

14 April 2008

To: Governor Jim Gibbons

From: James Hansen, NASA Goddard Institute and Columbia University Earth Institute

Subject: A Plea for Your Leadership

Dear Governor Gibbons,

I am honored to be the recipient of the Desert Research Institute's annual Nevada Medal this year and to attend the awards ceremonies hosted by you and the First Lady.

I hope that I may communicate with you as a fellow parent and grandparent about a matter that will have great effects upon the lives of our loved ones. I refer to climate change, specifically global warming in response to human-made carbon dioxide (CO₂) and other pollutants. This topic has long remained in the background, but it is now poised to become a dominant national and international issue in years ahead.

Global warming presents challenges to political leaders, but also great opportunities, especially for your state. Nevada has the potential to be a national leader in protecting the environment and implementing technologies that can mitigate the crisis posed by global warming.

First, however, I want to make you aware of rapid progress in understanding of global warming. Warming so far, averaging 2 degrees Fahrenheit over land areas, is smaller than weather fluctuations. Yet it already has noticeable effects and more is "in the pipeline", even without further increases of CO₂, because of climate system inertia that delays the full climate response.

Effects of global warming are already seen in Nevada. One result is increased wildfires. Longer summers mean more dried out fuels, allowing fires to ignite easier and spread faster. The wildfire season in the West is now 78 days longer than it was 30 years ago. And the average duration of fires covering more than 2,500 acres has risen five-fold.

As the planet continues to warm, these and other impacts will grow worse for Nevada and the American West. The world's leading climate researchers conclude that, if greenhouse gases continue to increase, the region faces:

- Longer and more intense droughts, thus widespread water shortages, especially in areas of high population growth and where water resources already are heavily utilized, such as Nevada.
- Thus still larger, more intense wildfires.
- More winter and spring flooding, but reduced summer and fall run-off, with rivers in these seasons reduced to a trickle in many years; this will intensify competition for over-allocated water resources.
- More intense precipitation and storms when it does rain, with a resulting increase in flood risk.
- Longer and more intense heat waves, with a correspondingly adverse impact on public health, particularly for the elderly.

Governor Gibbons, the scientific advances in just the past few years, paradoxically, carry both bad news and good news. The enclosed paper, "Target Atmospheric CO₂: Where Should Humanity

Aim” (<http://arxiv.org/abs/0804.1126> with Supporting Material at: <http://arxiv.org/abs/0804.1135>), makes clear that we have already passed the threshold of atmospheric CO₂ levels that we can allow to exist over the long-term. Mother Nature, as a friend of mine has noted, is wagging her finger at us, saying “Now you have gone too far!”

Consequences of ignoring this admonishment would be dire. The Earth is nearing climate “tipping points” with potentially irreversible effects, including extermination of countless species, ice sheet disintegration and sea-level rise, and mass dislocation of populations.

The good news is that it is still feasible to solve the problem, to reduce CO₂ emissions over coming decades and draw down the atmospheric CO₂ amount through natural processes and with the help of improved agricultural and forestry practices. By drawing down the CO₂ amount we can not only avert catastrophic irreversible effects mentioned above, but also alleviate problems that were beginning to seem intractable and inevitable. I refer here to regional effects such as those discussed above for the American West (and similar effects in the Mediterranean region, Australia, and parts of Africa and South America), acidification of the ocean with destruction of coral reefs, and recession of alpine glaciers worldwide with accompanying loss of a principal freshwater source for hundreds of millions of people during the dry season.

However, solution of the problem has one unavoidable implication for fossil fuels. As the attached “Fossil Fuel Facts” make clear, atmospheric CO₂ can be successfully constrained only if coal use is phased out except where the CO₂ is captured and sequestered so that it does not enter the atmosphere. In turn, the conclusion that coal use without sequestration must be phased out, over the next 20 years, foretells requirements and opportunities for Nevada.

The imperative of halting coal emissions does not recognize state or national boundaries. There is no doubt about the eventual position of the United States and the international community. The mutual peril has become crystal clear and it will soon be widely understood. The United States, although it was also slow to enter prior international battles with the future at stake, surely will begin to exercise leadership in this matter, independent of political parties, because of the clarity of the threat to the planet. Disinformation campaigns, by the fossil fuel industry and utilities, cannot succeed, and they raise great liability risks.

Utilities and the fossil fuel industry must reckon with the fact that the laws of Nature and the human instinct for survival will overrule any paper agreements that may exist now or be wrangled in the near-term. “Grandfathering” of fossil fuel plants and any ineffectual “cap and trade” scheme, should it be initiated, will necessarily be replaced by “cap and bulldoze”. Uncaptured CO₂ emissions from coal must be eliminated.

Is it possible that I am wrong, that the governments are so larded with fossil fuel special interests that they will allow us to destroy the planet that we leave for our children and grandchildren? Sure – just as there was a chance that the United States and the Soviet Union could have blown each other off the face of the planet with nuclear weapons – but it is much more likely that we will come to our senses soon, as the scientific story and empirical evidence overwhelm the deceit of short-term special interests.

One of the “Fossil Fuel Facts” is that a substantial fraction of fossil fuel CO₂ emissions stays in the air for what is, for all practical purposes “an eternity”, more than 1000 years. That is a well-established scientific fact – there is no debate. A direct implication is that we cannot be aiming for

a 50, 80 or 90 percent reduction of emissions. We must transition over the next several decades to practically zero net CO₂ emissions. Thus our energy focus must be to develop renewable energies and energy efficiency.

Indeed, when you created a climate change task force last year, you said “Nevada has to be a responsible member” of global society, and, with its abundant wind, solar and geothermal potential, the state can “leverage these resources to reduce greenhouse gas emissions by investing in its renewable energy industries, thus promoting economic growth and energy security while maintaining and enhancing the environment for future generations of Nevadans.”

Governor Gibbons, I understand that you have also supported proposals for new coal-fired power plants, in Ely, Mesquite and White Pine. These coal-fired power plants would expose ratepayers and Nevada to grave financial risk. Steeply rising construction costs and coal prices are themselves ratcheting up the cost of coal-fired electricity, and sure-to-appear federal legislation that demands elimination of CO₂ emissions will drive costs much higher. Given that Nevada’s geology is not very well-suited for storing CO₂, any assumption about retrofitting a coal-fired plant for CO₂ capture is a dubious and financially risky proposition.

A major additional disadvantage of coal is the pollution associated with it. There is no such thing as “clean coal”. Good stewardship of creation, of the planet that we inherited, suggests that the best place for coal is in the ground, where it is. Renewable energies are also superior in requiring little water, a resource that is becoming increasingly precious.

Although the fossil fuel industry pedals misinformation, claiming that renewable energies can only be a niche contribution to energy needs, that contention defies common sense. As proof of the contrary, consider just one of the renewable energies, solar power. The technology for solar thermal power stations already exists, power stations can be built rapidly, and as the market for them increases their unit costs will fall steadily, as the cost of coal power continues to rise. There is enough solar energy in a small fraction of our desert Southwest to provide all of the electrical needs of the United States. Nevada has the potential to be a leader in this field, providing power for itself and for distant locations as a low-loss grid is developed. Leadership would provide great economic benefit to Nevada and provide a large number of high-pay jobs and new businesses.

Note that renewable “fuels”, in addition to eliminating CO₂ emissions, are cost-free and the source will last practically forever. This is in stark contrast to coal. One reason that the cost of coal has been shooting up is that coal is a finite resource requiring increasing efforts for extraction. The notion that the United States has a 200-year supply of economically extractable coal is a myth. I strongly recommend that you invite Prof. David Rutledge of the California Institute of Technology to brief you on current analyses of coal reserves.

An indirect source of energy, with enormous potential, is efficiency. This potential can be tapped much more if rules for utility profits are changed such that profits increase when the utility helps customers improve efficiency, rather than when the customers use more energy.

Governor Gibbons, I know that you have backed the construction of new coal plants. I also know, from colleagues at the Desert Research Institute, that you have a scientific background and ask penetrating questions. This is a time when, as Nevada’s top elected official, entrusted with protecting the interests of Nevadans and the state’s environment, you can benefit most from the objective methods of science in reevaluating your energy options.

I realize also that there has been a tendency for positions on energy issues to divide along party lines, (for the sake of disclosure, I am an Independent), but I am confident that in making your decisions you will be guided by the considerations of the long-term prosperity of Nevada and the condition of the planet that we leave for our children and grandchildren. As governor, you can help inspire your state and the rest of the country to take the bold actions that are essential if we are to retain a hospitable climate and a prosperous future. If you should decide to come down firmly on the side of clean energy and energy efficiency, it could be a transformative moment for you, Nevada, and the future of coming generations.

Specifically, you could use your executive authority to suspend the permitting of the three proposed power plants until concrete plans for carbon capture are provided. Without a firm requirement and commitment for carbon capture, the likelihood that it actually would be included is remote. The proposed operators, in fact, are almost surely assuming that they will not need to capture the CO₂, and when carbon capture becomes a national imperative the jolt to Nevada ratepayers will be severe. Far better than importing coal from other states, with vagaries of availability and a growing price, would be for Nevada to assume leadership in the development of its abundant free renewable energies. Unlike coal plants, the renewable energies will not deplete precious groundwater, and they will provide a larger number of construction and professional jobs.

I close on a note of optimism. I mention in my presentations the power gap in the face-off of fossil fuel interests against young people and nature. Fossil interests permeate state governments, as well as Washington. Young people must seem puny in comparison, and animals are of little help (don't talk, don't vote). Yet, as in our national revolution more than two centuries ago, the puny are united by a powerful force, a common goal for the common good. I am heartened that young people will make the difference in this war, on the side of nature and humanity.

Recently I met remarkable young organizers, including Jessy Tolkan who led the New Voters Project in Wisconsin, registering over 130,000 18-24 year-old Wisconsin voters, making young people a powerful force in primary and general elections. These young people have now joined forces in a coalition of 47 youth organizations in support of bold climate action. The Energy Action coalition is determined to mobilize at least one million youth as a powerful force, on the side of nature and humanity, focused on the essential goal of zero carbon emissions as soon as humanly possible. I recently learned that Energy Action, League of Young Voters, Rock the Vote and several other youth civic groups have identified Nevada as a principal state for their voter outreach programs. According to Energy Action, there are numerous young students at the University of Nevada, Nevada State, and several of your community colleges who are getting involved with this climate campaign.

Youth may still seem puny, aligned against fossil interests, but it would be a mistake for industry and political leaders to sell them short. They are not fooled by "green" advertisements of industry or tokenism in political actions. The leaders who put our nation on a course to carbon-free energy, allowing us to be good stewards of creation, of our planet, will find a strongly supportive public.

Respectfully,

James Hansen

cc: Members of Nevada Climate Change Task Force
Nevada Public Utilities Commission

Basic Fossil Fuel Facts

The role of coal in global warming is clarified by a small number of well-documented facts. Figure 1 shows the fraction of fossil fuel carbon dioxide (CO₂) emissions that remains in the air over time. One-third of the CO₂ is still in the air after 100 years, and one-fifth is still in the air after 1000 years.

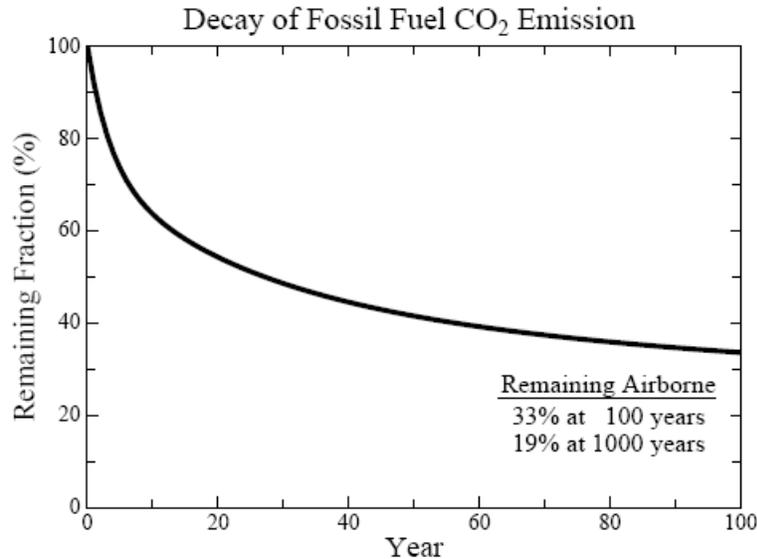


Figure 1. The fraction of CO₂ remaining in the air, after emission by fossil fuel burning, declines rapidly at first, but 1/3 remains in the air after a century and 1/5 after a millennium (Atmos. Chem. Phys. 7, 2287-2312, 2007).

Oil slightly exceeds coal as a source of CO₂ emissions today, as shown in Figure 2a. [IPCC = Intergovernmental Panel on Climate Change; WEC = World Energy Council] But, because of the long atmospheric lifetime of past emissions, fully half of the excess CO₂ in the air today (from fossil fuels), relative to pre-industrial times, is from coal (Figure 2b). Moreover, coal use is now increasing, while oil production has stagnated. Oil production will peak and will be constrained by available resources earlier than will coal production.

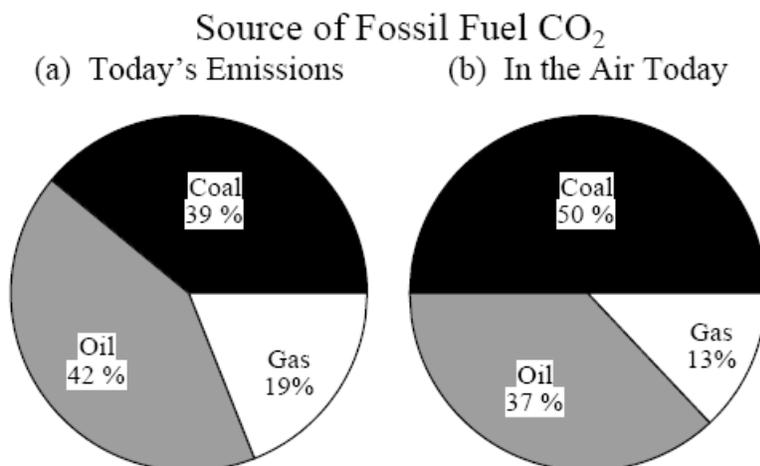


Figure 2. Percent contributions of different fossil fuels to 2006 CO₂ emissions (left side) and contributions to the excess CO₂ in the air today relative to pre-industrial CO₂ amount (CDIAC data for 1751-2004, BP for 2005-6; cf. Atmos. Chem. Phys. 7, 2287-2312, 2007).

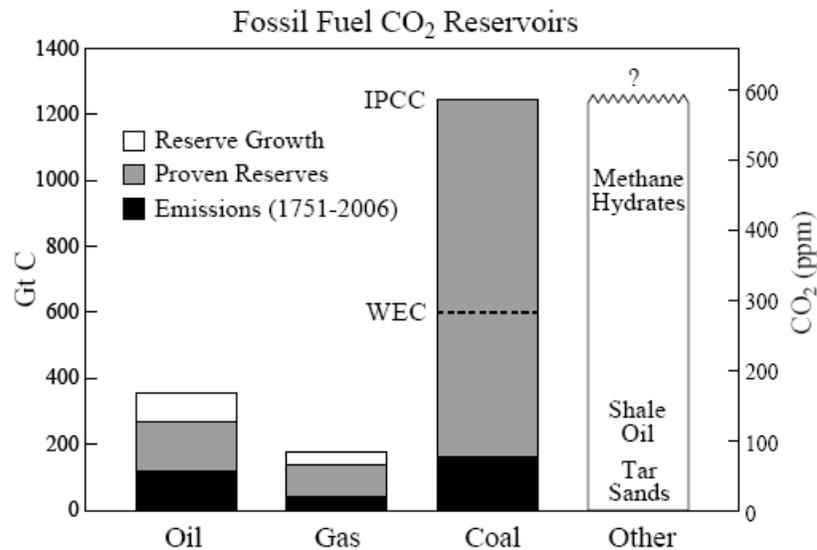


Figure 3. Estimated fossil fuel reserves; purple portions have already been used (Atmos. Chem. Phys. 7, 2287-2312, 2007).

Figure 3 shows reported fossil fuel reserves and resources (estimated undiscovered deposits). Reserves are hotly debated and may be exaggerated, but we know that enough oil and gas remain to take global warming close to, if not into, the realm of dangerous climate effects. Coal and unconventional fossil fuels such as tar shale contain enough carbon to produce a vastly different planet, a more dangerous and desolate planet, from the one on which civilization developed, a planet without Arctic sea ice, with crumbling ice sheets that ensure sea level catastrophes for our children and grandchildren, with shifting climate zones that cause great hardship for the world's poor and drive countless species to extinction, and with intensified hydrologic extremes that cause increased drought and wildfires but also stronger rain, floods, and storms.

Oil and coal uses differ fundamentally. Oil is burned primarily in small sources, in vehicles where it is impractical to capture the CO₂ emissions. Available oil reserves will be exploited eventually, regardless of efficiency standards on vehicles, and the CO₂ will be emitted to the atmosphere. The climate effect of oil is nearly independent of how fast we burn the oil, because much of the CO₂ remains in the air for centuries. [It is nevertheless important to improve efficiency of oil use, because that buys us time to develop technologies and fuels for the post-oil era, and high efficiency surely will be needed in the post-oil era.] However, the point is this: oil will not determine future climate change. Coal will.

Avoiding dangerous atmospheric CO₂ levels requires curtailment of CO₂ emissions from coal. Atmospheric CO₂ can be stabilized by phasing out coal use except where the CO₂ is captured and sequestered, as is feasible at power plants. Indeed, agreement to phase out coal use except where the CO₂ is captured is 80% of the solution to the global warming crisis. Of course, it is a tall order, as coal is now the world's largest source of electrical energy. Over the next few decades those coal plants must be closed or made to capture their CO₂ emissions. Yet it is a doable task. Compare that task, for example, with the efforts and sacrifices that went into World War II.

Responsibility for Global Warming

Responsibility for global warming is proportional to cumulative CO₂ emissions, not to current emission rates (http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_et_al_1.pdf). This is physical fact, not an ethical statement. It is a consequence of the long lifetime of atmospheric CO₂. Responsibility of the United States is more than three times larger than that of any other nation (Figure 4). Despite rapid growth of emissions from China, the United States will continue to be the nation most responsible for climate change for at least the next few decades.

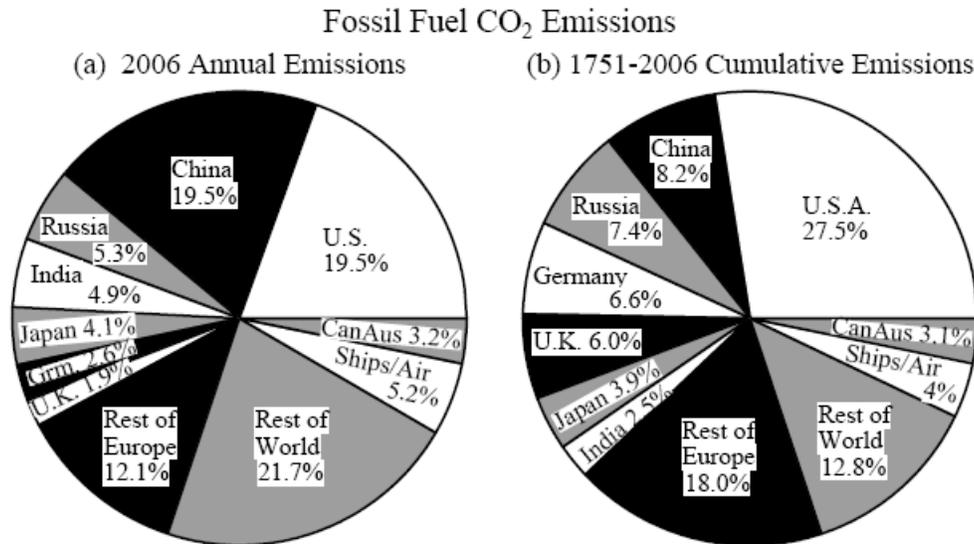


Figure 4. Annual and cumulative fossil fuel CO₂ emissions by country of emission (CDIAC data for 1751-2004, BP for 2005-6; cf. *Atmos. Chem. Phys.* 7, 2287-2312, 2007).

It is also useful to examine per capita fossil fuel CO₂ emissions. Figure 5a shows per capita emissions for the eight nations with largest total emissions, in order of decreasing total emissions. The United States and Canada have the largest per capita emissions, while emissions of Japan, Germany and the United Kingdom are half as large per capita.

Per capita responsibility for climate change, however, must be based on cumulative national emissions. The United Kingdom has the highest cumulative emissions per capita (2006 population), as shown in Figure 5b. The United States is second in per capita emissions and Germany is third. Increased per capita responsibility of the United Kingdom and Germany is a consequence of their early entries into the industrial era. Recognition of these facts is not an attempt to cast blame. Early emissions of CO₂ occurred before the climate problem was recognized and well before it was proven. Yet these facts are worth bearing in mind.

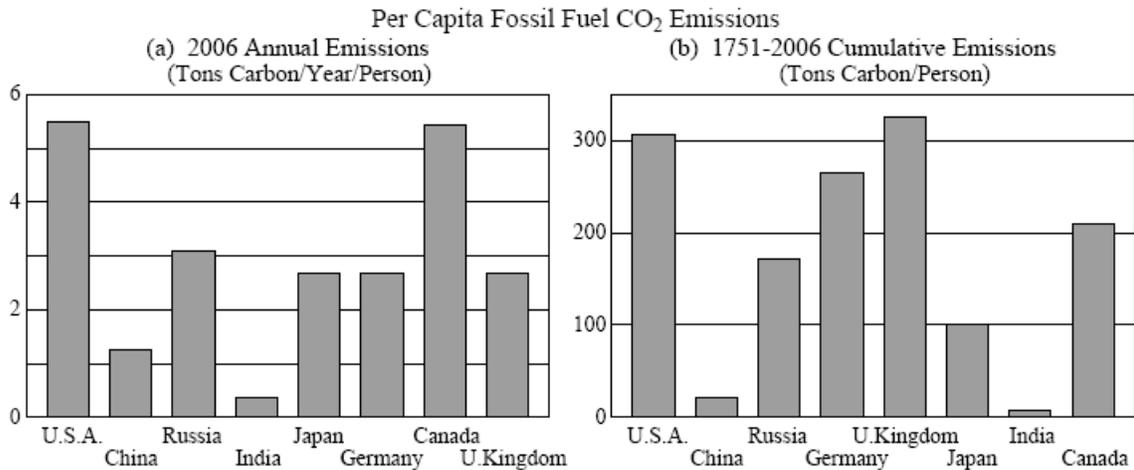


Figure 5. Per capita fossil fuel emissions (a) in order of national emissions today, (b) per capita cumulative emission (2006 population) in order of national cumulative emissions (CDIAC data for 1751-2004, BP for 2005-6; cf. *Atmos. Chem. Phys.* 7, 2287-2312, 2007).

Implications

Human-made climate change is unambiguously underway. Yet the urgency of the situation is not readily apparent to everybody. Chaotic weather fluctuations mask climate trends, even as climate change alters the nature of weather. Urgency is created by the very inertia of the climate system that delays the effects of gases already added to the air. This delay means that there is additional global warming “in the pipeline” due to human-produced gases already in the air.

Climate system inertia is due in part to the massive oceans, four kilometers deep on average, which are slow to warm in response to increasing greenhouse gases. The effect of this inertia is compounded by positive (amplifying) feedbacks, such as melting of ice and snow, which increases absorption of sunlight, engendering more melting. Such feedbacks are not “runaway” processes, but they make climate sensitive to even moderate climate forcings. [A climate forcing, natural or human-made, is an imposed perturbation of the planet’s energy balance. Examples include a change of the sun’s brightness or an increase of long-lived greenhouse gases, which trap the Earth’s heat radiation.]

Climate inertia and positive feedbacks together create the danger of passing climate “tipping points”. A tipping point exists when the climate reaches a point such that no additional forcing is needed to instigate large, relatively rapid climate change and impacts. Impacts of these large climate changes tend to be, overall, detrimental to humans, because civilization is adapted to the relatively stable interglacial period that has existed on our planet for about ten thousand years, and we have settled the land and built great infrastructure within and upon these relatively stable climate zones and coastlines.

Based on current information, we now realize that we have passed or are on the verge of passing several tipping points that pose grave risks for humanity and especially for a large fraction of our fellow species on the planet. This information is gleaned primarily from the Earth’s history and ongoing global observations of rapid climate changes, and to a lesser extent from climate models that help us interpret observed changes.

Potential consequences of passing these tipping points include (1) loss of warm season sea ice in the Arctic and thus increased stress on many polar species, possibly leading to extinctions, (2) increasing rates of disintegration of the West Antarctic and Greenland ice sheets, and thus more rapidly rising sea levels in coming decades, (3) expansion of subtropical climates adversely affecting water availability and human livability in regions such as the American West, the Mediterranean, and large areas in Africa and Australia, (4) reduction of alpine snowpack and water run-off that provides fresh water supplies for hundreds of millions of people in many regions around the world, and (5) increased intensity of the extremes of the hydrologic cycle, including more intense droughts and forest fires, on the one hand, but also heavier rains and greater floods, as well as stronger storms driven by latent heat, including tropical storms, tornados and thunderstorms.

The nearness of these climate tipping points is no cause for despair. On the contrary, the actions that are needed to avert the tipping point problems are not only feasible, they have side benefits that point to a brighter future for life on the planet, with cleaner air and cleaner water. It will be necessary to roll back the airborne amounts of several air pollutants, but that is plausible, given appropriate attention. Already all pollutants except CO₂ are falling at or below the lowest IPCC (Intergovernmental Panel on Climate Change) scenarios, and there is much potential for further reductions.

The tendency of the media to continually report bad news on climate change and the human-made factors that drive climate change sometimes paints a picture that is bleaker than that shown by careful analysis. Such information is often misleading about the true status of the Earth, and the impression created may be harmful if it leads to despair about the prospects for achieving a relatively stable climate with a cleaner atmosphere and ocean. I illustrate with data for CO₂, the most important climate forcing.

Figure 6 is the “airborne.fraction” of fossil fuel CO₂ emissions. This is the ratio: the annual increase of CO₂ that appears in the Earth’s atmosphere (well measured) divided by the annual human emission of fossil fuel CO₂ into the air (also well known). On average, the increase of CO₂ in the air is 57% of the fossil fuel emissions. Although this is a large amount, the 43% taken up by the ocean, soil and biosphere is also large. The uptake is large despite the fact that humans are also causing extensive, mostly unwise, deforestation, which adds CO₂ to the air. In addition our agricultural practices typically do not encourage storage of carbon in the soil.

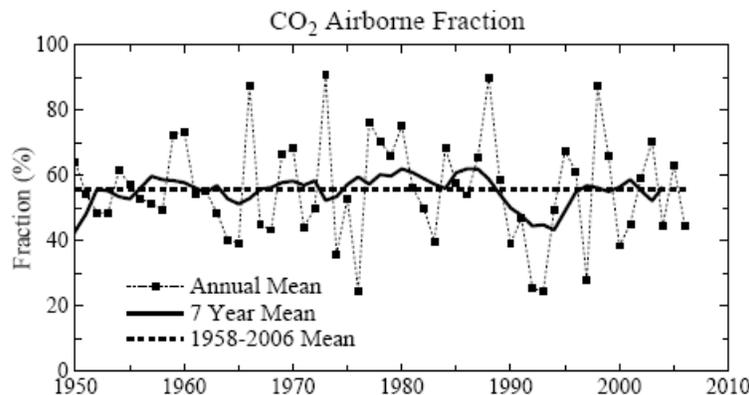


Figure 6. Ratio of observed atmospheric CO₂ increase to fossil fuel CO₂ emissions (Proc. Natl. Acad. Sci. 101, 16109-16114, 2004).

There is tremendous potential for reducing atmospheric CO₂ via reduction of deforestation, improved forestry practices, and improved agricultural practices that increase carbon storage in the soil. If governments were to encourage such practices, rather than the converse, and if coal use were phased out except where the CO₂ is captured, it would be possible to literally roll back the net human-made climate forcing to levels below those defining critical tipping points.

We must remember, at the same time, that the ability of the principal CO₂ sink, the ocean, to soak up human-made emissions is limited and slow (Figure 1). If we burn most of the available coal (Figure 3) without CO₂ capture, even with the lowest estimates of available coal reserves, it will be impractical if not impossible to avoid passing climate tipping points with disastrous consequences.

Summary: The Need for Leadership

I am optimistic that greenhouse gas emissions can be reduced and atmospheric composition stabilized at a level avoiding disastrous climate effects. My optimism is based in part on the fact that young people are beginning to make their voices heard. They have a powerful effect on our consciences, with an ability to influence policy makers and the captains of industry.

Many individuals are beginning to recognize and appreciate the nature of the climate problem. People want to take actions and they are willing to make sacrifices. However, individual actions cannot solve the problem by themselves.

Based on fossil fuel and carbon cycle facts summarized above, we cannot continue to burn the coal reserves without CO₂ capture and sequestration. Solution of this problem can be achieved only via strong government leadership.

Governments must recognize the relative magnitudes of fossil fuel resources, i.e., oil, gas, coal, and unconventional fossil fuels, and they must establish policies that influence consumption in ways consistent with preservation of our climate and life on Earth. The fossil fuel facts dictate essential actions

<http://arxiv.org/ftp/arxiv/papers/0706/0706.3720.pdf>:

(1) Phase-out of coal use that does not capture CO₂. This is 80% of the solution, creating a situation in which CO₂ emissions are declining sharply. (Coal use will also be affected by the second essential action. Indeed, it is likely that much of the coal will be left in the ground, as economic incentives spark innovations and positive feedbacks, accelerating progress to the cleaner world beyond fossil fuels.)

(2) A gradually but continually rising price on carbon emissions. This will ensure that, as oil production inevitably declines, humanity does not behave as a desperate addict, seeking every last drop of oil in the most extreme pristine environments and squeezing oil from tar shale, coal, and other high-carbon sources that would ensure destruction of our climate and most species on the planet. Recognition by industry of a continually rising carbon price (and elimination of fossil fuel subsidies) would drive innovations in energy efficiency, renewable energies, and other energy sources that do not produce greenhouse gases.

These are the two fundamental actions that must occur if we are to roll back the net climate forcing and avoid the dangerous climate tipping points, with their foreseeable consequences. Both of these actions are essential.

We can make a long list of supplementary actions that will be needed to avoid hardships and minimize dislocations as we phase into a cleaner world beyond fossil fuels. However, the two essential actions must be given priority and governments must explain the situation to the public.

Supplementary actions include improved efficiency standards on buildings, vehicles, appliances, etc. Rules must be changed so that utilities profit by encouraging efficiency, rather than selling more energy. These changes are necessary for success, and there are many economic opportunities associated with them. Yet governments must realize the essential actions dictated by the physics of the carbon cycle. Specifically, release of CO₂ to the air from the large carbon reservoirs, coal and unconventional fossil fuels, must be curtailed.

Further actions will be needed to achieve a rollback of the net climate forcing. These actions (<http://arxiv.org/ftp/arxiv/papers/0706/0706.3720.pdf>) include reduction of non-CO₂ climate forcings and improved agricultural and forestry practices. These actions are important and have multiple benefits, especially in developing countries, but they do not have the great urgency of halting construction of new coal plants without carbon capture. Power plants have long lifetimes, and once their CO₂ is released to the air, it is impractical to recover it.

Energy departments, influenced by fossil fuel interests, take it as a God-given fact that we will extract all fossil fuels from the ground and burn them before we move on to other ways of producing usable energy. The public is capable of changing this course dictated by fossil fuel interests, but clear-sighted leadership is needed now if the actions are to be achieved in time.

Tipping points and positive feedbacks exist among people, as well as in the climate system. I believe that the action with the greatest potential to initiate positive feedbacks, and lead to the benefits that will accompany a clean energy future, is a moratorium in the West on new coal-fired power plants unless and until CO₂ capture and sequestration technology is available. Such a moratorium would provide the West with sufficient moral authority to sit down with China and other developing countries to find ways, likely including technological assistance, for developing countries to also phase out coal use that does not capture CO₂.

Perhaps the most important question is this: can we find the leadership to initiate the tipping point among nations? Can we find a country that will place a moratorium on any new coal-fired power plants unless they capture and store the CO₂? Unless this happens soon, there is little hope of avoiding the climate tipping points, with all that implies for life on this planet.