

REACHING NET ZERO: 2022 END-OF-YEAR UPDATE

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Our outlook for future efforts to fight global warming is included as the last section of this report. This outlook is based upon our assessment of currently available information.

EXECUTIVE SUMMARY

Our last report, “Reaching Net Zero: 2022 Mid-Year Update,” was published in July 2022 and is available on our website, www.reachingnetzero.com. The following is a brief summary of important developments since our last report. Additional details are found following this summary.

WHERE ARE WE HEADED?

The most recent mid-range forecast by the International Panel on Climate Change (IPCC-AR6) is for the earth’s temperature increase to be from 2.1°C (3.8°F) to 3.5°C (6.3°F) by the end of this century, based upon present trends. Sea level could rise from between 0.5 meters (1.6 feet) to 1.25 meters (4.1 feet) by the end of this century. These forecasts are based upon latest country pledges to limit global warming. At the latest United Nations meeting on climate, held in Egypt in October 2022, it became clear that neither the U.S nor most other countries were meeting their self-imposed goals. It is now certain that the goal of limiting temperature rise to 1.5°C by 2050 **will not be met**.

According to the World Meteorological Organization (WMO), the last eight years have been warmer than all the previous years on record. Global warming is a slowly developing problems that is easy to ignore. Those who claim that we don’t have to give up fossil fuels make the implicit assumption that we can discharge massive amounts of greenhouse gases into the atmosphere indefinitely.

The global economy is increasingly distracted by war in Ukraine, renewed inflation, energy shortages in Europe, global energy price increases, and the prospects of a global recession. These concerns distract from international efforts to expand renewable energy and build out the necessary energy infrastructure, including energy storage, transmission lines, and distribution systems.

HARD FACTS

Total emissions:

In 2022, updated total greenhouse gas emissions were 58 billion metric tons/year. Emissions are on track to set a new record in 2023 following a temporary decline due to the virus pandemic. This includes CO₂ emissions of about 43 billion metric tons/year.

CO₂ concentrations:

In December 2022, the CO₂ concentration in the atmosphere set a new record, reaching 419 parts per million (ppm), an increase of 2.2 ppm over December 2021. CO₂ accounts for about 75 percent of total greenhouse gas emissions. About 50 percent of greenhouse gases in the atmosphere were put there in only the last 30 years (Figure 1).

Earth’s average temperature:

Due to the greenhouse effect, the earth’s average temperature has increased about 1.2°C (2.2°F) since the start of the industrial revolution in the U.S., about 1860. The rate of warming has increased to 0.18°C (0.32°F) per decade since 1981. A new temperature record is being set about every 3 years. The earth’s average temperature continues to increase (Figure 2). Globally, 2022 was the sixth hottest year on record, with 2016 being the hottest year ever. Overall, the average global temperature increase is now at 1.2°C (2.1°F). In 2022, more than a dozen European countries experienced the hottest summer ever recorded.

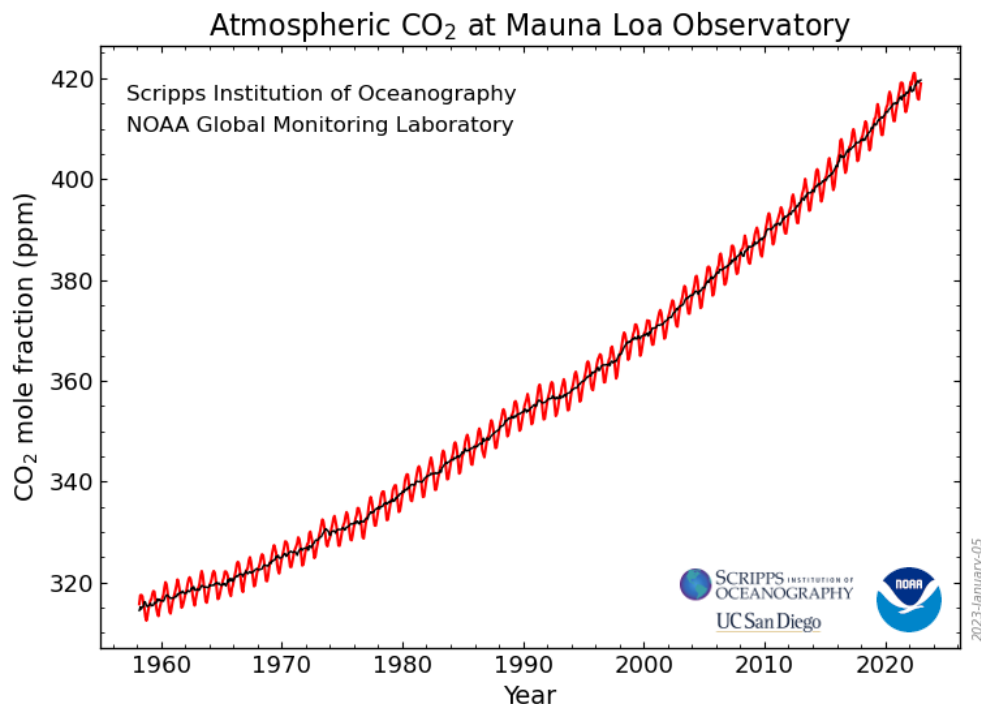
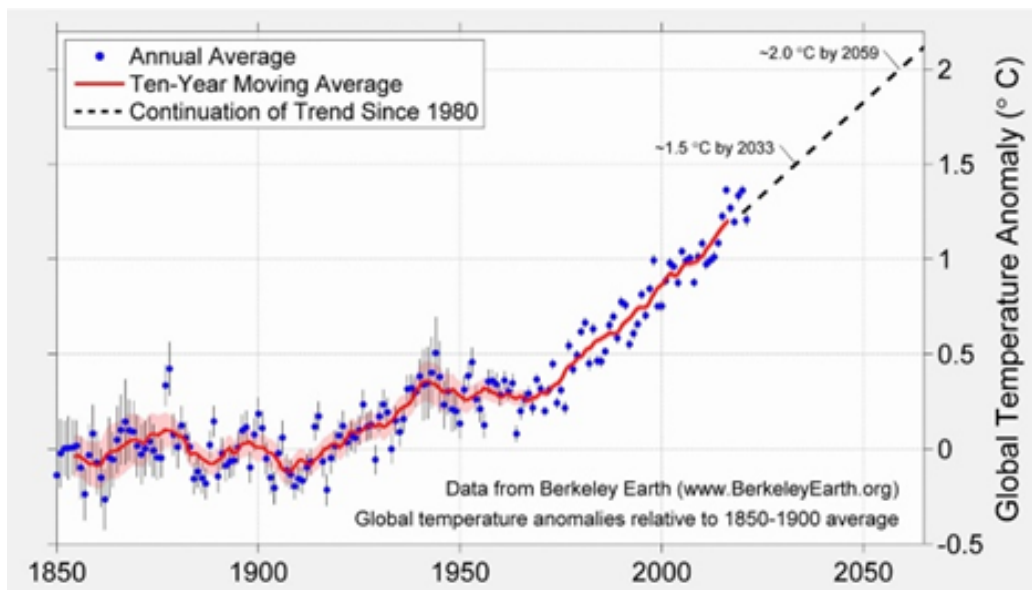
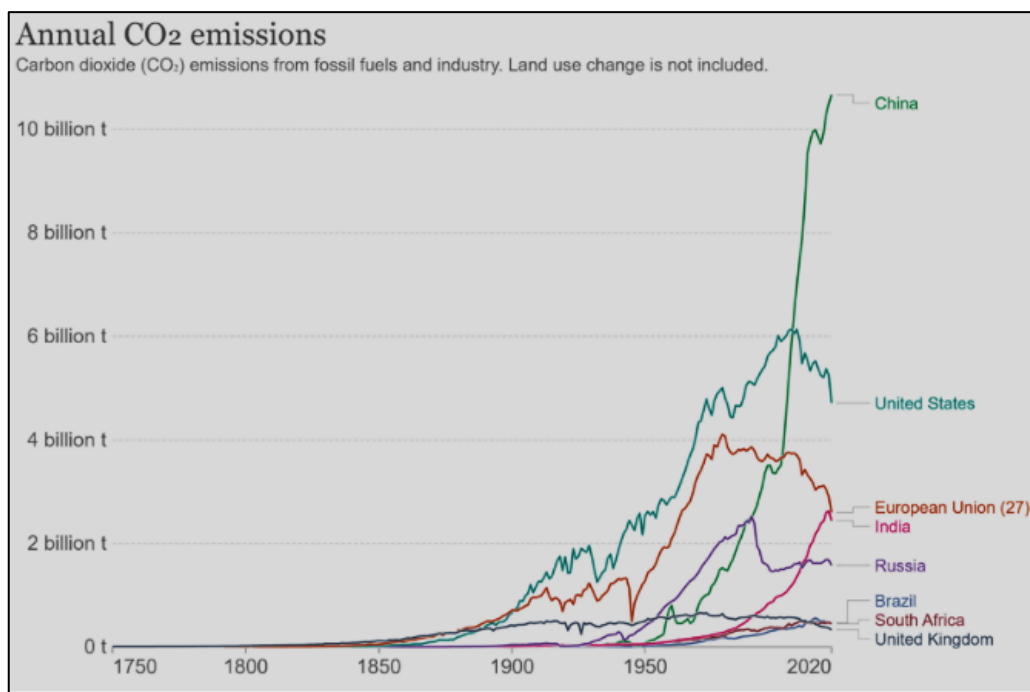
Figure 1: CO₂ in Atmosphere

Figure 2: Earth's Average Temperature Increase

Correlation between CO₂ release and earth's temperature increase:

Figure 2 is frequently disputed by climate deniers who argue that the earth's temperature increase is a natural phenomenon. However, in an article published in *Science*, researchers have discovered that Exxon's scientists predicted that there would be a global heating of about 0.2°C per decade due to the emissions of greenhouse gases from the burning of oil, coal, and other fossil fuels. Their analyses, done in the 1970s, were remarkably accurate. Company records indicate that Exxon

knew of climate change as early as 1981 but instead of reporting these facts, it funded climate deniers for 27 more years (Figure 3). Figure 4 shows current sources of CO₂.



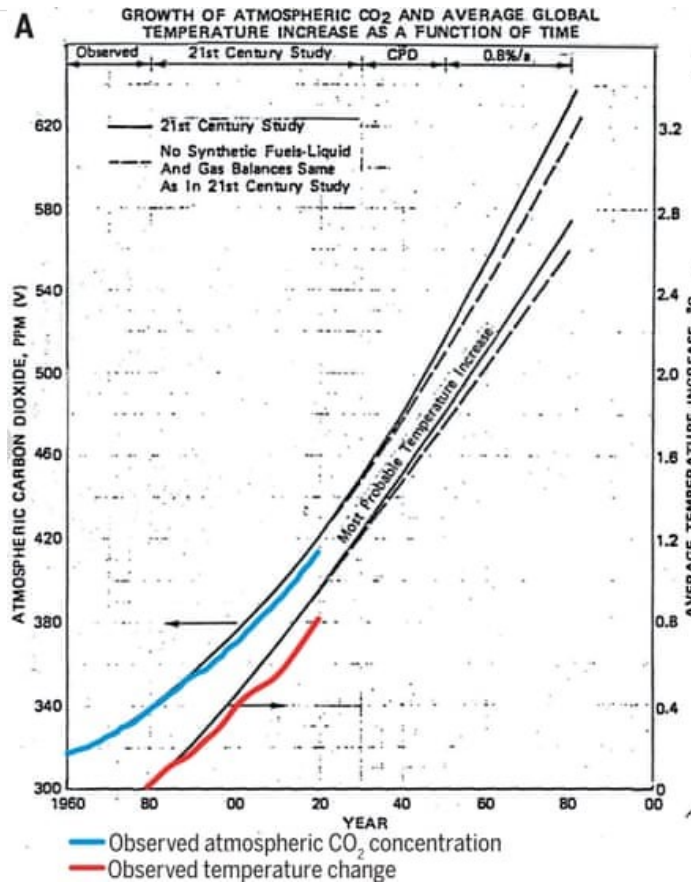


Figure 3: 1970's Era Exxon Scientists' Prediction of Global Temperature Rise.

Figure 4: Global Producers of Carbon Dioxide (<https://ourworldindata.org/co2-emissions>)

Arctic temperatures:

The Arctic is the “canary in the coal mine” concerning global warming. The Arctic is heating at two to three times the global average. Changes in the Arctic have a major effect on weather in the Northern Hemisphere. The most serious concerns about climate change are referred to as “tipping points,” when sudden changes occur that dramatically alter the sequence of events. Climate change is causing permafrost in the Arctic to thaw. This has several important effects. One is that frozen water melts and runs away, draining lakes and leading to droughts. It also causes subsidence, buckling roads and causing structures to sink. But the most important effect is that emissions of methane dramatically increase, releasing more greenhouse gases to the atmosphere and causing fires in Siberia and other northern countries.

Arctic ice, Antarctic ice, and glaciers:

One such tipping point is if the ice sheets in Greenland and West Antarctica collapsed, this would lead to a disastrous rise in sea level. One danger is that warmer seawater undercuts the sea ice barrier that keeps ice sheets on land. If the sea ice melts and gives way, it can lead to the ice sheets sliding into the sea. This fall, author William Fletcher traveled to Greenland to examine the coast at first hand, from the ocean (Figure 5).



Figure 5: Ice floes near Greenland (W.D. Fletcher, 10-22)

2022 marks the 26th year that Greenland has lost more ice than it gained in the wintertime. As temperatures continue to warm, the 2-mile-thick ice sheet could get out of balance, with snow and ice melting faster than they are being replaced. Melting of the Greenland ice sheet alone could cause up to 10 inches of sea level rise.

Ocean temperatures:

The ocean temperature is also increasing, but more slowly, about 0.8°C (1.4°F). The ocean is a huge heat sink and absorbs over 90 percent of the heat produced by global warming. As reported recently in the Smithsonian magazine, oceans hit their highest temperatures on record for the fourth year in a row. Sea surface temperatures have a major impact on the world’s weather, with warmer oceans causing more extreme hurricanes, heat waves, droughts and heavy rain. Warmer oceans also mean expanding water, causing rising sea levels and flooding. This poses extreme risks for many of the world’s coastal areas located at 1 m (3 feet) above mean sea level. Even a rise of 1 foot by 2050 is potentially disastrous for low-lying areas. This makes them susceptible to even greater damage by storm-caused surges, such as those that caused massive damage on the Florida Gulf Coast in 2022.

Coral reefs:

Earlier we mentioned the danger of exceeding tipping points. Coral reefs are highly sensitive to ocean water temperature, and as the seas warm, reefs die out. If the Earth's temperature reaches 2°C, scientists estimate that a large fraction of the world's coral reefs could be lost. While reefs occupy a small part of the world's oceans, they are vital to maintain the ocean ecosystem that supports fisheries. Millions of people around the globe in coastal areas depend on fishing for food and income.

Sea level rise, flooding:

The sea level has risen an average of about 10 inches due to melting ice and thermal expansion of water in the warming ocean. The rate is about 1.5 inches every 10 years and accelerating. Sydney Australia was one of the areas that experienced another round of flooding. In August, flooding in Pakistan caused a death toll that exceeded a thousand people and left half a million Pakistanis homeless in camps. The United Nations sought \$160 million in flood aid for Pakistan. In the U.S., a new flood map was released that shows the risk of projected future sea level rise in Miami, New York City, and Washington DC.

Drought:

In 2022 many parts of the world suffered from extreme droughts. This has led to loss of crops and famine in parts of Africa and other regions. The western United States has been particularly hard-hit with major rivers and water sources drying up and water levels on Colorado River dams reaching alarming low levels. Unless this is reversed, the dams will be incapable of generating hydroelectricity, and fossil fuel may be required to maintain adequate supplies of electric energy, particularly as trends to replace natural gas with electricity accelerate. This impact is being felt in Germany, China and other countries, with the Rhine River falling to low levels such that navigation was endangered. The Great Salt Lake and Salton Sea are drying up.

Weather disasters:

In September, Hurricane *Fiona* knocked out power in Puerto Rico and other Caribbean islands before moving on to the U.S. and even reaching the east coast of Canada. Following *Fiona*, Hurricane *Ian* hit Cuba and then devastated the Gulf Coast of Florida and caused extensive damage in South Carolina. It had a death toll that surpassed 50 persons, and the estimate of damage would reach in the billions of dollars. A majority of victims do not have flood insurance and flood insurance is likely to be more difficult and costly to obtain in the future. In the United States in 2022, billion-dollar disasters cost \$165 billion, up from \$155 billion in 2021. The only years more expensive than 2022 were 2017 and 2005. Estimated costs of the 2002 drought and heat wave in California exceeds \$20 billion and was the U.S.'s second most expensive disaster of the year.

Wild fires and deforestation:

2022 set new records for wildfires on a global basis. In the United States, 66,000 fires burned 7.5 million acres (30 million hectares). The Western states were hard hit. California had over 7,000 fires burning 364,000 acres (147,000 hectares). Europe and the Mediterranean area in particular also experienced a high number of fires. Due to dry conditions, brought about by drought and high temperature, fires were experienced in Africa, Australia, South America, and Asia. Deforestation due to logging and farming and cattle raising continues to be a major problem. In the last 30 years, over 1 billion acres (420 million hectares) have been lost. This is about 10% of the original extent of forested lands. In 2022 most of the loss occurred in Brazil, the Congo and Bolivia.

Species extinction:

Drought has led to severe impacts on wildlife globally. In Kenya, a massive death of wildlife occurred. The World Wildlife Federation states that 66 species became extinct in 2022. There is significant uncertainty because we do not actually know how many species there are. There are approximately 2 million known species, but as new species are identified frequently, the upper limit is thought to be perhaps 100 million different species. Based on geological and fossil data, scientists

believe that there have been five mass extinctions dating back 500 million years ago. Two of these are thought to have been caused by the impact of an asteroid or possibly a large volcano eruption. The others are attributed to massive changes in the Earth's temperature that extended over thousands of years. Some scientists argue that today the earth is entering a sixth extinction. Time will tell. One thing that can be said for certain is that the loss of species today is most likely due solely to one species—us. Eight billion *homo sapiens* are taking over available land, squeezing out other species and stripping the earth of natural resources to feed the masses.

EVENTS OF SIGNIFICANCE

War in Ukraine:

After 11 months, the war in Ukraine continues unabated, with no end in sight. Russia is responding to a series of battlefield defeats by victimizing the civilian population of Ukraine. Meanwhile, the conflict has led to fuel shortfalls in Europe, rising energy prices, and the risk of a broader conflict. In some ways the conflict has strengthened European resolve to expand renewable energy sources, while in other ways it has had a negative effect; one example being that the United States is now the leading exporter of liquefied natural gas. Elsewhere, the use of coal has expanded due to the embargo of Russian fossil fuels.

Global population increase:

In 2022 the world's population reached a milestone of 8 billion persons. Population growth amplifies the challenge of providing adequate renewable energy sources, as more people increase the demand for food, housing, and for an improved living standard.

U.N. Conference of Parties (COP27):

COP27 took place in November in Egypt. This conference was expected to yield stronger commitments to greenhouse gas emission reductions by member countries. Instead, very little was accomplished; in fact, the conference became known as “a tradeshow for international oil companies.” The one positive outcome was an agreement whereby wealthy countries would provide funds to poor countries for repairing damage caused by climate change or for improving resilience.

Fusion:

On December 13 the U.S. Department of Energy's Lawrence Livermore laboratory announced that for the first time, fusion had occurred in the laboratory where there was a net output of energy. This is widely acclaimed as a future source of limitless cheap energy that could eventually displace fossil fuels and other traditional sources. In our judgment, this appraisal is greatly exaggerated and fusion energy is unlikely to replace conventional sources for many decades, if ever.

SOME GOOD NEWS

U.S “Inflation Reduction Act:”

On August 16, 2022, President Biden signed into law an important measure known as the Inflation Reduction Act. This provided billions of dollars for various measures to strengthen the U.S. economy and improve benefits, such as reducing medical costs, canceling student loans and other measures. Most important, the bill provided over \$400 billion for climate change and energy security measures, including electric vehicle charging stations, rebates for purchase of electric vehicles and incentives to individuals and companies for installing renewable energy sources. This major measure marked a significant advance in the United States' commitments to reducing greenhouse gas emissions. It purportedly would bring the U.S. much closer to reducing greenhouse gas emissions by 50% by 2030, an improvement of 15% compared to current policies.

Amazon rain forest:

In October 2022, Luiz Inácio Lula Da Silva defeated Jair Bolsonaro for the presidency of Brazil. This marked a significant step in halting the destruction of the Amazon rain forest brought about by highway construction, mining, logging, and ranching that was encouraged by the former president.

After his inauguration, Lula appointed Marina Silva as the Minister of environment and climate change. She was born in the Amazon and has long been an advocate for protecting the area.

The decline of coal:

Despite a surge in coal use to generate electricity brought on by the Ukraine crisis, overall coal is declining. It now appears that by 2025 clean energy will overtake coal as the world's most popular energy source. With this, the global energy economy will be entering an extraordinary new phase. The International Energy Agency (IEA) is projecting that renewable energy use will increase as much in the next five years as it has in the last 20 years. Most sources of clean renewable energy are already cheaper than coal.

Steel/cement:

New technologies are emerging to enable these vital commodities to be produced with less use of fossil fuels.

Hydrogen:

Hydrogen is of interest as a fuel to replace natural gas. However, at present most hydrogen is manufactured from natural gas. Currently there is considerable investment and research and development underway to produce "green" hydrogen, for example by electrolysis of water.

Renewable energy costs are declining:

The costs of solar panels, wind turbines and utility-scale storage batteries are declining rapidly. Generation costs from large renewable energy plants today are cheaper than all other fuels and on par with natural gas.

OUR OUTLOOK

Regrettably, we do not find much to report that is positive, based on developments in the last half of 2022.

- With the impact of the Covid pandemic lessening, travel and economic activity is surging with a concomitant rise in emissions.
- The coming period is certain to experience inflation, rising interest rates, and rising energy costs. It is unclear whether these changes will stimulate or retard a greater use of renewable energy for electricity generation and transportation.
- The war in Ukraine has gone on for 11 months and is unlikely to end in the near term. Ongoing tensions will exacerbate uncertainty concerning energy supplies, possibly delaying new renewable energy projects.
- In the very near term, possibly by 2025 to 2030, Earth's average temperature increase will exceed 1.5°C.
- Global greenhouse gas emissions will set a new record in 2023.
- In summary, with conquest, war, famine, and death now very much in the news, our analogy of global warming to the biblical prophecy of the "*Four Horsemen of the Apocalypse*," seems more relevant than ever. (Reference: Craig B. Smith and William D. Fletcher, "Are we Facing a Climate Apocalypse?" *Peace Magazine*, pp.16-19, Jan-Mar 2021. This article can be found on our website, see link below).

Craig B. Smith and William D. Fletcher

Bill Fletcher and Craig Smith are coauthors of *Reaching Net Zero: What It Takes to Solve the Global Climate Crisis*, Elsevier, July 2020. (<https://reachingnetzero.com/book/>)