph below – nominally a doubling of the concentration of carbon dioxide in the atmosphere by 2100.[7]

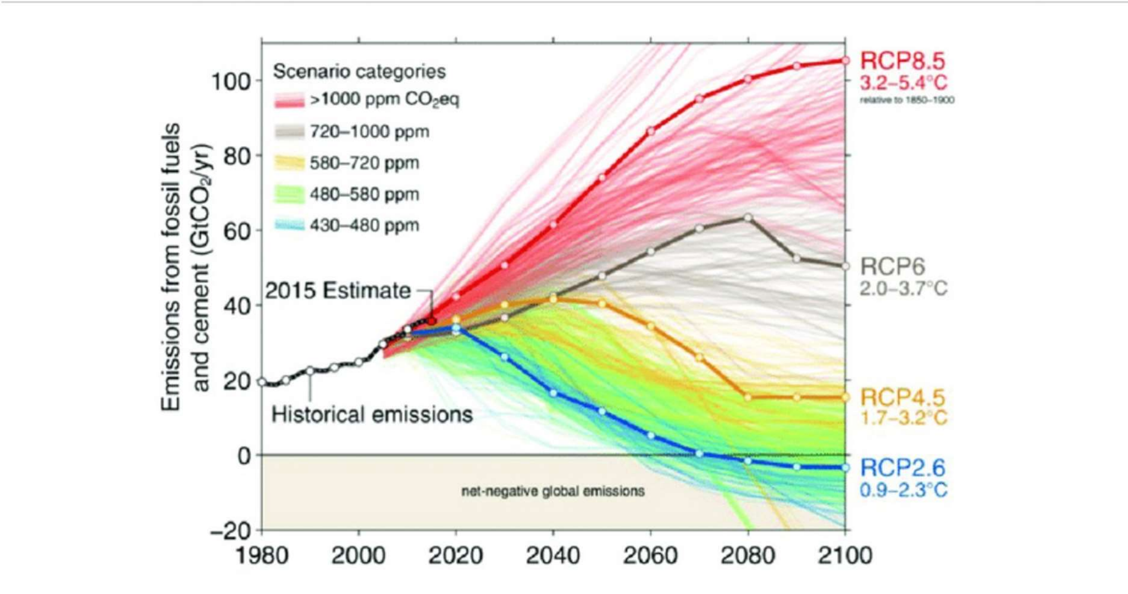

Figure 4. A graph of four major scenarios for carbon emissions based on differing carbon forcing conclusions, where RCP 8.5 assumes a forcing level of 8.5 W/m^2 and the others shown in the figure correspond to the best-case number of 2.6 W/m^2 for RCP 2.6, 4.5 W/m^2 for RCP 4.5, and 6.0 W/m^2 for RCP 6, respectively. (Image credit: Neil Craik, University of Waterloo.[7]

To provide an even more graphic understanding of what the difference between taking drastic action to reduce carbon emissions (the RCP 2.6 scenario) and letting things proceed on their current trajectory (the RCP 8.5 scenario), the following graph is helpful.

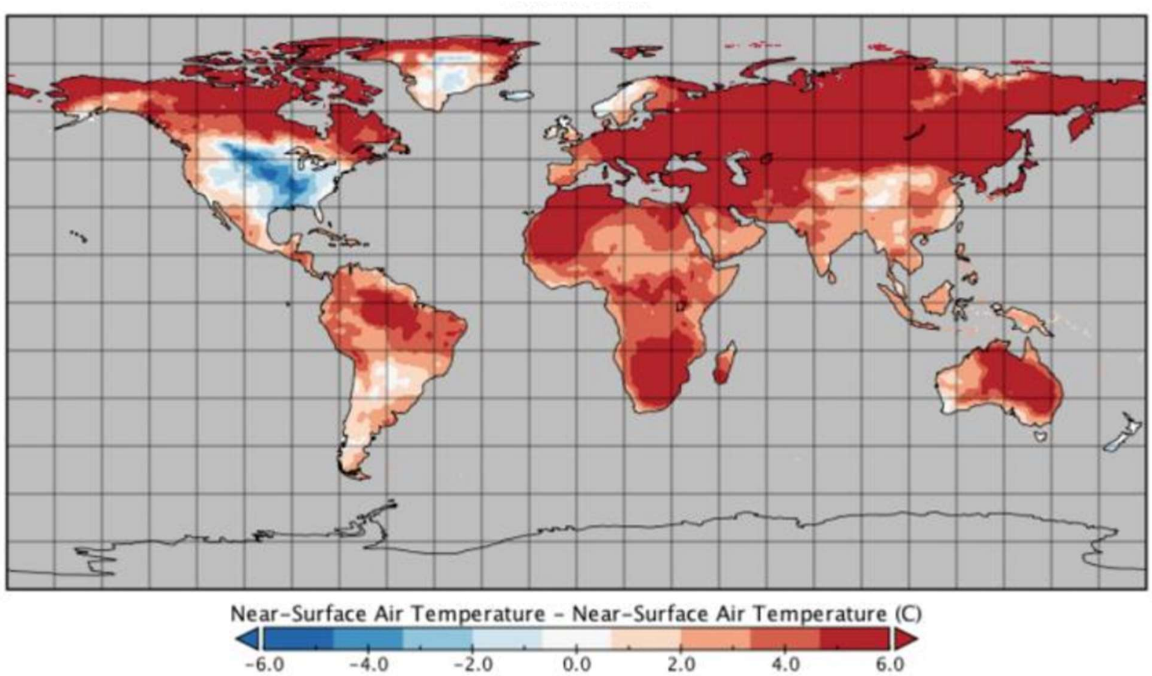

Figure 5. Map showing projected near surface temperature differences for the planet as of December 2100 between a highly unlikely RCP 2.6 scenario and the RCP 8.5 scenario. Red colors indicate locations where the RCP 2.6 scenario has lower temperatures, while blue colors indicate locations where the RCP 2.6 scenario has higher temperatures.[8]

Based on past correlation curves like the above, a logical conclusion is that the planet will rise in average temperature by just short of 6° C by the end of the century just based on projected total emissions given increased population, energy use, and energy source mix.

While many challenge the assumption that the RCP 8.5 scenario will come to pass, consider that the European Commission just proposed to its member nations a plan to allow the use of natural-gas-fired power plants as part of their strategy to achieve net zero carbon emissions by 2100.[9] They argue that by tightening leak management in the power plants, that this is an acceptable bridge strategy into the future. The plan appears to ignore any consideration of the vast methane leaks which can happen through the natural gas (methane) supply chain, up to the point it reaches a power plant.

That the EC could consider this at all represents a good example of the desperation world leaders are facing as they approach their own solutions on how to get to a carbon neutral position by mid-century.

If one adds in other amplifying effects to the climate crisis, such as the decreased albedo (reflectance) of the planetary surface when most of the snow, ice and glaciers have melted away, released carbon from wildfires and permafrost melting, methane unleashed from within warmer oceans, and conversion of multiple rainforests such as the Amazon from net carbon sinks to net carbon emitters over time, there is the possibility that the real temperature rise by the end of the century could be worse.

With such high temperatures likely unless we make major changes in the way we live, by 2100 the planet will have suffered cataclysmic extinctions of almost every major species category in existence. Entirely new levels of hurricanes, cyclones, and typhoons will engulf the coastlines. Sea levels will rise by many meters, submerging entire countries and forcing human climate migration. Ocean currents which helped drive the delicate balance of nature will slow or stop, forcing marine climate migration. The coral reefs that launch global food chains everywhere will be dead.

The people who will survive this calamity will know a very different planet from the one where their grandparents were born.

The Siren Song of Net Zero

While avoiding this completely is now likely impossible, the one obvious thing for all responsible governments, companies, and others to do to slow the pace of the climate crisis is to cut back dramatically now on carbon emissions from all sources.

As the first three graphs of this paper show as projections, first scientists, then private institutions, and even most governments are finally acknowledging that we are presently on a course that most living species may not survive. What those same institutions and leaders also understand is that making the radical course corrections to change the trajectory of carbon emissions buildup in the atmosphere is going to require political and/or organizational will which has never been realizable in the past.

The nations of the world gathered in 2015 at the historic United Nations Climate Change Conference in Paris to address that collective risk. Though not stated, the single most important objective of the conference was to agree on a joint plan to cut carbon emissions. By making it something all nations would contribute to, it avoided the need for any single hero nation to do it on its own, though one could certainly argue that the top carbon emitters on the planet from China, the United States, and India, have more responsibility than the others to change their ways.

While the idea may have seemed sound, the Paris agreement – to date at least – has failed to achieve its intended goal of putting in place global plans that would bring global emissions in line for two reasons.

One was the nature of the goal the countries set for themselves, which was to keep the overall planetary temperature from ever to increase by more than 2° C, and ideally less than 1.5° C, relative to temperatures present at the time of the Industrial Revolution in the mid-1800s. The idea behind that goal was to minimize catastrophic ecosystem collapse, put an end to rapid melting of glaciers and ice at the two poles, in Greenland, and the Himalayas, and allow the biomechanical stresses on the planet to ease.

That target was flawed from the beginning since, as numerous scholars have already demonstrated, the average temperature of the planet – at least where most people live – had already exceeded the 2° C objective. The consequences of sea level rise, extreme weather, blistering high temperatures, record-setting drought in some places and flooding in others, and heat waves both on land and the oceans were already with us.

The second reason the goal failed lies paradoxically in its collective nature. By pooling the goals of the many nations of the world together, individual national responsibility for meeting their piece of the targets was easy to dodge. The collective goal allowed even the biggest of countries from being held accountable for continuing to kill the planet.

By the time the next UN COP (Conference of the Parties) pulled together to review how countries were doing relative to their targets, it became obvious that the idea of actively curtailing actual carbon emissions by enough to matter was not going to work. It was either going to cost too much to shift from carbon-based fuels for power and transportation, damage the economies of the nations who did more than just talk about the transition to a low carbon economy, or force out the politicians and corporate leaders who dared demand radical change on their turf.

Faced with these choices, politicians began to scramble. And so, when the five-year anniversary of the Paris Accords arrived in 2020, and the main meeting was postponed another year because of the pandemic to fall 2022 in Glasgow, corporate and political leaders alike sought some other solution to allow them to appear to be making progress on fossil fuel emissions goals.

What they found was the climate crisis political equivalent of the Holy Grail: the concept of Net Zero Carbon Emissions.

The idea behind Net Zero is far from new. For some time, local governments, corporations, and even individuals had been offered ways to acquire and invest in *carbon offset* credits as a means of appearing to be doing something positive for the environment even while continuing business as usual and dumping ever-increasing quantities of carbon dioxide, methane, and other greenhouse gases into the atmosphere.

While some of these options did and still do provide for the creation of new technologies which may help slow the pace of greenhouse gas emission production, all too often this is just about the all-too-common practice of “greenwashing,” the act of painting something as good for the environment more as a public relations strategy than anything else.One option for carbon offsets include allowing carbon use to go up in one part of the world, while paying to ensure an equivalent amount of green energy production in another. Other solutions include investment in reforestation as a means to offset carbon emissions output, on the grounds that forests can act as carbon sinks. While these are legitimate, they are hard to calculate properly as to their real impact.

It is always better never to have released greenhouse gases than to compensate for them through a parallel investment.

The trend to embrace Net Zero is a logical progression of the original concept of carbon offsets, broadened considerably.

It embraces the idea that the sum of whatever carbon emissions a corporation or country may emit, minus whatever it claims as a deduction that may be a net absorber of carbon emissions, is the only total carbon emissions number it needs to focus on. When it says then that it will achieve “Net Zero” carbon emissions by a given time, the entity claiming that is effectively saying that despite continuing to emit new carbon emissions (potentially in large volumes) it says it has claimed the equivalent amount of carbon it is emitting into the atmosphere is being either trapped before it can reach the atmosphere, is being absorbed somewhere else (such as by a forest, which breathes in carbon dioxide and breathes out oxygen), or is being sucked out of the air (and presumably pumped back into the ground) by something like the high-tech carbon capture equipment currently being prototyped by multiple startups.

It makes for a good policy statement, to say that by 2050 for example a country plans to achieve net zero emissions. It also avoids having to take responsibility for cutting anywhere the amount of fossil fuel emissions that would be required otherwise to meet targets agreed to in the Paris Accords. It also completely sidesteps the problem that most global economies will not shift from carbon-based power generation and transportation methodologies to renewable energy ones by mid-century, which would at least be a path to creating far few emissions overall.

There is also the challenge that everything from construction to manufacturing and agriculture also constitute major contributors to carbon emissions, so that even if somehow all other carbon emissions were dropped to zero, the world would not be able to convert those parts of the economy without radical surgery to the way we build (e.g., stop using concrete, which contributes 7% or more of all global carbon emissions), in construction, shift the making of materials like steel to forges powered by solar or other renewable means, or shift food production away from one based to a significant extent on livestock, where many farm animals produce large quantities of methane, for example, to one which is principally vegan.

So, when a company, country, or other institution can simply eliminate the need for all those policy shift challenges with one or more Net Zero “magic wands”, there is no wonder almost every single major entity in the world has moved to that premise as the basis for claiming they are compliant with the Paris Accords.

The Many Faces of the Net Zero Fallacy

As with the original siren song that lured Odysseus to crash against the rocky reefs In Homer’s story, the Net Zero argument is seductive and dangerous at the same time. Seductive because it is an all too easy sell that there may be no need for radical policy changes to slow or perhaps even reverse the direction of global heating. Dangerous because, if it lulls all of us into a belief that all will be okay anyway, almost no one will make the hard decisions needed to save even a fraction of the planet from mass extinction.

It is also a tough truth to accept that many of the "carbon offset" balance sheet calculations proposed by the Net Zero proponents are either flawed or wildly distorted misrepresentations of reality.

To illustrate, let's examine three of the more popular means by which policymakers and even some scientists maintain net carbon emissions could decrease rapidly in the next few decades.

Option 1: The Forests Will Save Us

One of the more dominant of the Net Zero arguments is that the combination of the forests we already have on the planet, ones we could plant in the future, and implementing better conservation measures for both should allow drawing in a significant percentage of the carbon we keep adding to the atmosphere over time by multiple means.

The concept sounds good. After all, it seems to us that the planet is a finely-tuned but well-balanced machine, with many animal species – like us -- breathing in oxygen and expelling carbon dioxide as part of our biological processes and plant species absorbing carbon as part of their biological functioning and expelling oxygen as a waste product. There are also a lot of plants and trees everywhere, with the boreal forests of Canada as one example, the Amazon rainforest as another, as well as throughout India, the Pacific Northwest in North America, in the bush country of Australia, and even in the Siberian Arctic. Provided they are not making headlines by burning because of rising temperatures, drought, and lightning strikes from extreme weather sources, these forests should continue to do a great job reducing net carbon emissions until the end of time. Besides, if we need more forests to absorb carbon, we can just plant more trees to assist. Right?

Wrong.

To understand why this line of argument just does not add up, consider the following analysis courtesy of Bonnie Waring, a researcher and lecturer in climate science from the Grantham Institute – Climate Change and Environment, Imperial College London. She and colleagues who worked together with her have studied the potential of Earth's forests as a potential balance for carbon emissions in depth.

In a paper published in the journal *Frontiers for Global Change*, in the 8 May 2020 issue[10], the researchers begin by doing some calculations on exactly how much carbon the world's forests can capture. Among their initial observations are that existing forests on the planet currently hold about 45% of the world's organic carbon, in trees and other plants as well as in the soil.[11] The authors add that based on a separate 2019 study[12], "extant old-growth and regenerating forests absorb ~2 gigatons (GtC) of carbon annually.

To put that number in perspective, that compares to the Paris-based International Energy Association (IEA) estimate that even during 2020 -- the first year of the pandemic, when much global transportation was shut down, we human beings collectively emitted 31.5 GtC.[13] That means that the forests as a whole, assuming they continue to function equally efficiently, today are only able to absorb around 6% of the total carbon we add to the atmosphere every year, at current rates.

It also compares, as the paper by Waring and her colleagues point out, to the existing approximately 600 GtC already present in the atmosphere.

Waring's survey article then takes this a step further, by looking at the prospects of doing mass planting of new trees to absorb some of that excess carbon. One credible study they identified estimated it might be possible – provided other obstacles such as existing land ownership were ironed out -- to plant as many as 0.9 billion hectares (9 million square kilometers, or 3.5 million square miles) of trees throughout available land areas.[14] That works out to a region just slightly smaller than the estimated 3.8 million square miles' surface area in the United States.

That much additional forest would provide a major new carbon sink for the world, which is why world leaders are so enamored with the idea. The study which suggested the 0.9 kilometers this much additional forest could absorb as much as one-third of the total ~600 GtC already in the atmosphere.

So far so good, except there are several problems with this analysis. As Waring et. al. explain further, there is matter of those forests being able to grow to their full carbon-absorbing potential, which the researchers estimates could take 100 years from the day they are first inserted in the ground as seedlings.

The authors also point out two other potential problems with the forest carbon capture estimate. One is that the actual potential for forest carbon capture may be overstated.[15] Another is that there will likely be nowhere near 0.9 billion hectares available of appropriate planting lands or freshwater sources to keep them watered.[16]

The survey article next addresses the issue of where the carbon emitted into the atmosphere is absorbed. Based on multiple scientific studies, just 55 percent of the carbon added to the atmosphere is absorbed into land areas and into the oceans, since there is no equivalent of a giant vacuum cleaner pulling the air out of the sky and forcing it into the forests. There is then the relative inefficiency with which the increased tree count would process the atmospheric carbon which must be considered as a factor as well.

Another paper Waring and her team looked to as a reference determined that of the estimated 60 to 90 GtC which newly planted forests might be able to take in, that at best they could only cut total atmospheric concentrations by between 17 and 31 ppm.[17] That in turn compares to the current peak carbon dioxide concentration of the atmosphere which peaked in May 2021 at over 420 ppm[18], a value only continues to increase and which is over 100 ppm over total carbon concentrations from before 1960.

Even at its best, this argument assumes the rest of the world's forests continue to draw in carbon emissions the way they used to. That too is not correct.

Take the Amazon Rainforest, for example. A region which long ago acquired a nickname as the "Lungs of the Planet," continues to be written about in popular articles as responsible for producing around one-fifth of the world's oxygen.[19] It supposedly does so thanks to its over half a million square kilometers (2.1 million square miles) of rainforest, via a process sometimes referred to as bioremediation. It is also described as one of the most important nature-based carbon sinks in the world.

The problem with this as with many other misconceptions about the climate crisis and sustainability is that the Amazon is no longer a net carbon absorber but instead a net carbon emitter.

Figure 6. The Amazon Rainforest has lost its ability to act as a "carbon sink" to absorb carbon dioxide from the atmosphere. Photo by Neil Palmer for CIAT, CC.

According to an article[20] published in the March 11, 2021, issue of *Frontiers for Global Change*, the combination of deforestation by man and nature, fires, expansion of cattle and agricultural regions where the Amazon Rainforest used to exist, the expanded presence of hydropower and reservoirs, oil extraction and mining, and other activities such as fishing and hunting, many of which are actively encouraged by governments such as that of Brazil, the former "lungs of the world" have begun to collapse.

As the paper notes in its abstract, past analyses of the Amazon have mostly "focused on the cycling and storage of carbon", and in the form of carbon dioxide. This time the scientists conducted a detailed "consideration of other significant biophysical climate feedbacks [i.e., CH_4 (methane), N_2O (nitrous oxide), black carbon, biogenic volatile organic compounds (BVOCs), aerosols, evapotranspiration, and albedo] and their dynamic responses to both localized (fire, land-use change, infrastructure development, and storms) and global (warming, drying, and some related to El Niño or to warming in the tropical Atlantic) changes."

After their digging through multiple different databases of information, as well as after considering the margins of error in that data, they realized the previous focus on carbon dioxide retention within the rich ecosystems of the Amazon had managed to overlook something serious going on there.

"We conclude that current warming from non-CO_2 agents (especially CH_4 and N_2O) in the Amazon Basin largely offsets—and most likely exceeds—the climate service provided by atmospheric CO_2 uptake," the scientists wrote. "We also find that the majority of anthropogenic impacts act to increase the radiative forcing potential of the Basin."

The research for this last study was funded by the *National Geographic Society*.

While this paper covers just the Amazon Rainforest, the same scenarios exist elsewhere in the world. And even where other situations may not be as bad from the perspective of human destruction of a forest's once-powerful bioremediation capabilities, the struggle to balance human demands for other uses for forest land versus leaving them intact continues unabated. That points to policymakers doing everything possible to preserve the world's forests rather than letting us destroy them.

The unavoidable conclusion of all this is that, as Bonnie Waring herself noted in another article published in April 2021, "There aren't enough trees in the world to offset society's carbon emissions – and there never will be."[21]

Option 2: Countries and Companies with More Emissions Can Balance Their Higher Emissions Against Trade and Investment with Others with Less Emissions

On June 23, 1988, James Hansen, who was at the time head of NASA's Institute for Space Studies at its Goddard Space Flight Center, testified to the Senate that increasing greenhouse gas emissions thanks to human use of fossil fuels was already warming the planet at alarming rates. If left unchecked, those emissions would eventually kill most living things on the planet, including us.

"Global warming has reached a level," he said, with many graphs and charts to back his analysis, "such that we can ascribe with a high degree of confidence a cause-and-effect relationship between the greenhouse effect and observed warming…In my opinion, the greenhouse effect has been detected, and it is changing our climate now."[22]Along with other information which soon became broadly available, Hansen's warnings triggered a gathering of nations four years later to address the global crisis our greenhouse gas emissions were creating. That event, the United Nations Framework Convention on Climate Change (UNFCC), concluded with 165 nations signing a pledge to keep future planetary temperature increases to just 2° C, by reducing carbon emissions.

The UNFCC went into effect on March 21, 1994. It put the primary burden for greenhouse gas emissions reductions on developed nations known as the Annex I group. It further provided that these Annex I nations would provide new financial assistance to developing countries, to help those countries grow without the need for emitting greenhouse gas emissions at the same high per capita rates as had already happened with the developed countries. There was also the prospect that those developing nations might be able to leapfrog their energy systems into a cleaner set of options for the future.

On December 11, 1997, the nations behind the UNFCC adopted what is known as the Kyoto Protocol. As the UN itself describes it, that document operationalized the UNFCC "by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets." The Kyoto Protocol included what it referred to as "binding emission reduction targets" for 37 industrialized countries, the European Union, and economies in transition.

With so much on the line, it is perhaps no surprise it took over seven years to put the agreement into force, on February 16, 2005.

Within the agreement were three "market-based" means of achieving the goals of that agreement. Those included the creation of a "Clean Development Mechanism (CDM)" by which economies could still grow but reduce overall emissions in the process, "Joint Implementation (JI)," the idea of working together to achieve the Kyoto Protocol objectives, and "International Emissions Trading."

As the United Nations wrote at the time:

"These mechanisms ideally encourage GHG abatement to start where it is most cost-effective, for example, in the developing world. It does not matter where emissions are reduced, as long as they are removed from the atmosphere. This has the parallel benefits of stimulating green investment in developing countries and including the private sector in this endeavor to cut and hold steady GHG emissions at a safe level. It also makes leap-frogging—that is, the possibility of skipping the use of older, dirtier technology for newer, cleaner infrastructure and systems, with obvious longer-term benefits—more economical."[23]

While the ideas of the UNFCC and the Kyoto Protocol might have seemed powerful enough to drive real reductions in carbon emissions within at least major countries, what has happened instead is a global focus on carbon offsets, as called for in the International Emissions Trading part of the 2005 agreement and managed under its Clean Development Mechanism structure.

As a financial mechanism for investment and as a means of claiming the nations of the world were doing something about greenhouse gas emissions, carbon offsets and, later, carbon taxes if one produced more carbon that was allowed by a local regulator, boomed faster than many expected. In the year 2009, for example, just four years after the Kyoto Protocol went into effect, 8.2 billion metric tons of what were referred to as "carbon dioxide equivalents" changed hands in a twelve-month period. By 2016, approximately U.S. $191.3 million of carbon offset credits were purchased annually in the voluntary market, a value corresponding to about 63.4 million metric tons of CO2 equivalent. Those numbers soared to 98 million metric tons in 2018 and 104 million in 2019.

What those carbon offsets "bought" was an enormous grab bag of multiple useful means which could – if they were diverse enough, well-implemented, and continued over time – help transform the economies of the planet away from conventional fossil-fuel dependence and ease carbon emissions at the same time. Some of the many investment areas available for purchase as carbon offsets include: renewable energy options such as solar, wind farms, biomass fuel and bioreactors; energy efficiency upgrades; planting of trees and mass reforestation; geologically stored carbon solutions (connected to carbon capture methodologies); alternatives to construction materials such cement and steel which use less carbon in the process; clean hydrogen power alternatives to fossil fuels, including fuel cell, refueling, heating solutions using them, and entire supply chain mechanisms for the use of hydrogen; and net-carbon-negative items such as biochar for electrical power generation and heating.

As time has proceeded since the original carbon tax and carbon offset concepts were first developed, the markets for these items have become more sophisticated and broadly accessible. They have brought together unusual participants, such as the entire state of California, which works together almost as its own "nation" in the trading of offset credits with other countries, in a move designed to support green economy initiatives back home while fostering international cooperation on climate initiatives. Companies also invest in such carbon offsets as a means of achieving decarbonization goals without having to make all the direct cuts in how they operate internally.

The market for such carbon offsets is growing sufficiently fast that Berenberg, and major German bank monitoring such things, estimates the total market size for carbon offsets could grow to $200 billion by 2050. That the date for such predictions is 2050 is not random; it is the same date many nations have set for when they claim they will become carbon neutral.

Even Bank of America, one of the biggest global banks in the world, has set a goal to achieve net zero greenhouse gas emissions by 2050, by changing how it operates, what it finances, and supply chains it is involved with.[24] It will be accomplishing its own Net Zero targets by, in its own words, helping "spur the growth of zero carbon power solutions, sustainable transportation and agriculture, and other sector transformations, while generating more climate resilient and equitable opportunities for our future."

The Bank also signed up to a means for what it claims will help keep its investments on track to meet their Net Zero goals, by joining the Partnership for Carbon Accounting Financials (PCAF). Other groups it is collaborating with to agree on how to account for their investments include the Prince of Wales' Sustainable Markets Initiative, the World Economic Forum's Environmental, Social and Governance (ESG) *Stakeholder Capitalism Metrics*, and the currently over 70 company-wide *Alliance of CEO Climate Leaders*.

The problem with such initiatives is that the organizations involved acknowledge this is a way to use the money they generate to make up for the carbon emissions their organization continues to emit on its own.

They defend themselves by declaring, as Karen Fang, the Head of Global Sustainable Finance at Bank of America, did, that "using carbon offsets in an organization decarbonization pledge is not being lazy, it's a reality."[25]

While that may seem a legitimate defense, there are several problems with that. The first is that the accounting measures they are using are still new enough in concept that it is highly unlikely the total supply chain carbon investment balance sheet in the carbon credits is a correct one, especially when everything from raw materials sourcing needed all the way to shipping, distribution and installation of what is being invested in are considered. A second is most companies spending so much time talking about carbon offsets spend far too little time discussing the carbon emissions which are more directly under their control to cut. After all, Net Zero means there are still carbon emissions being generated by the entity claiming the balance sheet is working in their favor. Those need to be kept out in the open rather than buried in the details of a balance sheet.

More generally, there is also the issue with carbon offsets and carbon taxes that they are extremely hard to track for compliance purposes, a critical step in achieving the goal of achieving overall rapid reductions in greenhouse gas emissions to save the planet.

Finally, for this section at least, there is the evidence that regardless of how nice an idea carbon offsets might be, one would assume that by now, almost 16 years since the Kyoto Protocols went into effect, not a single major northern industrial nation has achieved its agreed-upon emissions cuts as defined either by the Kyoto terms or the Paris accords. Since that is where all this elaborate climate accounting such as the Bank of America partners is going on, there should have been some success stories, but there are none.

For now, this second option needs to be rejected as something to rely upon to save the planet. Carbon offsets and especially taxes on excess carbon emissions should be considered mostly a means of financial bookkeeping and a means of profiting off the climate crisis, rather than a means of saving money from it.

Option 3: Man-Made Innovations Such as Carbon Capture Will Save Us

The next big thing which crept into planetary planning at the highest levels was the idea of carbon capture.

It too began with a simple and practical concept. The idea was to continue to use fossil fuel sources just as we had in the past but get more aggressive about capturing the waste carbon dioxide and other greenhouse gases before they could escape into the atmosphere. Then one could convert the CO_2, methane, and other gases into other forms and bury the residue beneath the earth's surface. There were options also proposed which channeled the waste carbon dioxide gases directly underground, in chambers where it was felt they would not leak.

One of the first major incarnations of that idea began in Iceland took shape beginning in 2012.

In the late 2000s, with concerns about carbon dioxide emissions into the atmosphere growing, a collaborative research project began which brought together experts from Reyjavik Energy (the utility company responsible for the geothermal power plant), the University of Iceland, Columbia University from the United States, and France's National Centre for Scientific Research.

In 2012, the scientists involved in the primary research announced they had developed a means of capturing carbon dioxide emitted by the normal geothermal process and injecting it into porous basalt rock for long-term storage. What was in question at the time was whether that sort of injection methodology could create man-made carbonate minerals in a relatively short amount of time. Previous research had suggested full integration of the carbon dioxide into the rock could take hundreds of thousands of years but based on small-scale experiments the researchers believed those assumptions were wrong.

To test the potential production feasibility of the process, they built a pilot facility at an underground location in southwest Iceland. What they discovered was that the process of storing human-created carbon dioxide emissions could be injected into the natural basalt rocks readily available in the surrounding area and could be fully assimilated as carbonate minerals in less than two years. While that meant wherever the basalt was stored would need to be sealed off during the assimilation process, it did point to a major opportunity for doing direct "carbon capture" in a production geothermal well environment for the first time.[26]

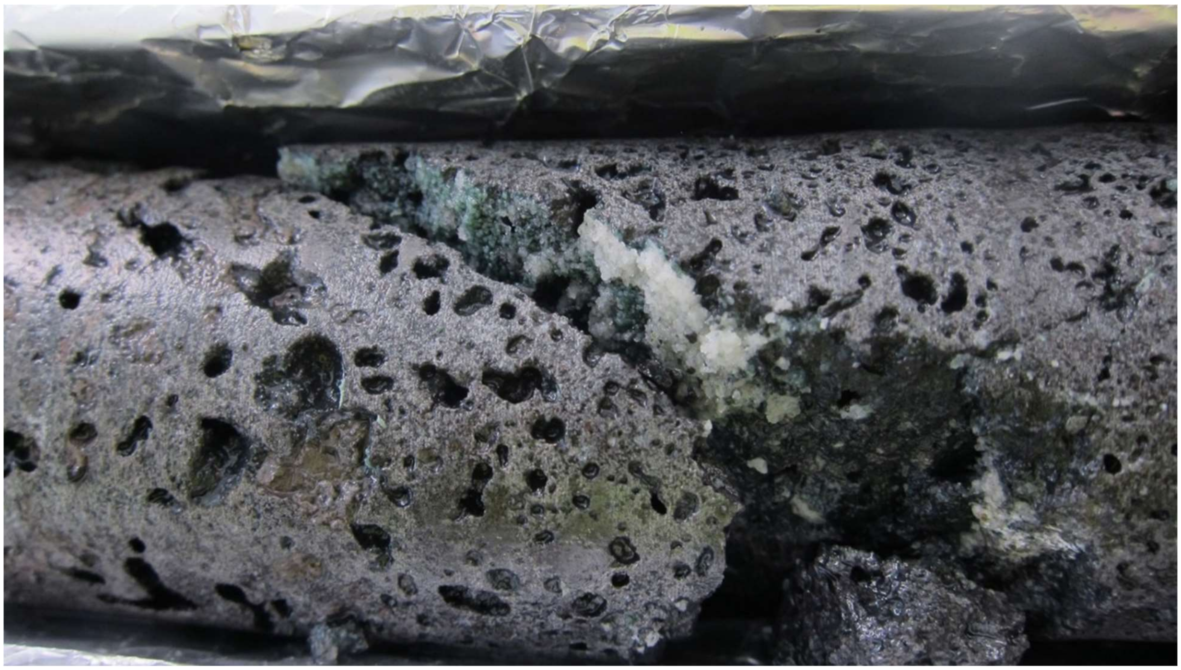

Figure 7. Basalt rocks injected with carbon dioxide captured from the CarbFix installation in Iceland. Photo provided by CarbFix.

The carbon capture concept would also have large potential for many other carbon emissions capture operations.

Together the scientists and the larger science/industry consortium developed what has become known as the CarbFix project. It is now an active part of much of Iceland's geothermal energy operations and has been a major success.

Because the basalt rock is also common in many parts of the earth, there is hope that making use of what the CarbFix team created could become a key to direct capture of carbon emissions and storage throughout the world.

Since that time others have been examining the potential of carbon storage for a far more ambitious idea. What if systems such as what CarbFix pioneered in Iceland could be applied to remove the carbon dioxide humanity has already pumped into the atmosphere, just like the giant vacuum cleaner idea mentioned a few times earlier in this paper? Could such an idea save us all from the climate crisis?

While there are different versions of this much bigger concept, the one that Carbon Engineering Ltd., based in Vancouver, British Columbia, is typical. Its pilot facility, located in Squamish, British Columbia, works by drawing ordinary air over a sorbent filter embedded with a solution of potassium hydroxide (KOH), more commonly known as potash. Potash itself is a mixture of mined and manufactured salts used for multiple ordinary manufacturing processes, including the making of soap. It is also used as an agricultural fertilizer. As Carbon Engineering's founder, David W. Keith, and some of his colleagues explained in a technical paper[27], in that first step the potash captures the carbon dioxide. The process eventually converts that carbon dioxide into a precipitate which can be stored.

The analysis estimates a direct air capture (DAC) plant which can process 1 Mt CO2/year would cost about $94 to $232 per ton of CO2 to operate.

While the technology appears technically feasible, there are many questions about its scalability as a means of lowering the carbon dioxide concentration in the atmosphere, at least by enough to significantly slow the rate of global heating in the future.

The first is: How many of these devices would we have to deploy and how much would they cost to pull sufficient carbon dioxide out of the atmosphere to meet our Net Zero carbon emissions goals?

According to a data[28] published in July 2019 by authors from the RFF-CMCC European Institute on Economics and the Environment, the Imperial College of London's Grantham Institute, and MaREI Centre of Environmental Research Institute at Ireland's University of Cork, building just enough plants to deal the amount of carbon emissions humanity pumps into the atmosphere every year would be a massive undertaking bigger than anything done before.

A sample calculation for that could start with declaring that the first tier of DAC technology the world should even consider should be enough to mitigate the estimated 36 gigatons of carbon dioxide entering the atmosphere every year, at current rates.

Based on the authors' calculations, it would require 30,000 large-scale DAC plants to do the job, which they point out is the equivalent of more than three facilities for every coal-fired power plant already in existence. The authors estimate a net construction cost of $500 million per plant, not counting the cost of land, water supplies, storage facilities, etc. That puts the total cost of the project, without even beginning to consider the infrastructure, personnel, and ongoing power costs to operate them, at roughly $15 trillion.[29]

That $15 trillion represents approximately one-sixth of the total global GDP of $94 trillion.[30] It is of a scale the world has never seen before for such a speculative enterprise.And remember, all that does is build plants which can pull out of the atmosphere every year the same amount of carbon dioxide we are putting into it. It keeps the solar energy trapping capacity of the atmosphere at the same as it has been for some time, so that temperatures on the planet will continue to heat up over time.

Other questions connected with direct carbon capture which are still unclear include:

> What is the real operational efficiency of the plants over time? Little is yet publicly known about the relative cost of operation of these plants. The production yields in terms of carbon dioxide conversion need to be better understood as well.
>
> What is the carbon footprint for building those 30,000 plants? Depending on the materials used, the impact on planetary carbon emissions will likely be extremely significant. What also are the ongoing energy consumption needs of the plants?
>
> What would it cost to maintain and operate the facilities over time?
>
> Who would coordinate the project globally? Many nations would need to be involved.
>
> Who would pay for them?
>
> When will the first reliable commercial full-scale direct carbon capture plant be operational?

How long would it take to authorize, build, and deploy enough carbon capture facilities to begin to stabilize the amount of carbon in the atmosphere?

There are further issues currently being evaluated regarding carbon capture as to precisely how secure the carbon will be when buried beneath the Earth's surface. In the United Kingdom, which is a bit ahead of other countries in its research into some of the practical limitations of carbon capture, four sites are currently under evaluation as to what the limitations are on preventing previously-injected – or stored otherwise – carbon dioxide or methane which has been put underground from leaking back out of it.[31] Such research will take time and will also need to be part of the ultimate carbon capture engineering needs and cost analysis.

In addition to these issues, there is also evidence from recent scientific analyses that using direct air capture to achieve the equivalent of never having put carbon dioxide into the atmosphere in the first place may not be as simple as it sounds mathematically. That is the conclusion of a paper[32] published in June 2021 by authors at Simon Fraser University.

"Because of the complexity of the Earth's system, things are not as simple as "one ton of CO2 in, equals one ton of CO2 out," says Kirsten Zickfeld, a distinguished professor of climate science in SFU's Department of Geography, and lead author for the report. "CO2 emissions are more effective at raising atmospheric CO2 concentration than CO2 removals are at lowering it."

The reasons have much to do with effects of the land and oceans in holding onto to some of the carbon emissions which initially enter the atmosphere. Once in the atmosphere, the carbon dioxide becomes part of a more involved global cycle of emissions. Just pulling out the carbon dioxide we put into the air to begin with will not be enough. By how much more is not clear, but what it suggests is that any calculations on the number of DAC plants needed probably need to be considerably higher.

Even beyond that argument, there are also now so many emissions feedback loops which the past decades of carbon dioxide and methane releases into the air, that carbon releases from melting permafrost, from heating where snow and ice used to be in the cryosphere and once reflected the sunlight, and from frozen methane hydrate in ocean waters which will release without warning once moved out of place or melted as the seas warm, that the real needs for carbon dioxide removal from the atmosphere to save us would likely be considerably higher than any current estimate.

While direct carbon capture may sound like a good idea as a means of bringing us to Net Zero carbon emissions, then, and even if investing them is something which should be done, it will likely cost more and take more time than expected, before we find out if they will ever do what we need them to do.

Though other technology ideas have been floated to deal with the climate crisis, notably including at least one proposal to put a massive space umbrella in place between the Earth and the Sun, so that global heating will not produce so much excess heat in the future, what they have in common is they are not proven, they will cost a fortune, and they will take too much time to put in place before we will know if they will work.

The Net Zero Fallacy in Practice: Lessons from COP26 in November 2021

Despite what should be obvious by now, that far more needs to be done about real solutions and far less about betting on the future of one Net Zero mitigation idea after another, that did not stop the nations of the world from continuing that bet when the United Nations' 26th "Conference of the Parties" (COP26) gathered in Glasgow this fall to discuss their latest commitments to slow the pace of global heating.

In their defense, most who had signed up to support the goal for keeping global heating from increasing too much submitted detailed written plans for how they would achieve their commitments to reign in greenhouse gas emissions. It was only when one began reading the documents that one realized how much fluff, hype, misdirection, or in some cases fully made-up assumptions were embedded in the documents.

In the interest of looking the best they could to the world, those nations also embellished on their bets by distorting the reality of how well their own Net Zero strategies might really work.

Just to name a few of the grossmiscalculations and misrepresentations which appear in the submittals this year, consider these gems from the report, one for each other major categories of greenhouse gas emissions:

Malaysia, which relied heavily on **net carbon offsets** from the trees in that country's forests, made their Net Zero calculation by claiming their trees absorb carbon at a rate at least four times as rapidly as equivalent forests not so far away geographically, in Indonesia. In 2016, according to data gathered by the UN's Food and Agriculture Organization, Malaysia released some 422 million tons of greenhouse gases. Thanks to its magic tree forest, its 2021 report showed net emissions of just 81 million tons.[33]

In a report[34] put together by the International Energy Association (IEA), **Russia is listed as having in 2020 emitted 14,886 kilotons of methane**, the single most potent greenhouse gas in the world in terms of solar forcing, a measure of how much solar energy it traps close to the planet. Thanks to that total, Russia is ranked as the worst such emitter, with the United States at number 12,297 kilotons of methane dumped into the air the same year. Yet **Russia claimed it emitted only a net 4 million metric tons of methane just one year earlier, in 2019**. Russia claims it has many systems in place that prevent methane from leaking out, but there is no information which backs up those claims. With such great but apparently highly invisible systems in place, Russia has been able to sidestep admitting it has no hope of meeting its total greenhouse gas emissions commitments.

Vietnam also worked a bit of its own magic relative to release of fluorinated gases. Known as F-gases for short, these are used in everything from air conditioning to refrigeration systems and the electricity industry. In that country's report to the UN this past year, Vietnam noted its total fluorinated gases in 2016 amounted to an equivalent CO2 level – the way such comparisons are made in the UN greenhouse gas emissions commitments documents – had fallen to just 23,000 tons. Yet according to a scholarly research article published in 2021 using multiple independent databases[35], the country's UN emissions estimates for its F-gases were 500 times as large. When pressed for the difference, Vietnam said none of their fluorinated gases leak from any of cooling and electrical systems any longer.[26] This compares, by the way, with numbers showing U.S. supermarkets, which are a major user of such F-gases for cooling, leak an average of 25 percent of these gases into the air every year.

The United States has its own problems in addressing the climate crisis, not the least of which is that it keeps subsidizing fossil fuel producers, but that did not stop U.S. Climate Envoy John Kerry from adding to the cloud of misleading information about how Washington planned to achieve its emissions commitments. During an interview in May 2021 with BBC One's Andrew Marr, avoided having to deliver any sort of tough message to the American people about what they might have to do to survive the climate apocalypse ahead.The interviewer attempted to ask Kerry several important tough questions about the sacrifices people might need to make, to achieve a much low carbon lifestyle than the one we have now. He began by naming a simple example, about how eliminating meat from our diets might help reduce emissions (because of methane produced by livestock) and would make more efficient use of the increasingly limited agricultural land everywhere. The implication was that even this simple lifestyle change could be a challenging switch for people to make, and by comparison other changes in lifestyle – such as to travel a lot less and use less power – would be monumental things to ask of the public.

Kerry shrugged that off by saying the American people would "not necessarily" be forced to do that.

"You don't have to give up a quality of life to achieve some of the things that we know we have to achieve. That's the brilliance of some of the things that we know how to do," Kerry told Marr. "I am told by scientists that 50% of the reductions we have to make to get to net zero are going to come from technologies that we don't yet have. That's just a reality."

While one can empathize with Kerry's desperation as to how to get the United States on track to reduce carbon emissions by any significant amount, his statement came across as just one more empty political promise to do something about the climate crisis, when it aired.

While it is more than reasonable to expect some surprise innovations ahead that may help save us all, the one message those of us who hope to survive the climate crisis should take with us is that **gambling on anything not yet proven to mitigate the deadly effects of the climate crisis** is a deadly mistake none of us should tolerate.

The second message which should also be clear by this point is that relying on global political, corporate, and institutional leaders to save us will not work either. Most have already hitched their hopes to some form of Net Zero balancing act such as those which have been debunked earlier in this paper, rather than to take the critical steps necessary to save even a small fraction of the world's population from temperatures rising as much as 6° C by the end of the century, and all the collateral climate event damage that will come with it.

CONCLUSIONS

The world has come a long way from James Hansen's seminal presentation to the U.S. Congress in June 1988, warning about fossil fuel use and global warming.

In the 34 years since that time, the nations of the world proved they took the issue of the climate crisis somewhat seriously. Under the auspices of the United Nations, they were able to mobilize and create the Kyoto Protocol, a first attempt at allocating responsibility for greenhouse gas emissions. That evolved to become the Paris Agreement of 2015, which demanded tough emissions reduction plans from each country.

The rough target the nations have set for themselves is to get to a position of a zero-carbon footprint by mid-century.

The intent from the beginning was to have each country agree to hard cutbacks in the release of GHGs. While most nations do endorse pledges to cut back on fossil fuel use and invest in green energy alternatives, their plans increasingly involve one or another Net Zero approach to meeting their targets.

As we have shown in this paper, there are enough issues with Net Zero to call into question the core concept.

Ultimately, it all boils down to this: instead of turning over to business analysts the problem of how to prove the Net Zero calculations, our leaders must immediately begin making the difficult but necessary decisions on how to restructure a global economy to run without fossil fuels.

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