The Wicked Problem of Climate Change

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WHAT IS CLIMATE CHANGE DOING TO US AND FOR US?

by Paul H. Carr

Abstract. *What are we doing to our climate?* Emissions from fossil fuel burning have raised carbon dioxide concentrations 35 percent higher than in the past millions of years. This increase is warming our planet via the greenhouse effect. *What is climate change doing to and for us?* Dry regions are drier and wet ones wetter. Wildfires have increased threefold, hurricanes more violent, floods setting record heights, glaciers melting, and seas rising. Parts of Earth are increasingly uninhabitable. Climate change requires us to act as a global community. Climate justice enjoins emitters to pay the social-environmental costs of fossil fuel burning. This would expedite green solar, wind, and next-generation nuclear energy sources. Individuals should conserve resources, waste less food, and eat a plant-rich diet.

Keywords: carbon dioxide; climate change; environment; fossil fuel burning; globalization; global warming; green energy; greenhouse effect; rising seas; weather extremes

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Climate change is an unintended consequence of carbon dioxide (CO_2) emissions from burning fossil fuels. By pricing in the social and

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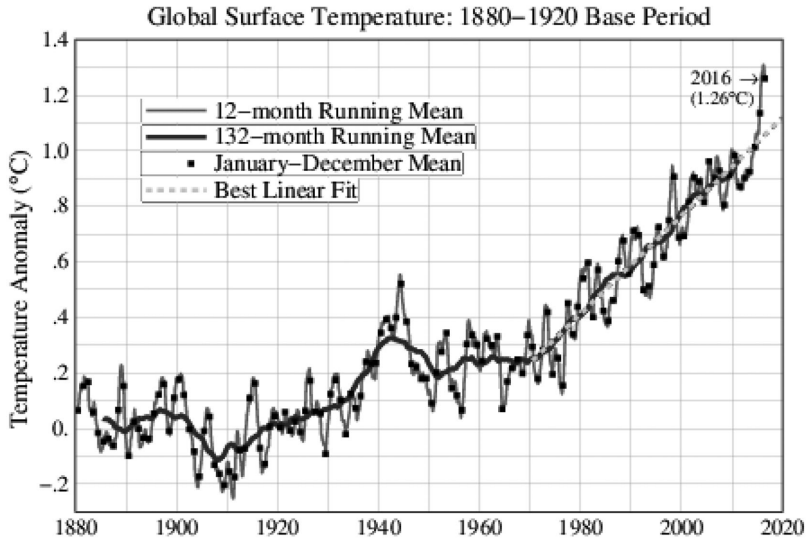

Figure 1. Plot of temperature anomaly versus time with base period 1880–1920. Since 1981 "CO_2 warming has emerged from the noise of natural variability" (Hansen et al. 1981). The year 2016 was the warmest on record. Source: NASA GISS.

environmental cost of these emissions, we can expedite their reduction. Let us harness profit greed toward green technology development. The environmental challenge is to balance the beauty and sacredness of nature with its utility. This article is in three sections: (1) What are we doing to our climate?, (2) What is it doing to us?, and (3) What can we do?

What Are We Doing to Our Climate? The Scientific Consensus

Our present age of human flourishing and increasing domination of the whole earth is known as the Holocene Era. For the last 11,700 years, the temperatures and carbon dioxide concentrations in the atmosphere have been stable. Our population increased from 3 million, before the invention of agriculture, to 7 billion at present.

Since the beginning of the industrial era about 250 years ago, temperatures (Figure 1), tides, and carbon dioxide levels have been rising. This is mostly from the increased burning of fossil fuels, first coal and then oil and natural gas. This burning releases carbon dioxide. Its increase is an unintended consequence of the improved standard of living brought about by fossil fuel burning.

The greenhouse effect in the earth's atmosphere is apparent when we compare our climate to that of the moon, which has no atmosphere

with heat-trapping gases. Temperatures on the moon are above boiling, 123 °C (396 Kelvin) during the day and extremely cold, −233 °C (40 Kelvin) at night. On earth, even on cloudless nights, noncondensing, persistent, and increasing carbon dioxide trap the heat radiation to keep us warmer than on the moon. The increasing carbon dioxide levels are increasing the warming effect of greenhouse gases.

Climate scientist James Hansen's paper "Climate Impact of Increasing Atmospheric Carbon Dioxide," published with six co-authors in *Science* Magazine (1981), observed that carbon dioxide levels had increased to 355 parts per million (PPM) in 1980 from 280 ppm in 1880 (a 0.27 percent per year increase). There was a corresponding increase of 0.4 °C in the average temperatures. Hansen et al. (1981) predicted "CO_2 warming should emerge from the noise of natural variability." Their predictions have come true. In the thirty-six years since then, carbon dioxide levels have increased to 410 ppm (0.43 percent per year increase) while temperature has increased an additional 0.9 °C. The years 2015 and 2016 have been the warmest on record (NOAA 2016).

Are these temperature increases due to the increased greenhouse effect alone or might there be other causes? One possibility is that the energy from the sun may have increased. Many satellites have been measuring this solar energy (Duffy et al. 2009). These measurements show the eleven-year sun-spot cycle, but have not detected an increase in the solar energy since 1980. There are smaller increases from other greenhouse gases like methane and from deforestation, but the carbon dioxide increase continues to have the greatest influence on our warming.

What happened to our climate before the Holocene Era that started 11,700 years ago? About 18,000 years ago the ice age, that had started 90,000 years ago, began to warm. During this ice age, the northern polar ice sheet extended as far south as today's state of Pennsylvania. Changes in the earth's tilt and orbit triggered a temperature rise and a carbon dioxide release from the ocean. The solubility of carbon dioxide decreases with increasing temperature, as is evident from the fact that carbonated drinks like beer are served cold. Thus, as the temperature warms, more carbon dioxide is released from the oceans to the atmosphere. Atmospheric CO_2 rose dramatically. It increased the greenhouse effect centuries ahead of the temperature rise during the great deglaciation (Shakun et al. 2012). The rising temperature melted the polar ice caps to where they were in 1900, raising sea levels about a hundred meters or 324 feet. This is a possible naturalistic explanation for flood stories like Noah's ark in the Bible. There are ancient cities submerged under the Black Sea which were flooded as the rising Mediterranean Sea broke over the Bosporus land bridge. Since 11,700 years ago, average temperatures and sea levels were relatively stable until the beginning of the industrial era about 1750. Presently, sea levels are rising at the rate of one foot per century, which is four times the rate in 1900.

Our present rate of carbon dioxide increase of 2.5 ppm per year is three hundred times faster than that observed when the earth recovered from the last ice age. During this age, the polar ice caps extended as far south as today's state of Pennsylvania. The present concentration of carbon dioxide of 410 ppm is 35 percent higher than the highest carbon dioxide level in the last three million years.

Carbon dating of our carbon dioxide increase in the atmosphere confirms that the present increase is from the burning of fossil fuels, which are hundreds of millions of years old. During the period of 18,000 to 11,000 years ago, the increase in the average global temperature was 3.5 °C. Since the beginning of the industrial era about 1750, our average temperatures have risen 1.3 °C. As temperatures rise, carbon dissolved in the oceans and sequestered in the soil is released to the atmosphere (Crowther et al. 2016). This is particularly true in the Arctic.

A darker Arctic is boosting global warming. Since 1979, less reflecting ice, more absorbing water has made the North Pole warm twice as fast as the rest of the earth. Carbon dioxide, methane, nitrous oxide, and viruses are being released as the frozen tundra melts. Massive phytoplankton blooms have been observed under the Arctic sea ice (Arrigo et al. 2012, 1408; Pickart 2018). Light transmission has increased in recent decades because of thinning ice cover and the proliferation of melt ponds. Phytoplankton increases the absorption of sunlight and amplifies arctic warming. Warming oceans are driving lobster harvests north of New England (Metcalfe 2016). Adult lobsters are not migrating north. Infant lobsters cannot develop in the warmer waters. Lobster harvests north of New England are increasing. The major cod and halibut fisheries are moving toward Iceland and north of Scandinavia (Costa-Pierce 2015). Ecological aquaculture with social-ecological partnerships of scientists working with fishermen, farmers, and civil society is needed to feed the world's increasing population (Costa-Pierce 2016).

In summary, the United Nations Intergovernmental Panel on Climate Change (IPCC), consisting of hundreds of scientists, concluded in 2013 that "It is extremely likely (>95 percent likely) that human influence has been the dominant cause of the observed warming since the mid-20th century" (www.ipcc.ch). Richard Muller's independent nongovernment-funded research team, www.BerkeleyEarth.org, showed how all warming since 1900 is due to human greenhouse gas emissions. The 2017 US Global Change Research Program's Climate Science Special Report (USGCRP 2017) concluded that "It is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence."

What Is Our Climate Change Doing to Us? "The Earth and Its Poor Cry Out, and We Must Listen" (Pope Francis)

First, we are experiencing rising sea levels from thermal expansion and from melting mountain glaciers in Greenland and Antarctica. Second, oceans are becoming more acidic from CO_2 absorption, threatening the bottom of the food chain. Third, weather extremes are increasing: wet areas are becoming wetter due to floods and snow, because the atmosphere holds more water vapor at higher temperatures. At the same time, dry areas are becoming drier: droughts and wildfires. Fourth, there are more climate refugees ("CLIMmigration") from droughts. Fifth, in the north there are more diseases.

Rising Sea Levels

Miami Beach and other coastal areas are now flood zones during the king high tides. Miami is spending almost a billion dollars to raise roads and install pumps. Rising salt water levels are encroaching on fresh water supplies.

If our present rate of carbon dioxide increase continues, carbon dioxide concentrations could double, reaching 800 ppm by the end of the century. About 8 million years ago, when carbon dioxide levels were at the present level of 410 ppm the Arctic had completely melted. About 40 million years ago, when carbon dioxide levels were 800 ppm, our earth, including the Antarctic, was ice free and seal levels were 100 meters or 328 feet higher than today.

At present our Arctic is half melted. Sea levels are presently rising at the rate of one foot per century, which is four times faster than in 1900. The sea level rise is from the melting of Greenland, Antarctica, mountain glaciers, and thermal expansion of the oceans. The rate of sea level rise is increasing as reflecting snow is replaced by sunlight-absorbing water and land. In the paper "Ice Melt, Sea Level Rise and Superstorms," Hansen et al. (2016) predict that sea levels could rise as much as one meter (3.28 feet) by 2050. That would be high enough for the world hopefully to drastically reduce its carbon dioxide emissions. Hansen et al. (2016) also predict that sea levels could rise by five meters (16.4 feet) by 2058, causing significant flooding around the world. Given the fact that the lifetime of carbon dioxide in the atmosphere is hundreds of years, would eight years be enough time to prevent a rise from one meter to five meters? Richard Alley, a glaciologist at Penn State University and an author of the last IPCC report, is concerned about the Thwaites Glacier in Western Antarctica, which is the size of Mexico. If it should break free from it rocky berth, it would raise sea levels ten feet. Further, rising sea levels add to the storm surge flood damage of hurricanes. We need to act now or swim later.

Oceans Are More Acidic

Atmospheric carbon dioxide is absorbed by our oceans. It becomes carbonic acid, which is dissolving the carbonate shells of sea creatures. Oyster and clam shells are becoming thinner from the fact that the ocean is now 30 percent more acidic than before the beginning of the industrial era. Baby oysters cannot form their carbonate shells at present acid levels. Oyster farmers use chemicals to reduce the acidity.

The ocean's present rate of acid increase is a hundred times faster than in the last twenty million years. The acidification will more than double in the next forty years. At this rate of increase, it is unlikely sea life will be able to adapt. The phytoplankton at the bottom of the food chain has carbonate shells which are becoming thinner. If the plankton population dies off, the whole ocean food chain could collapse.

Weather Extremes Are Increasing

Since 1980, weather extremes have more than doubled (Carr 2013). Normally dry areas are becoming drier, with more droughts and wildfires. The California drought from 2011 to 2017 is the longest one on record. Wet areas are becoming wetter from the fact that the atmosphere holds more moisture at higher temperatures. When it does rain, there is more of it. Hundred-year-floods are happening more frequently. The rainfall from the 2017 hurricane Harvey set a new record of fifty-two inches in Houston, Texas, for the most rain in a single storm in the United States.

There has been a threefold increase in wildfires since 1970. In addition to the contribution of dryness, warmer winters no longer kill off the Western pine beetles. They are killing more trees and making more timber to feed wildfires. In May 2016, an out-of-control wildfire forced the evacuation of 80,000 people from Fort McMurray, Alberta, Canada. This is the center of the tar sands oil region, which requires heat from fossil fuel burning to melt the oil tar so it can flow for processing and refining. This is the most carbon-dioxide emitting type of oil. Could the forest fire be "environmental justice" in the sense that the tar sands emissions are increasing global warming? Could Nature be "crying out?"

The Russian drought in the summer of 2010 was so severe that Russia could no longer export wheat. The price of wheat thereafter reached record highs, contributing to the Arab Spring. Population explosions also contributed. For example, the population of Egypt in 1950 was about twenty million; it has increased to eighty million. In addition, most family income is spent on food, so when its price increases many cannot afford to eat.

Climates of Migration (CLIMmigration)

Population increases and droughts preceded the Syrian revolution. Because of the drought from 2006 to 2009, over 1.5 million farmers were forced to

leave their land and migrate to urban areas. The government did little for them before the revolution which started in 2011. CLIMmigration from Syria is a continuing challenge (Fountain 2015).

Hurricane Katrina in New Orleans forced millions to migrate all over the United States. There are 150 million people in Bangladesh living only one to four feet above sea level. Recently, one million people were evacuated from coastal areas as a tropical storm approached.

The 2017 hurricane Irma set new record for a category five storm with 185 miles per hour wind speeds for three days, with major damage to Puerto Rico, the Florida Keys, and southwest Florida up to Naples.

By 2040 the deserts in the American Southwest are predicted to expand into now productive farmland. The Ogallala Aquifer of the central United States is one of the world's great aquifers, but in places it is being rapidly depleted by growing water municipal use, and continuing agricultural use. This huge aquifer, which underlies portions of eight states, contains primarily fossil water from the time of the last glaciation. Farming will move north to underpopulated Canada, whose northern lands will become more suitable for agriculture.

Similarly, southern China will become too hot and dry for agriculture, while underpopulated Siberia will become more suitable. The potential CLIMmigration of China's over one billion people to a different country to the north will have international reverberations.

More Diseases in the North

The incidence of tick-borne Lyme disease in the United States has more than doubled. In 1995, there were 11,700 confirmed cases. In 2013, there were 27,203 confirmed cases, as well as another 9,104 probable cases. Ninety-five percent of reported cases in 2013 came from fourteen states, located primarily in the Mid-Atlantic, Northeast, and upper Midwest. Lyme disease is the most commonly reported vector-borne disease reported in the United States. Climate change is increasing not only the range in which Lyme disease–carrying ticks can survive—ticks are moving into warming Canada and other northern locations.

An extensive nineteen-year field study of the blacklegged tick has led researcher Richard Ostfeld and colleagues (2006) to conclude that the Lyme disease increase is mainly due to the increased population of mice and chipmunks, which are hosts to the disease-transmitting ticks. Ostfeld and a team of researchers conducted an analysis using observations of tick life-cycle behaviors from more than 50,000 mice, 12,000 chipmunks, 403,000 larval ticks, and 44,000 nymphal ticks collected in the 2,000 acres of forest that is part of the Cary Institute's campus in Millbrook, NY, which happens to be a tick hot spot. The researchers concluded that in warmer years ticks emerged as much as three weeks early, which poses a risk to public health.

Cases of West-Nile and Zika viruses, which have been mostly in the south, could move north. Anthrax cases have been reported as the frozen Arctic melts and releases its germs. Air pollutants from coal combustion act on the respiratory system, contributing to serious health effects including asthma, lung disease, and lung cancer.

What Can We Do? Harness Greed; Develop Green Technology

The bottom line is that we must harness greed (profit) toward developing green technology. There are three options: the first is adaptation to what we cannot change due to the hundred-year lifetime of carbon dioxide. The second is mitigation to reduce our carbon emissions by conservation and non–carbon emitting technology, such as solar, wind, storage, and next-generation nuclear reactors. A carbon fee which accounts for the true cost of burning fossil fuels will expedite reduced emissions. The third is do nothing different, then complain, blame, and suffer. Pope Francis (2015) has expressed his concern that the poor will suffer the most.

Options for Individuals

Conservation and improved energy efficiency are continuing options. For example, many of us grew up hanging up our washed clothes on clotheslines, where solar energy made them dry. Many lived in towns with no buses because everyone walked to school, work, and grocery stores.

The book *Drawdown: A Comprehensive Plan to Reverse Global Warming* (Hawken) ranks one hundred possible solutions to reverse global warming. The third and fourth ranked solutions are "reduce food waste" and "plant-rich diet." Food expert Solomon Katz shared the following at the IRAS 2017 Conference. He was perplexed. He felt he would sin when his dinner host offered him a plate of meatballs. He would commit a sin against our planet by eating them or a greater one of waste if he did not. He had just read *Drawdown*. He asked his host, "What kind of meatballs are these?" His host replied, "These are SYNthetic meatballs made from soy beans." Katz ate them with a clear conscience, saved by modern food technology (Katz and Costa-Pierce 2017).

A vegetarian diet requires the least energy and carbon emissions. Legumes like soybeans are the most efficient source of protein. The energy required for chicken protein is about four times that of soy, and beef about eight times soy (Keim 2013). For the average American, simply replacing meat-based calories with eggs and dairy products would result in an energy savings akin to switching from a Camry to a Prius.

Atmospheric scientist Peter Kalmus (2017) in his *Being the Change: Live Well and Spark a Climate Revolution* tells how he reduced his family's carbon dioxide emissions to one-tenth that of the average American family. By

eating vegetarian food, the reduction was 50 percent. His other reductions included less airplane travel and riding his bicycle. All this made Peter's life more interesting, satisfying, and joyful.

To motivate individuals to drive energy-efficient automobiles, a conservative religious group raised the question, "If Jesus were to return to earth, what car would he drive?" My wife believes he would drive a Prius "to prius from our sins." A biblical answer is, "Jesus would drive a Honda Accord, because in Acts 2:1 it states, "all the disciples were in one accord."

On June 21, 2008, The *Economist* had a cover article envisioning non-carbon emitting electric cars charged by electricity from windmills, solar photovoltaic (PV) arrays, and next-generation nuclear fission reactors. This vision has been fulfilled. The cost of electricity from wind and solar PV arrays is now equal to or less than that generated by fossil fuels (Wikipedia 2017). Solar PV panels are now being installed on the rooftops of individual homes, saving homeowners many dollars over the twenty-year lifetime of the array.

For several years, Tesla Motors has marketed an electric car with a range of over two hundred miles per charge, but costing over $70,000. The electricity cost is equivalent to a conventional car getting a hundred miles per gallon. Electric motors have high torque at low speeds and require a simple one-speed transmission. The Tesla Model S will accelerate from zero to sixty miles per second in three seconds. In 2017, Chevrolet marketed its Bolt, which has the same two hundred miles per charge range. It accelerates from zero to sixty miles per hour in six seconds, but costs only $35,000 after the federal tax rebate. The Bolt has a fuel savings of $4,250 over five years as compared to the average new vehicle. Although the Bolt is assembled in Michigan, its motor, single-speed transmission, and batteries are manufactured in South Korea.

Technology advances promise to make longer range electric cars likely. John Goodenough, age ninety-four, co-inventor in 1980 of the lithium-ion battery, has discovered a lithium- or sodium-glass battery that has three times the energy storage capacity of present lithium-ion batteries (Anderson 2017). There are still some technological problems that need to be solved before this can be scaled up to large-scale cells (Cornell 2017). The United States should increase its energy research budget from $3 billion to higher than $15 billion to encourage innovative research and development such as this.

What Climate Change Is Doing for the Global Community

Climate change requires us to act together as a global community. "We must hang together, or hang separately," to quote Benjamin Franklin. Climate change impacts everyone independent of nationality, culture, religion, or language. Mother Nature is bigger than our ideologies. "The universe is a

Figure 2. Chaplain Rev. Dr. Mary Westfall leading the 2017 IRAS Climate conferees in singing "The tide is rising, and so are we! This is where we are called to be" in the Star Island chapel. (Photo by Robert Schaible)

communion of subjects rather than a collection of objects" (Swimme and Berry 1994, 243).

On September 24, 2015, Rabbi Shoshana led the singing of "The tide is rising, and so are we! This is where we are called to be" at an historic service bringing together national religious leaders at the National Cathedral in Washington DC. The service aimed to lift up Pope Francis's (2015) call to action on climate change and creation care. "The Tide is Rising, and So Are We" also became a theme song in the morning chapel services on Star Island, led by the Rev. Dr. Mary Westfall, as shown in Figure 2. For her six chapel services (Sunday–Friday), her theme was "Mastery, Mystery, and Mindfulness: Thriving in a Broken and Beautiful World."

In December 2015, 195 United Nations countries met in Paris for COP21 (Council of Parties) and made voluntary commitments to lower their carbon dioxide emissions. Pope Francis's encyclical *Laudato Si': On Care for Our Common Home*, published in June 2015, aided this global advance. Pope Francis stated that we have a moral obligation to stop plundering our planet for profit, the poor suffering the most. A graduate of Matthew Fox's master's program in creation spirituality wrote a large part of the encyclical. In Fox's essay "Praise Be to You Pope Francis" Fox notes that the encyclical cites beauty twenty-seven times (Fox 2016). Experiencing and appreciating the beauty of the earth is evidence of creation spirituality, which challenges our species to a new evolutionary awakening. Creation spirituality can give us the courage needed to overcome denial and anthropocentricism (Fox 2018).

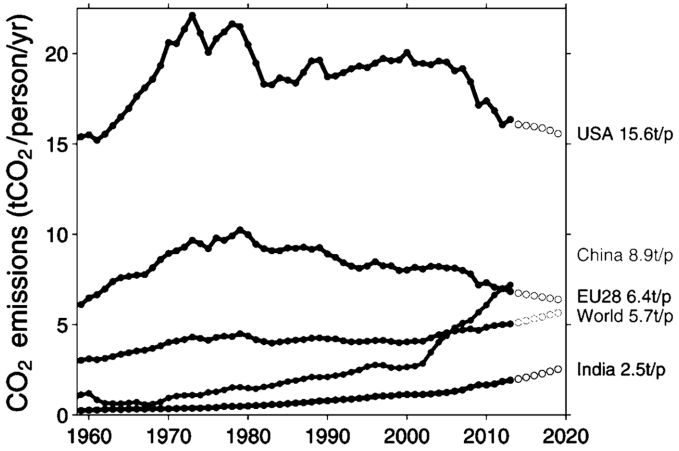

Figure 3. Per capita carbon dioxide emissions. The US emissions are about twice that of the European Union. In 2011, China's emissions increased to be equal to those of Europe (Canadell). Reprinted with permission from Canadell (2014).

In December 2015, President Obama's commitment to the Paris Accord was to reduce coal burning, which was already in progress. Fracked natural gas was a less expensive way of generating electricity than coal. However, six months later President Trump announced that the United States would start the four-year process of withdrawing from the Paris Accord. In response, the organization United States Climate Alliance was formed. It plans to show the world, and the United Nations Framework Convention on Climate Change (UNFCCC), how the US is contributing to a worldwide solution. The United States Climate Alliance consists of 125 cities, 13 states, 902 businesses (including Apple and Google) together with their investors, and 183 colleges. Participating cities and states represent 120 million Americans and contribute $6.2 trillion to the US economy. Billionaire philanthropist and former New York City Mayor Michael Bloomberg has pledged to contribute $15 million the US owes to the United Nations climate fund if the Trump administration will not (see Bloomberg et al. 2014). At the G-20 Economic Summit in July 2017, world leaders agreed to go forward, calling the Paris Agreement "irreversible."

How is the global community doing in reducing its fossil fuel burning? Since 2006, China has become the world's greatest carbon dioxide emitter. However, since 1960 the United States has been and continues to be the world's largest carbon per capita emitter, about twice that of the European Union (EU) (Figure 3). In 2011, China's per capita emission rose to be equal to that of Europe. India's per capita emissions are significantly less than those of China. However, India has over a billion people, comparable to the population of China. India could therefore be a "wild card" whose

emissions could equal those of China in the future (Sivaram 2017). Ten of the word's twenty most polluted cities are in India.

Why are the per capita carbon emissions of the United States about twice that of the European Union, which is equally developed (see Figure 3)? Adam Smith's "invisible hand" of economics is evident in the cost of gasoline, which is about two times higher in the European Union than in the United States Oil is an internationally traded commodity whose cost is the same worldwide. The Europeans tax gasoline and use it to subside public transportation whose per capita cost per mile is much lower than driving an individual automobile.

Adam Smith's "invisible hand" is also evident in two time periods when the per capita carbon emissions in the United States decreased. In Figure 3, one of these was from after 1978, when carbon emissions decreased 25 percent. From 1960 to 1970, the cost of gasoline had increased from $0.30 per gallon to $1.00, respectively. Emissions peaked during the period from 1970 to 1978. Since 2010, US carbon emissions have been declining as coal-generated electricity has been largely replaced by less expensive natural gas. Natural gas is less polluting than coal and its carbon dioxide emissions are one-half that of coal for the same amount of energy. Overall, the carbon emissions of the United States and the European Union have been slowly decreasing, while at the same time their gross domestic products (GDP) have been increasing. This disproves the skeptic's and President Trump's claim that decreasing carbon dioxide emissions would destroy economic growth (Carr 2017a, 2017b).

Climate scientist James Hansen (2009) has said that we must figure out how to live without fossil fuels some day. Why not now, before we have destroyed the creation? Coal burning is the biggest contributor to increases in carbon dioxide levels. Each year several hundred thousand people in the world die of air pollution from coal. If that many people died from a nuclear plant malfunction, we would shut them all down. A moratorium on building new coal plants without carbon sequestration and a phasing out of present ones within twenty years could enable our earth to recover a sustainable CO_2 level.

Economic Policy

Economic policy can reduce carbon dioxide emissions. Sweden introduced a CO_2 tax in 1991. Since then its GDP has grown 60 percent, and at the same time its emissions have been reduced by 25 percent (Andersson 2016). In 2009, the US House of Representatives passed the Waxman-Markey bill, which placed a price on carbon, but the Senate did not. This cap-and-trade bill would have placed a limit or cap on the amount of carbon that a coal-fired generating plant can emit. To exceed this limit, the coal plant would have to buy tradable permits. Nevertheless, Sweden,

California, Quebec, and the Northeast Regional Greenhouse Gas Initiative are using cap-and-trade to decrease coal burning and give an economic advantage to non–carbon emitting geothermal, hydro, nuclear, wind, and solar energy sources. This energy is free, after capital and maintenance costs are paid, and will last until the sun burns out, billions of years from now.

China has recently taken its first steps to build what is destined to be the world's second-biggest carbon emissions market. Guangdong province has the largest of seven pilot programs for a proposed national market within a year. Exchanges will trade permits to emit an estimated one billion metric tons of greenhouse gases a year by 2018, close to half the volume in the EU system.

Former Treasury Secretary under President Reagan, George Shultz, has proposed a revenue-neutral carbon fee with the dividend returned to everyone (Shultz 2015). According to an independent study by Regional Economic Modeling Inc., this proposal will create 2.8 million jobs, save over 230,000 lives, and reduce emissions by 50 percent within twenty years, while allowing two-thirds of households to break even or come out ahead financially. A typical family of four would get about $2 thousand per year. This proposal would spur green energy innovation, giving it an economic advantage over fossil fuels. The carbon fee would make the economic system work because carbon emitters would be paying the true social and environmental cost of their use (https://citizensclimatelobby.org).

Next-Generation Nuclear Fission Energy

In "How Fear of Nuclear Power Is Hurting the Environment," Michael Shellenberger (2016) observed that the world is presently decommissioning nuclear reactors faster than the increase in wind and solar power. Solar energy is only available 26 percent of the time and wind 30 percent. Nuclear is 24/7. To make up for the net nuclear decrease, the word is increasing its burning of fossil fuels. They are raising carbon dioxide emissions that are warming our planet. This is particularly true in Germany, where the cost of electricity is twice that in the United States. Neighboring France gets most of its electricity from its nuclear reactors. Its carbon dioxide emissions and its electricity costs are lower than in Germany.

Solar energy is nuclear. The energy that enables life on earth comes from the nuclear fusion of hydrogen into helium in our sun. The temperatures are so high that no materials can contain these fusion reactions here on earth. For this reason, present nuclear reactors get energy from the fission of uranium into lower elements in the periodic table. As Marie Curie put it, "Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less" (quoted in Benarde 1973, v). Curie was the first woman to receive a Nobel Prize. It was for her pioneering research on radioactivity, a term which she coined.

NASA's James Hansen, MIT's Kerry Emanuel, and two other top climate scientists wrote an open letter, "Nuclear Power Paves the Only Viable Path Forward on Climate Change" (Hansen et al. 2015). They stated, "Modern nuclear technology can reduce proliferation risks and solve the waste disposal problem by burning current waste and using fuel more efficiently. Innovation and economies of scale can make new power plants even cheaper than existing plants."

Engineers at MIT are designing a nuclear plant that could be moored at sea, like an oil rig. It would cost about one-third less than a conventional nuclear reactor and take about half the time to build. Floating reactors would not be in anyone's backyard (NIMBY). According to MIT professor of nuclear science and engineering Ian Hutchison, "The Republicans are less scared of nuclear energy than the Democrats" (Hutchinson 2016). Bill Gates is presently funding next-generation nuclear power. TerraPower's nuclear pilot plant is being built in China, whose National Nuclear Corporation has a contract with Bill Gates. This traveling wave reactor converts depleted uranium, a byproduct of the nuclear fission process, into usable fuel. This is solving our nuclear storage problem (Conca 2015). China is leading the world in the construction of twenty-three new nuclear reactors, with thirty-three planned.

Thorium molten salt nuclear reactors (MSR), demonstrated at Oak Ridge National Laboratory 1965–1970, consume nearly 100 percent of their fuel, compared with 3 percent for older reactors with solid uranium fuel (Cornell 2017). MSRs eliminate the need for Yucca Mountain storage by consuming nuclear waste. Thorium fluoride molten fuel for MSRs is of no weapons value. Thorium fuel is more abundant and cheaper than uranium. MSRs require no expensive containment since they operate close to atmospheric pressure. Thorium reactors are designed to shut down automatically without operator intervention in case they overheat. They have a zero chance of a meltdown. China is investing $350 million over five years to develop molten salt thorium reactors. It plans to build a two-megawatt test reactor by 2020. According to Richard Martin (2003), thorium is "the green energy source for the future."

Since thorium nuclear reactors are better for peacetime, why are there so many uranium reactors? Alvin Weinberg demonstrated a thorium nuclear fission reactor at Oak Ridge in 1965–1970. Its fission byproducts had no weapons value during the Cold War's nuclear arms race. Thorium reactors lost to Admiral Rickover's uranium ones for nuclear submarines and aircraft carriers (Kelly-Detwiler 2014). Present uranium civilian reactors, which generate 20 percent of our electricity without carbon emissions, are a spinoff from Rickover's navy technology.

India has large thorium reserves and little uranium. It has almost completed the world's first thorium five-hundred-megawatt nuclear reactor (Follett 2017), and plans to get 25 percent of its electrical energy from

thorium by 2050. These plus solar microgrids in rural areas will hopefully keep India from becoming like China in being a country with the largest carbon dioxide emissions.

China now leads the world in the construction of its twenty-three nuclear reactors, with thirty-three planned. India is third, with four reactors under construction and twenty planned. China also has the largest market share of solar PV panels. With its solar, wind, and nuclear advances, it is well on its way of getting 20 percent of its electricity from non–carbon emitting sources by 2020 (Figureres et al. 2017).

Three Years to Safeguard Our Climate

Christina Figureres and her colleagues in their article "Three Years to Safeguard our Climate" (2017) state that the year 2020 is crucial. If emissions keep rising beyond that time, the goals set in Paris may be unattainable. If we harness the momentum from the Paris accords, the good news is that there is still time if emissions begin to fall in 2020. Waiting until 2025 spells disaster. Emissions in the United States fell 3 percent last year while GDP grew 1.6 percent. In China, emissions fell 1 percent while GDP grew 6.7 percent. Two-thirds of China's 5.4 percent extra demand for electricity came from carbon-free sources. In the European Union, wind and solar made up three-quarters of new power. In the United States, two-thirds of the new installations were renewable. The International Energy Agency (IEA) predicted that by 2020 renewable sources could supply 26–27 percent of electricity compared with 23.7 percent at end of 2015. Growth in electric vehicles could displace 2 million gallons of oil each day by 2025. Solar power alone could supply 29 percent of electricity by 2050. This would remove coal and leave natural gas with only 1 percent of the market.

Investors are growing wary of carbon risks (Figureres et al. 2017). BlackRock and Vanguard, the two largest fund managers, voted against Exxon-Mobile management at a meeting on May 31, 2017, and they instructed the company to report the profit impact of measures to combat climate change (Figureres et al. 2017). Norway has asked banks to disclose how their lending affects global warming (Norway's wealth is based on oil). Last year the installed capacity of renewables set a record of 161 Gigawatts. In 2015, investment in renewables reached $286 billion—more than six times that in 2004. There is a strong headwind against this progress, notably in the US Congress. But a fossil-free economy is already profitable.

Six Milestones

These goals are realistic at best and unrealistic at worst. This focus should release ingenuity. Here is where the world needs to be by 2020: first, energy. Renewables will be at 30 percent. No coal-fired plants are approved. Older plants will be retired. Second, infrastructure. Cities and states will

have initiated action to fully decarbonize buildings and structures by 2050 with funding of $300 billion annually. Third, transport. Electric vehicles will constitute at least 15 percent of car sales globally. Mass transit in cities will be doubled. There will be a 20 percent increase in fuel efficiency of heavy vehicles, and a 20 percent decrease in greenhouse gas emissions from aircraft. Fourth, land. Reforestation efforts will rise. Deforestation will be cut to zero and used as carbon sink (Figureres et al. 2017). Fifth, industry. Heavy industry will be developing and publishing plans for increasing efficiency and cutting CO_2. The "Three Years to Safeguard our Climate" article notes the heavy emissions from iron, steel, cement, oil, and gas. Finally, finance. The financial sector will have rethought how it deploys capital and will be mobilizing $1 trillion a year for climate action. Governments, private banks, and lenders need to issue more "green bonds." This would create an annual market of more than ten times the $81 billion issued in 2015 (Figureres et al. 2017).

Further, Faster, Together

If we delay, the prospects for human prosperity will be severely curtailed. There are three practical steps to avoid this. First, we must use science to guide decisions and set targets. Policies must be based on robust evidence and on uncensored and transparent communication. Those in power should stand up for science: French Prime Minister Macron's "Make Our Planet Great Again" is an example. Second, existing solutions must be scaled up rapidly. Third, optimism should be encouraged. "Impossible" is not a fact; it is an attitude. More ambitious targets must become easier to set. There will always be those who hide their heads in the sand and ignore the global risks. But there are many more of us committed to overcoming this inertia. Let us stay optimistic and act boldly together (Figureres et al. 2017).

Conclusions

Because fossil fuels are a limited resource, by 2100 fossil fuel burning will be declining due to the depletion of the finite world resource. The world's primary sources of electricity will be renewable intermittent wind and solar, next-generation nuclear fission power plants, and hydro, all of which generate 24/7. By then electricity stored in batteries will power most of our transportation. Let us deploy these technologies now before we have caused irreparable damage to our earthly home.

The Golden Rule of ethics must rebalance our economy. At present, those with the gold make the rules. Pope Francis's *Laudato Si': On Care for Our Common Home* states that we have the moral imperative to stop plundering our planet for profit, the poor suffering the most.

Does Adam Smith's "invisible hand" guide the pursuit of individual gain towards creating the *Wealth of Nations*? Let us update this 1776 view of economics and rebalance it with Garrett Hardin's 1968 "Tragedy of the Commons," in which the pursuit of individual gain leads to negation of the common good. If carbon emitters and users would pay the true cost of their emissions, our world economy would keep the world's remaining carbon in the ground. Let us harness the greed for profit toward developing carbon-free technology.

The environmental challenge is to balance the beauty of nature with its utility (Carr 2006). Is beauty "in the eye of the beholder" or/and an encounter with the Divine? Without divinely created beauty, nature becomes an object that may be ravaged. For example, a coal mine can be beautiful in the eye of its owner because it is a source of black gold. Hopefully, we will re-envision beauty to transform our relationship with nature in time to lessen the impact of weather extremes and rising tides and temperatures.

Margaret Mead, who was a plenary speaker at the 1969 IRAS conference once said, "Never doubt that a small group of thoughtful committed citizens can change the world; indeed, it is the only thing that ever has" (quoted in Sommers and Dineen 1984). Rachael Carson's best-selling *Silent Spring* (1962) led to an environmental movement that banned DDT.

Echoing President John Kennedy: Ask not what our country can do for you. Ask what we can do now to save our planet.

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