27 March 2008

The Hon Kevin Rudd, MP
Prime Minister of Australia
Australian Parliament
Canberra, Australian Capital Territory, 2600

Dear Prime Minister,

Your leadership is needed on a matter concerning coal-fired power plants and carbon dioxide emission rates in your country, a matter with ramifications for life on our planet, including all species. Prospects for today's children, and especially the world's poor, hinge upon our success in stabilizing climate.

For the sake of identification, I am a United States citizen, director of the NASA Goddard Institute for Space Studies and Adjunct Professor at the Columbia University Earth Institute. I am a member of our National Academy of Sciences, have testified before our Senate and House of Representatives on many occasions, have advised our Vice President and Cabinet members on climate change and its relation to energy requirements, and have received numerous awards including the World Wildlife Fund's Duke of Edinburgh Conservation Medal from Prince Philip.

I write, however, as a private citizen, a resident of Kintnersville, Pennsylvania, USA. I was assisted in composing this letter by colleagues, including Australians, Americans, and Europeans, who commented upon a draft letter. Because of the urgency of the matter, I have not collected signatures, but your advisors will verify the authenticity of the science discussion.

I recognize that for years you have been a strong supporter of aggressive forward-looking actions to mitigate dangerous climate change. Also, since your election as Prime Minister of Australia, your government has been active in pressing the international community to take appropriate actions. We are now at a point that bold leadership is needed, ***leadership that could change the course of human history.***

I have read and commend the Interim Report of Professor Ross Garnaut, submitted to your government. The conclusion that net carbon emissions must be cut to a fraction of current emissions must be stunning and sobering to policy-makers. Yet the science is unambiguous: if we burn most of the fossil fuels, releasing the CO_2 to the air, we will assuredly destroy much of the fabric of life on the planet. Achievement of required near-zero net emissions by mid-century implies a track with substantial cuts of emissions by 2020. Aggressive near-term fostering of

energy efficiency and climate friendly technologies is an imperative for mitigation of the looming climate crisis and optimization of the economic pathway to the eventual clean-energy world.

Global climate is near critical tipping points that could lead to loss of all summer sea ice in the Arctic with detrimental effects on wildlife, initiation of ice sheet disintegration in West Antarctica and Greenland with progressive, unstoppable global sea level rise, shifting of climatic zones with extermination of many animal and plant species, reduction of freshwater supplies for hundreds of millions of people, and a more intense hydrologic cycle with stronger droughts and forest fires, but also heavier rains and floods, and stronger storms driven by latent heat, including tropical storms, tornados and thunderstorms.

Feasible actions now could still point the world onto a course that minimizes climate change. Coal clearly emerges as central to the climate problem from the facts summarized in the attached ***Fossil Fuel Facts****. Coal caused fully half of the fossil fuel increase of carbon dioxide (CO_2) in the air today, and on the long run coal has the potential to be an even greater source of CO_2. Due to the dominant role of coal, solution to global warming must include phase-out of coal except for uses where the CO_2 is captured and sequestered. Failing that, we cannot avoid large climate change, because a substantial fraction of the emitted CO_2 will stay in the air more than 1000 years.*

Yet there are plans for continuing mining of coal, export of coal, and construction of new coal-fired power plants around the world, including in Australia, plants that would have a lifetime of half a century or more. Your leadership in halting these plans could seed a transition that is needed to solve the global warming problem.

Choices among alternative energy sources - renewable energies, energy efficiency, nuclear power, fossil fuels with carbon capture - these are local matters. But decision to phase out coal use unless the CO_2 is captured is a global imperative, if we are to preserve the wonders of nature, our coastlines, and our social and economic well being.

Although coal is the dominant issue, there are many important subsidiary ramifications, including the need for rapid transition from oil-fired energy utilities, industrial facilities and transport systems, to clean (solar, hydrogen, gas, wind, geothermal, hot rocks, tide) energy sources, as well as removal of barriers to increased energy efficiency.

If the West makes a firm commitment to this course, discussion with developing countries can be prompt. Given the potential of technology assistance, realization of adverse impacts of climate change, and leverage and increasing interdependence from global trade, success in cooperation of developed and developing worlds is feasible.

The western world has contributed most to fossil fuel CO_2 in the air today, on a per capita basis. This is not an attempt to cast blame. It only recognizes the reality of the early industrial development in these countries, and points to a responsibility to lead in finding a solution to global warming.

A firm choice to halt building of coal-fired power plants that do not capture CO_2 would be a major step toward solution of the global warming problem. Australia has strong interest in solving the climate problem. Citizens in the United States are stepping up to block one coal plant after another, and major changes can be anticipated after the upcoming national election.

If Australia halted construction of coal-fired power plants that do not capture and sequester the CO_2, it could be a tipping point for the world. There is still time to find that tipping point, but just barely. I hope that you will give these considerations your attention in setting your national policies. You have the potential to influence the future of the planet.

Prime Minister Rudd, we cannot avert our eyes from the basic fossil fuel facts, or the consequences for life on our planet of ignoring these fossil fuel facts. If we continue to build coal-fired power plants without carbon capture, we will lock in future climate disasters associated with passing climate tipping points. We must solve the coal problem now.

For your information, I plan to send a similar letter to the Australian States Premiers.

I commend to you the following Australian climate, paleoclimate and Earth scientists to provide further elaboration of the science reported in my attached paper (Hansen et al., 2008):

Professor Barry Brook, Professor of climate change, University of Adelaide
Dr Andrew Glikson, Australian National University
Professor Janette Lindesay, Australian National University
Dr Graeme Pearman, Monash University
Dr Barrie Pittock, CSIRO
Dr Michael Raupach, CSIRO
Professor Will Steffen, Australian National University

Sincerely,

James E. Hansen
Kintnersville, Pennsylvania
United States of America

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 (CO_2) emissions that remains in the air over time. One-third of the CO_2 is still in the air after 100 years, and one-fifth is still in the air after 1000 years.

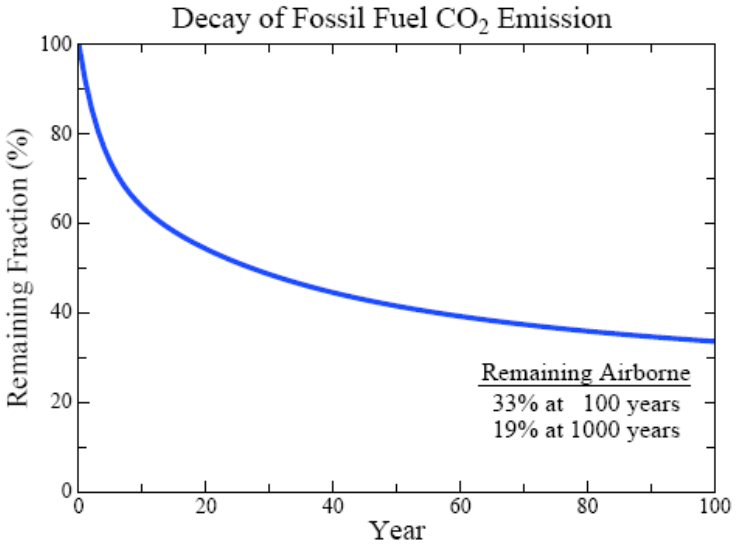

Figure 1. The fraction of CO_2 remaining in the air, after emission by fossil fuel burning, declines rapidly at first, but 1/3 remains in the air after a century and 1/5 after a millennium (Atmos. Chem. Phys. 7, 2287-2312, 2007).

Oil slightly exceeds coal as a source of CO_2 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 CO_2 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.

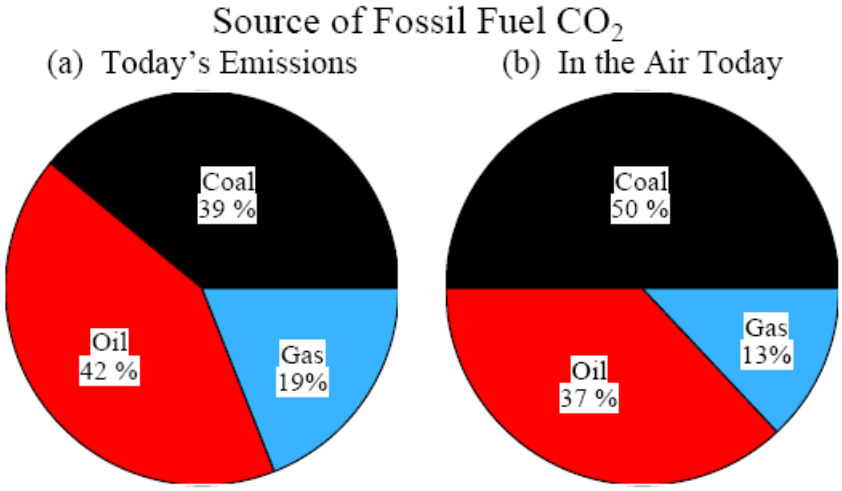

Figure 2. Percent contributions of different fossil fuels to 2006 CO_2 emissions (left side) and contributions to the excess CO_2 in the air today relative to pre-industrial CO_2 amount (CDIAC data for 1751-2004, BP for 2005-6; cf. Atmos. Chem. Phys. 7, 2287-2312, 2007).

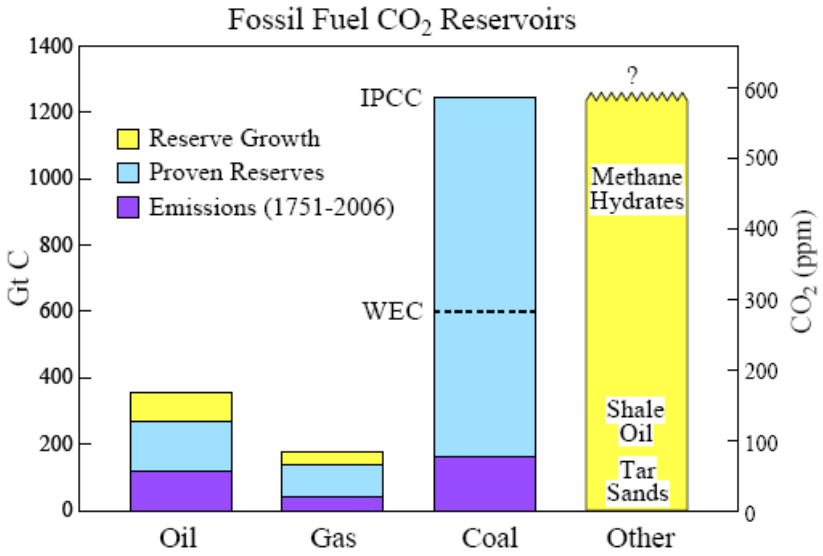

Figure 3. Estimated fossil fuel reserves; purple portions have already been used (Atmos. Chem. Phys. 7, 2287-2312, 2007).

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 CO_2 emissions. Available oil reserves will be exploited eventually, regardless of efficiency standards on vehicles, and the CO_2 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 CO_2 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 CO_2 levels requires curtailment of CO_2 emissions from coal. Atmospheric CO_2 can be stabilized by phasing out coal use except where the CO_2 is captured and sequestered, as is feasible at power plants. Indeed, agreement to phase out coal use except where the CO_2 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 CO_2 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 CO_2 emissions, not to current emission rates (http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_etal_1.pdf). This is physical fact, not an ethical statement. It is a consequence of the long lifetime of atmospheric CO_2. 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.

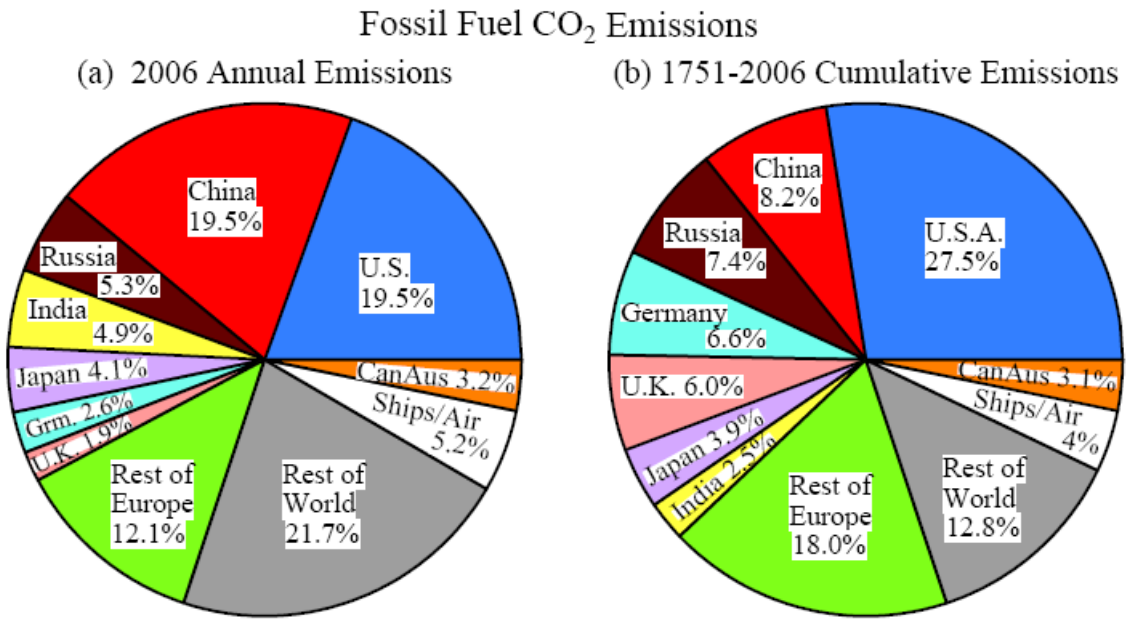

Figure 4. Annual and cumulative fossil fuel CO_2 emissions by country of emission (CDIAC data for 1751-2004, BP for 2005-6; cf. Atmos. Chem. Phys. 7, 2287-2312, 2007).

It is also useful to examine per capita fossil fuel CO_2 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.

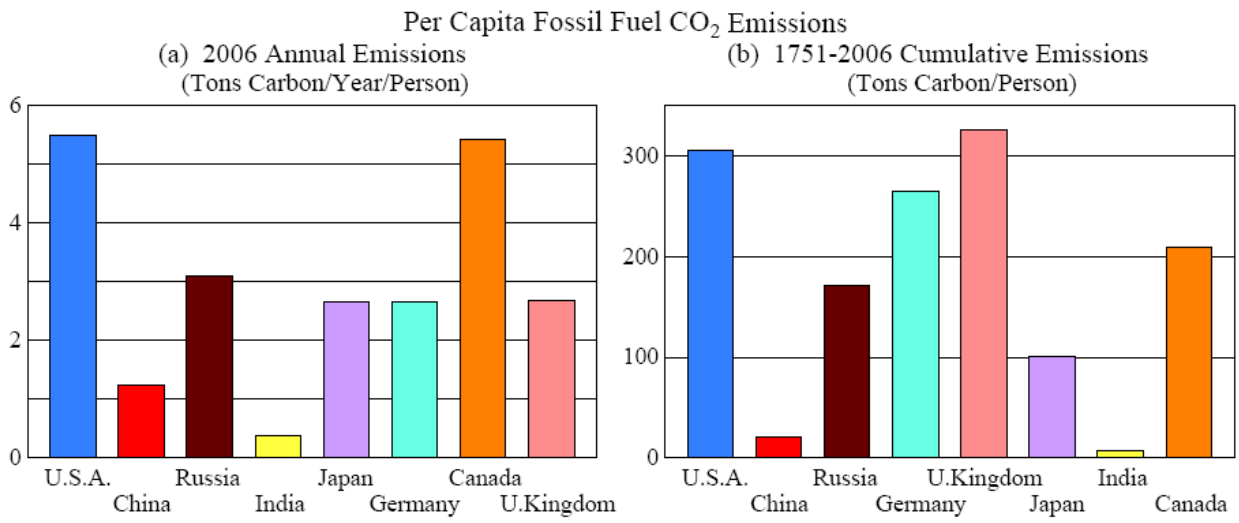

Figure 5. Per capita fossil fuel emissions (a) in order of national emissions today, (b) per capita cumulative emission (2006 population) in order of national cumulative emissions (CDIAC data for 1751-2004, BP for 2005-6; cf. Atmos. Chem. Phys. 7, 2287-2312, 2007).

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 CO_2 occurred before the climate problem was recognized and well before it was proven. Yet these facts are worth bearing in mind.

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 sub-tropical 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 CO_2 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 CO_2, the most important climate forcing.

Figure 6 is the "airborne.fraction" of fossil fuel CO_2 emissions. This is the ratio: the annual increase of CO_2 that appears in the Earth's atmosphere (well measured) divided by the annual human emission of fossil fuel CO_2 into the air (also well known). On average, the increase of CO_2 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 CO_2 to the air. In addition our agricultural practices typically do not encourage storage of carbon in the soil.

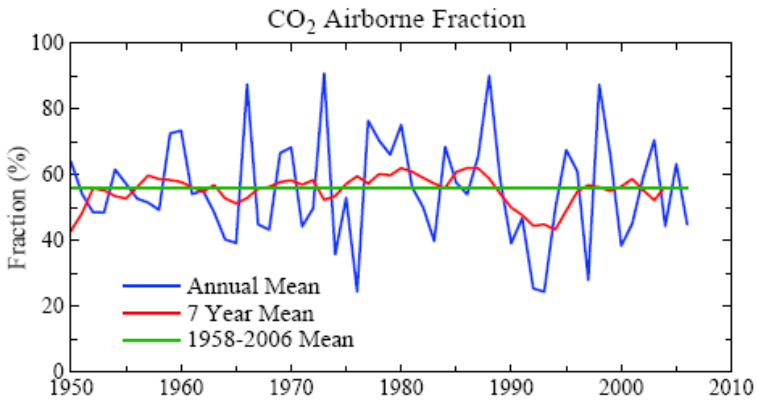

Figure 6. Ratio of observed atmospheric CO_2 increase to fossil fuel CO_2 emissions (Proc. Natl. Acad. Sci. 101, 16109-16114, 2004).

There is tremendous potential for reducing atmospheric CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2. This is 80% of the solution, creating a situation in which CO_2 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 CO_2 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-CO_2 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 CO_2 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 CO_2 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 CO_2.

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 CO_2? Unless this happens soon, there is little hope of avoiding the climate tipping points, with all that implies for life on this planet.