



REVIEW

Global Environmental Forecast and Roadmap Based on 420 kY of Paleoclimatology

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ABSTRACT

As the world's population has tripled (3x) since 1950, with another 50% increase expected by 2100, global annual carbon dioxide emissions growth rate has quadrupled (4x) since 1950 and global energy demand has quintupled (5x), all in the same time period. This discontinuous combination can be called a "3-4-5 Triad" and the sudden acceleration in all three arenas is too stressful on the environment and the damaging effects will be felt globally for centuries to come unless drastic action is taken. More importantly, the energy demand at 5x is outstripping the other two. This clearly means that as the population explodes at 3x, the *emerging middle class wants almost twice as much as their usual share* as fossil-fueled generators spread around the globe and modern conveniences become more and more desirable. However, such energy demand at 5x is an artificial human need that is predicted by RMI.org to result in four to five billion new window-mounted air conditioners by 2050 that will add even more to the global warming caused by increasing atmospheric carbon. By an examination of paleoclimatology for the past 420,000 years, it is demonstrable that reducing the concentration of this single most prolific heat-trapping gas by geoengineering back to pre-industrial levels of less than 300 ppm can actually give humankind a collective control over the world's rapidly rising average global temperature and once more, a temperate climate to live in.

1. Introduction

The surprising rate of growth for our accelerating carbon dioxide emissions globally is dramatically shown in Figure 1 from a slide used in a 2019 slide presentation by this author (www.tinyurl.com/ValoneClimateSlideshow). Worldwide energy consumption reached a record 37 billion tons of CO₂ (*for a single year's total emission*) at the end of 2018, with the U.S, India, and China leading the increase. Note that

only ten years before, the carbon dioxide annual emission rate was less than 30 gigatons. The total carbon emission growth rate in 2017 was only 1.7 percent while carbon growth for 2018 shown in Fig. 1 increased 2.7 percent (Figure 1), thus proving an accelerating trend that has no foreseeable "peak" in the growth rate or the actual magnitude of carbon dioxide annual emissions in the near future. As for China, coal accounts for about 60 percent of China's total energy consumption^[1]. A major new paleoclimatology study also shows that current global

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warming has reversed the past 6,500 years of global cooling [2].

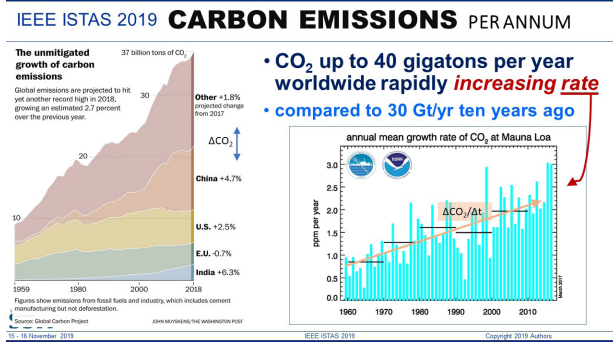


Figure 1. Annual global carbon emissions (left) and parts per million per year (right)

Global annual carbon dioxide emissions 1959-2018 as shown in Figure 1 started a new exponential surge upwards in 2017 [3]. Fossil fuel carbon emissions are now steadily increasing annually in several major countries in the world, which translates to the *rate of growth* having an upward slope, without a predictable peak, of either rate or magnitude, in the foreseeable future. Recent climate reports suggest a widely accepted range of one and a half (1.5°C) to two degrees (2°C) Celsius as an achievable global limit to climate change, which is unfounded, naïve, and basically misinformation. It is a direct contradiction to the observationally informed, published projections of climate science underlying global warming. A weather research station on Seymour Island in the Antarctic Peninsula, for example, registered a temperature of 69.3 degrees F (20.75 Celsius) on Feb. 9, 2020 according to Márcio Rocha Francelino, a professor at the Federal University of Vicosa in Brazil. The nearly 70-degree temperature is significantly higher than the 65-degree reading taken Feb. 6 at the Esperanza Base along Antarctica's Trinity Peninsula. The World Meteorological Organization (WMO) will decide whether it qualifies as the continent's hottest temperature on record. The new data came from a 12-year-old research station, used mainly for monitoring the layer of permafrost [4]. Furthermore, a Siberian town on the Arctic Circle hit 100 degrees F (38 degrees Celsius) near the end of June, 2020 setting a record. NOAA also reports that May, 2020 was the warmest May on record for Asia (NBC News, nbc.com).

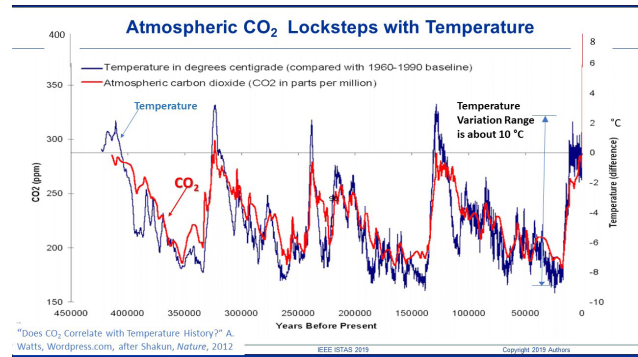


Figure 2. Carbon dioxide (ppm) levels and temperature (°C) for the past 400 kY

In Figure 2, we see a blue and red colored plot of the world average temperature and CO₂ data from air bubble analysis of the Vostok Station Antarctica ice core. In 1999, the Vostok ice core 420,000-year record of carbon dioxide was published by Petit et al [5]. *Exhibiting great stability, the CO₂ levels clearly have never exceeded 290 ppm worldwide even through four ice ages.* However, in the isolated monitoring station cited above for our modern, with our worldwide fossil fuel gluttony, the latest global carbon dioxide levels have now exceeded 410 ppm, with apparent universal disregard for the consequences. Clearly noticeable in Figure 2 is the tight correlation of temperature (blue graph) and carbon dioxide (red graph) for the past 420,000 years, which drives paleoclimatologists to reluctantly include the surprisingly high red line at the end (*present time on right side*) that has to be that high, to stay on the same scale and show the present world rise past 400 ppm of CO₂. Since the historic red and blue data lines show an actual climate record of the earth-atmospheric system, then the axis label of CO₂ concentration on the left necessarily correlates to the axis label of global temperature on the right, where the disturbing alignment near 8°C is registered in Figure 2. This dual graph begs the question, "Does CO₂ Correlate with Temperature History?" as Watts asks online at Wordpress.com after Shakun did so in Nature, 2012. The scientific answer has to be "yes" since humans have increased the level of CO₂ from the temperature-stabilizing 290 ppm up to 410 ppm presently, which equals a 43% increase in such a potent, heat-trapping substance surrounding our home. Any quantity in the earth system that balloons that much will always have a discontinuous impact and CO₂ definitely does. That is the only reason this article argues that geoengineering is required BEFORE the earth starts reaching the feared 6 to 8°C as it inevitably will in less than 100 years. An international consortium needs to perform hundred-

gigaton carbon capture and sequestration (CCS) *per year*, as soon as possible, in order to reduce the present level of carbon dioxide in the atmosphere back down toward 290 ppm or the survival of much of humankind is in question. However, the temperatures and humidity predicted for later this century are already here. Worse than that, the wet-bulb temperature (thermometer wrapped in a wet cloth) is closing in on 35°C (95°F), 25 to 30 times a year in several parts of the world already, which is the “survivability” wet-bulb temperature that defies sweating of even a healthy, young person, thus “endangering hundreds of millions of people” [6].

Jim Hansen's Table of Vostok data points for 400,000 years

Carbon dioxide p.p.m.	Average Earth temp. °C	Sea level meters
300	15.5	10
290	15.0	0
280	14.5	-10
270	14.0	-20
260	13.5	-30
250	13.0	-40
240	12.5	-50
230	12.0	-60
220	11.5	-70
210	11.0	-80
200	10.5	-90
190	10.0	-100
180	9.5	-110
170	9.0	-120

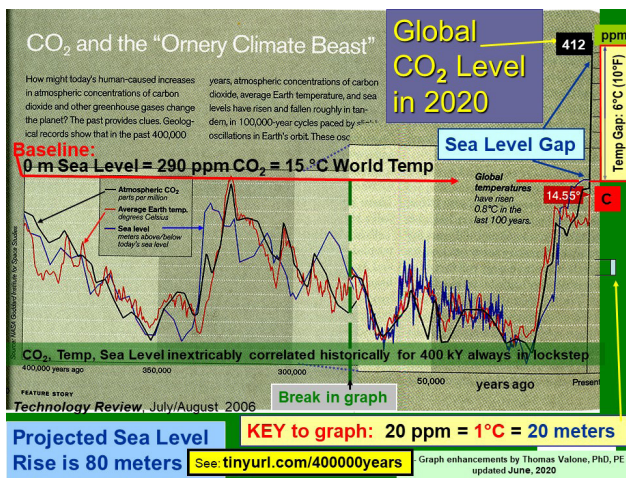


Figure 3. Author’s summary of a predictive climate graph from Hansen (Tech. Rev., July, 2006)

In Figure 3, we have a condensed version of another 400,000 year old Vostok ice core record, along with scientific extrapolation of ancient sea levels, which in this case was published by famed climatologist James Hansen

[7]. This author has annotated the beginning and end of his graph, as well as *included the data table* (on the left) to show the unexpectedly linear data that connects the three variables plotted (temperature, carbon dioxide, and sea level). Visiting www.tinyurl.com/400000years offers the reader a complete view of the entire 400,000 year history which is only partially shown and summarized in Figure 3. Note that the indicated “Temp Gap” or temperature gap is measured from the chosen historic maximum baseline is 15°C, which unfortunately is a contradiction in reality. Usually, any “baseline” in science is an average or a minimum from a time scale record. However, in this case, we have an extrema to deal with for a “baseline”: the maximum value of temperature at 15°C and the maximum value of CO₂ for the past 400,000 years. Be that as it may, the prediction of a 6°C increase in temperature is arrived at quite simply. The temperature, carbon dioxide level, and sea level data clearly shown in the Table is easily translated into a simple equation seen in Figure 4. The equation is designed to allow anyone to compress the Table data into a formula that is easy to memorize. Thus, taking the values of 410 ppm (present) - 290 ppm (baseline) = 120 ppm, which equals the excess amount of CO₂ in the air. Dividing this excess by the 20 ppm discerned from the KEY of Figure 3 “per degree equivalent,” the equation of Figure 4 makes it explicit so we convert to six (6°C), which must correspond to the equivalent, thermally connected system value of *temperature indebtedness*, that HAS to manifest as soon as the earth-atmosphere Gaia interaction allows. Stanford Research Institute suggests that a realistic extrapolation of the present temperature increasing data brings us to around 2100 for the extra 6°C to become the norm [8]. For humans, this expected scenario, with business as usual, will be an intolerable, inhospitable climate resulting in mass starvation, millions of deaths, desertification of vast tracts of land, including much of the mid-West United States, equatorial regions like the Arabian peninsula, with eventual tropical rainforest environments created in northernly climates, after the wildfires cease.

+/- 20 ppm = 1°C = 20 meters

Figure 4. The Hansen Equation linking global CO₂, temperature, and sea level

What may be the most reassuring part of the formula in Figure 4 is the +/- sign. As clearly seen in Figures 2 and 3, the response of the earth-atmosphere Gaia system to any change in global CO₂ levels entrains the other two to follow, with a corresponding delay. In other words, as humans wantonly pushed the CO₂ level rapidly above the 290 ppm baseline only in the past few decades with

very little delay in the rising temperature response to the heat-trapping gas increase, the reverse will also be seen to have a rapid effect worldwide. The reverse entails the world learning and implementing a lowering of the global level of carbon dioxide to 290 ppm, by CCS on an annual hundred-gigaton level, as renewable energy is gradually brought online.

While climatologists know the linear relationship between carbon dioxide levels and temperature exists, the United Nations Environmental Program (UNEP) and the International Panel on Climate Change (IPCC) among others are choosing to ignore the consequences of the present CO₂ excess, which now surpasses 43% of the maximum 290 ppm the earth has ever experienced in over 420,000 years. It is vital that the reader comprehends the blatant fact that the earth-atmosphere system, often referred to as “Gaia”, is now indebted for 6 to 8 degrees C increase in temperature as shown in Figure 3 with the clarification of Figure 4. The trend graphs of Figure 5 tell the experts and any of the public who will take notice, the consequence of 400 ppm will manifest in approximately 80 years, by 2100 *compounded by the fact* that by then, we will most likely reach or surpass 800 ppm, unless something drastic is done to reduce the amount of carbon dioxide in the atmosphere globally. Note that this assessment of a predicted temperature rise of a 6 to 8 degrees C increase, will only become even more egregious and higher beyond 2100 unless carbon capture and storage (CCS) is instituted to bring down the concentration of CO₂ to pre-1950 levels of 290 ppm.

Looking at the sea level rise that the world is indebted for, we go back to the forsaken 370 ppm of CO₂ we saw in the air around the year 2006, when Hansen published his graph in Technology Review. We can take the rounded number 370-290 (zero value) = 80 ppm and divide by the 20 ppm from the formula into 80 ppm to get the disturbing number of 4 to multiply by 20 meters. Or we can just simply note that the numerical values of CO₂ and sea level change are the same, so sea level increase destined by Gaia is 80 meters, which is probably the maximum sea level increase possible. Any CO₂ value above the 30% increase from baseline, or about 370 ppm of that year, is hitting the ceiling of globally available ice since the major contributors to sea level rise are the landlocked glacier ice from Antarctica and Greenland. These huge glaciated island continents are the only two main landlocked glacier ice of frozen water on earth. Antarctica will contribute about 60 meters of sea level rise and Greenland is estimated to contribute about 10 meters which equals 70 meters, so even the 80-meter result may an overestimate.

2. Future Impact and Resolution

In Figure 5, we see the conclusion of the University of Washington (USA) which published a series of slides on the paleoclimatological implications of an 500-1000 ppm level of CO₂ that we are headed for by 2100^[9].

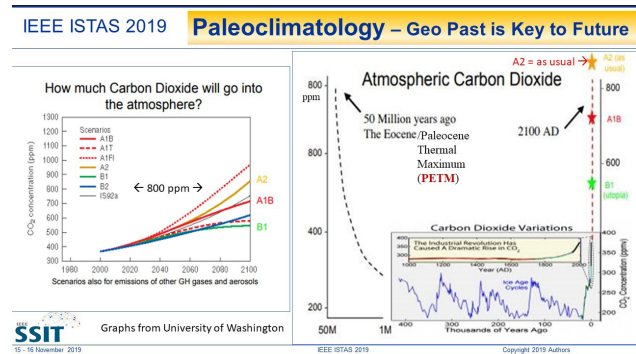


Figure 5. Computer projections for CO₂ at 2100 compared to the PETM with same levels of CO₂

The Eocene-Paleocene Thermal Maximum (PETM), which reached 800 ppm at its peak, is exactly what the experts predict for us even by the end of this century (2100). This is because of the clear trend in the exponential growth of CO₂ emissions worldwide, which is reflected in our Figures 1 and 2 CO₂ emissions graph with the rate of CO₂ emissions reaching about 3% presently in 2020, as well as the shocking projection of 800 ppm by 2100 as the “business as usual” most likely scenario for planet earth. Note that the earth-atmosphere system exhibits a **very short temporal feedback loop** between CO₂ average levels and global temperature: every report indicates hotter seasons than the previous ones as each year goes by. It can be estimated that there may be only a 20-year gap in the response curve of an increased (or decreased) global average level of CO₂ and the increase (or decrease) in worldwide average temperature. Therefore, more and more the primary recommendation of informed climatologists is that carbon capture and storage (CCS), also called “carbon sequestration”, is the only hope for controlling the world’s average temperature for the immediate and long-term future. The exciting reward is the quick response that the earth-atmosphere system will predictably offer, in only a few decades, to the responsible geoengineering of CCS on the hundreds of gigatons level that actually REDUCES the overall global average level of CO₂ by even thirty to fifty parts per million (ppm) perhaps.

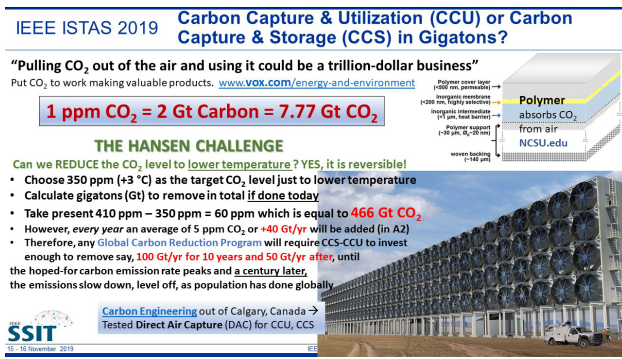


Figure 6. Proposed CCS for excess atmospheric CO₂ to restore preindustrial 290 ppm levels

In Figure 6, we delineate the relationship between the concentration of carbon dioxide and the amount 7.77 Gt (in gigatons), of the corresponding 1 ppm of CO₂. To explain, the main calculation driving the realistically predicted 6°C warming this century, by experts like Hansen and Caldeira, is the present 410 ppm of CO₂ in the air as compared to the 290 ppm that Dr. James Hansen and others regard as the BASELINE for the comfortable 15°C humans have enjoyed for centuries (see Figure 3, IRI 2020 Climate Chart based on Hansen’s Vostok ice core graph). To summarize, 410 - 290 = 120 ppm and each part per million (ppm) equals 7.77 gigatons of CO₂. So when we multiply the 7.77 gigatons by the 41% increasing level of 120 ppm of heat-trapping CO₂, it yields a **scary 932 gigatons or almost one trillion tons of CO₂** that must be removed to restore our comfortable 15°C that everyone has enjoyed for centuries.

Late in 2020, Project Vesta plans to spread a green volcanic mineral known as olivine, ground down to the size of sand particles, across one of the world’s beaches. The waves will further break down the highly reactive material, accelerating a series of chemical reactions that pull the greenhouse gas out of the air and lock it up in the shells and skeletons of mollusks and corals. This process, along with other forms of what’s known as enhanced mineral weathering, could potentially store trillions of tons of carbon dioxide, according to a National Academies report last year. That is far more carbon dioxide than humans have pumped out since the start of the Industrial Revolution. Unlike methods of carbon removal that rely on soil, plants, and trees, it would be effectively permanent. Project Vesta at least believes it could be on the order of \$10 per ton of stored carbon dioxide once it is done on a large scale^[10].

The task of reducing the overall 410 ppm of CO₂ back down to 290 ppm, to completely and directly reverse the heat-trapping, global warming trend, is extremely important to comprehend and constitutes the main reason

for publishing this information at this time, since the CCS responsibility it implies is staggering and unfortunately, increasing each year by more than 40 Gt. The amount of CCS needed is indeed huge but not impossible to engineer, only if a multi-nation conglomerate is formed in the next few years, if not sooner. Attention is directed to the equivalent formula in Figure 6 for converting the parts-per-million (ppm) amount of CO₂ to gigatons (Gt) of CO₂ for calculating the capture mode that can perhaps be used. This slide is taken from a presentation on this vital topic to an audience of professors and students at Tufts University in November, 2019 by this author, for the IEEE International Symposium on Technology And Society^[11]. Note that in Figure 6, reference is made to “A2” which is found in Figure 5, which indicates a trend toward “business as usual” that so far, is the most reliable forecasting for the future unfortunately.

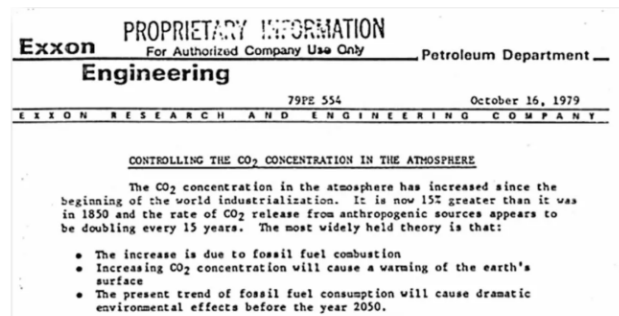


Figure 7. Surprising Exxon 1979 memo linking fossil fuels to atmospheric CO₂

Many states in America are now suing oil companies for fraud today (Minnesota, Rhode Island, Massachusetts, New York, Washington DC, etc.) since memos stating that “controlling the CO₂ concentration in the atmosphere” have been directly connected to fossil fuel combustion and warming of the earth, since at least 1979 (Figure 7)^[12]. If oil companies are acutely aware of the long-term health and environmental damage they are doing, with no clear resolution in sight, what are municipalities and governments supposed to do? The only rational hope is to take the lessons learned from the COVID-19 crisis and start international networking on a grand scale, using the worldwide response to the virus as a template that works. Creating a sense of urgency and even emergency is the beginning to cause action.

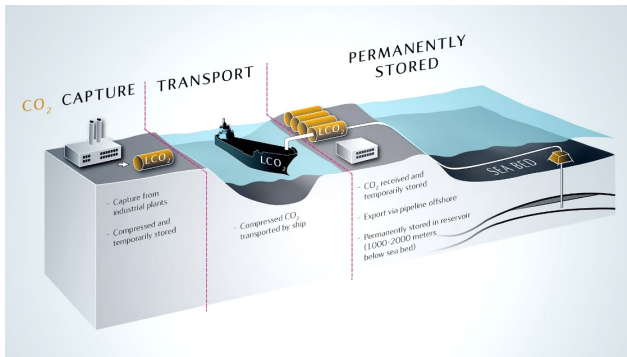


Figure 8. Simple diagram illustrating a method for successful CCS

There is presently in the latter part of 2020, a steady public shift away from outright climate denial, as exhibited by rank-and-file members of the U.S. Republican Party, as evidence that attitudes can move toward action, no matter how meager. Now that the unconscious repression of the truth is finally dissolving, an avalanche of action could soon follow. As Rear Admiral David Titley once said, “We may be much closer to catastrophic success right now. Things can change, and not always for the worse. They can change for the better. It can happen very, very quickly” [13].

To happen very quickly, a CCS process like Project Vesta or Project Northern Lights [14] (Figure 8) would have to be ramped up to the hundred-gigaton level indicated above. It also requires a cooperative international fund donation of at least \$1 to \$10 trillion, if and only if the estimated price per ton can be brought down, through government subsidies perhaps, to \$1 to \$10 per ton. Then and only then, the excess, *global warming driver* of 932 gigatons of CO₂ can be rapidly (over a ten-year period in the least) captured and stored (see Figures 6-9) with that total investment. Then, within only a few decades, the response of the earth-atmosphere Gaia system will joyfully reward us with cooler temperatures back down to pre-industrial levels, besides helping to stop glacial melting and perhaps instead, refreeze the glaciers. We see in Figure 9 a third process, from the Carbon Engineering company plan for a grand scale removal of one megaton per year of CO₂ from the atmosphere (artist drawing of their fan-driven assembly is in Figure 6), using a potassium hydroxide sorbent coupled with a calcium caustic recovery loop seen in the process diagram [15].

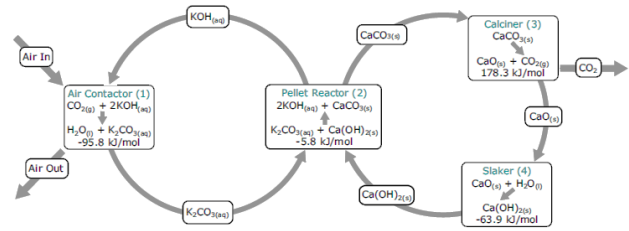


Figure 9. Industrial process diagram for removing one megaton of CO₂ per year from air

The lowest cost estimate from the article about Carbon Engineering’s plan, in today’s Canadian dollars, is slightly less than \$100/ton of processed CO₂ which is a prohibitive price for large scale implementation in the gigaton range and beyond at the present time. Their industrial process, being the first to provide complete details for implementing large scale direct air capture (DAC) of atmospheric CO₂, serves two purposes. First, the process can assist in making carbon neutral hydrocarbon fuels, especially if the process is solar-driven. Even the aviation industry can decarbonize in this way with DAC-CO₂ and electrolytic hydrogen to make high-energy-density jet fuel. Second, by adding storage (sequestration) DAC enables a quantity of carbon removal from the atmosphere permanently. To help further public research in this vital area, an exhaustive set of references is provided, from 2004 to the present, on capturing and removing CO₂ from ambient air, many of which provide open access to their article [16-27].

It is genuinely hoped that this information will be widely distributed to decision-makers, climatologists, and billionaires worldwide, telling them that global warming is reversible, and CCS action needs to be taken sooner, rather than later, to avert skyrocketing annual increases in costs, besides severe biological impacts by 2100 of heat, drought, crop failure, hunger, migratory unrest, strife, border wars, and widespread death and disease that such a high, global temperature increase of 6 to 8°C within 80 to 100 years entails.

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