Climate Change: A Catastrophe in Slow Motion

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I. INTRODUCTION

The word catastrophe usually brings to mind phenomena like tsunamis, earthquakes, mudslides, or asteroid impacts—disasters that are over in an instant and have immediately evident dire consequences. The changes in Earth's climate wrought by industrial carbon dioxide emissions do not at first glance seem to fit this mold since they take a century or more for their consequences to fully manifest. However, viewed from the perspective of geological time, human-induced climate change, known more familiarly as "global warming," is a catastrophe equal to nearly any other in our planet's history. Seen by a geologist a million years from now, the era of global warming will probably not seem as consequential as the asteroid impact that killed the dinosaurs. It will, however, appear in the geological record as an event comparable to such major events as the onset or termination of an ice age or the transition to the hot, relatively ice-free climates that prevailed seventy million years ago when dinosaurs roamed the Earth. It will be all the more cataclysmic for having taken place in the span of one or a few centuries, rather than millennia or millions of years.

Humans have become a major geological force with the power to commit future millennia to practically irreversible changes in global conditions. This is what Bill McKibben refers to as "The End of Nature."[1] As an example of the impact life has on global climate, the imminent global warming caused by humans does not stand out as unique or even unusually impressive. When oxygen-generating photosynthetic algae evolved between one and two-and-a half

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1 See William McKibben, *The End of Nature* (Random House 1989).

billion years ago, they changed the composition of one-fifth of the atmosphere, poisoned much of the previous ecosystem, and more or less terminated the dominant role of methane as a greenhouse gas (oxygenation also, to be fair, set the stage for evolution of multi-celled organisms—the animals and plants we know and love). And when plants colonized land half a billion years ago, they vastly increased the rate at which atmospheric carbon dioxide is converted to limestone in the soil, leading to severe global cooling. One hardly wants to contemplate the kind of environmental impact statement that would have to be filed for either of these innovations.

What makes global warming unique in the four billion year history of the planet is that the causative agents—humans—are sentient. We can foresee the consequences of our actions, albeit imperfectly, and we have the power, if not necessarily the will, to change our behavior so as to effectuate a different future. The conjuncture of foresight and unprecedented willful power over the global future thrusts the matter onto the stage where notions of responsibility, culpability, and ethics come into play. The philosopher Hans Jonas finds in this "imperative of responsibility" a need for a fundamentally new formulation of ethics—one that takes greater cognizance of future generations and of the biosphere at large.[2] It is against this backdrop that the foundation of international institutions capable of dealing with the catastrophe of global warming must be seen.

II. UNIQUE PHYSICAL ASPECTS OF THE CLIMATE CHANGE PROBLEM: IMPOSING OUR WILL ON THE NEXT 5000 GENERATIONS

In this section I will review the basic physical features that make global warming fundamentally different from all other pollution problems faced by humans. The problem of ozone destruction by chlorofluorocarbons (the "ozone hole" problem) was a small warm-up act sharing some characteristics with the global warming problem. But because the ozone hole problem was somewhat more limited in scope, and abatement of chlorofluorocarbons did not force society to confront any really difficult economic decisions, it is in a qualitatively different class. Human-induced emissions of several gases other than carbon dioxide also contribute to global warming, but in the long run, carbon dioxide is by far the biggest player and the most embedded in economic activity. I will thus restrict my discussion to this gas alone.

Carbon dioxide is present only in very low concentrations in the atmosphere. Immediately before the beginning of the industrial era, you would

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[2] See Hans Jonas, ***The Imperative of Responsibility*** (Chicago 1985).

have needed to sift through a million molecules of air to find 280 molecules of carbon dioxide. If all of the carbon dioxide in the atmosphere were gathered together into a layer near the ground, the layer would be about two meters deep. Most of us would have to stand on a chair to breathe. It is because there is relatively little carbon dioxide in the atmosphere that human economic activity has the prospect of doubling its concentration within the twenty-first century, with greater increases in sight thereafter. It would be much harder for anything we do to significantly change the atmosphere's oxygen content, which makes up about a fifth of the atmosphere. Despite its low concentration, carbon dioxide plays a key role in determining the Earth's climate because this gas greatly retards the efficiency with which the planet loses energy to space by infrared (heat) radiation. The major constituents of the atmosphere are essentially transparent to infrared radiation. Carbon dioxide warms the Earth in the same way a sleeping bag or down comforter warms a person—by reducing the rate of heat loss. For the Earth, this additional blanketing allows the planet to maintain a higher temperature than would otherwise be possible, given the rate of solar energy input from the Sun.

Water vapor is the other major player in the Earth's energy budget, but its concentration in the atmosphere is buffered on a time scale of weeks by the huge oceanic reservoir of water, which can rapidly evaporate into the atmosphere and equally rapidly rain out. Water vapor thus adjusts in response to other changes in climate (principally temperature); rather than being a prime mover, it is a feedback amplifying other causes of climate change, including carbon dioxide increase. This is why water vapor, though an important greenhouse gas, is not regulated under the Kyoto Protocol[3] or under proposed California state-level climate control regulations.

Carbon dioxide, in contrast, has a very long lifetime in the atmosphere and very weak natural sources; therefore, changes in the rate at which carbon dioxide is put into the atmosphere have great leverage over the atmosphere's carbon dioxide content. Carbon dioxide is implicated in virtually all of the great climate shifts in Earth's history, including the coming and going of the Ice Ages; the eons of warm ice-free states that the dinosaurs lived in some seventy million years ago; the collapse of the Earth into a globally frozen state in the Neoproterozoic era some six hundred million years ago; and the maintenance of conditions favorable to life on the very young Earth, when the Sun was much fainter than it is today. We know from Earth's history that carbon dioxide has an enormous impact on the habitability of our planet, but history also humbles us by revealing major gaps in our understanding of the nature and severity of the

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[3] Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997), 37 ILM (1998).

impact. For a geologist, the idea of doubling the atmosphere's carbon dioxide concentration is outright terrifying, akin to closing one's eyes and spinning a thermostat dial that has not been touched in a long time, and without even the benefit of knowing quite whether it is a gas furnace or a hydrogen bomb at the nether end of the thermostat's wires.

The unique character of the challenge posed by carbon dioxide pollution derives from a triad of properties. First, human-induced emissions of carbon dioxide constitute a huge disturbance of the natural carbon cycle, causing changes in the atmosphere's carbon dioxide concentration that are large and of unprecedented speed in the annals of geological history. In the absence of fossil fuel burning, the natural carbon dioxide level is maintained by volcanic activity, specifically an escape of about five hundred million metric tons of carbon per year into the atmosphere from the Earth's interior. Fossil fuel burning currently puts about fifteen times this amount into the atmosphere annually, and the rate is increasing exponentially. As a result, the atmospheric carbon dioxide level has already increased from its pre-industrial value of 280 molecules per million to a present value of 370 molecules per million, and this level is expected to reach twice the pre-industrial value before the end of the current century.[4] By way of comparison, carbon dioxide concentration during the two million years prior to the industrial era, encompassing the entire history of the human species, had fluctuated between a low of 180 molecules per million during the Ice Ages and a high of about 300 molecules per million during the inter-glacial periods. One has to go back perhaps ten million years to find another time when the carbon dioxide concentration was as high as we will make it during the next century. Looking a little further into the future, fossil fuel burning could quadruple the pre-industrial concentration within four hundred years under a business-as-usual scenario. This is comparable to the values that climate modelers use to reproduce the steamy, ice-free climate of the Cretaceous that existed some seventy million years ago.[5] To turn back the climate clock seventy million years in the course of a few centuries is not a thing to be undertaken lightly.

Second, the expected changes in temperature caused by the increase of carbon dioxide are of a direction and magnitude unprecedented in the past two million years. During that time, the climate has fluctuated from a maximum global mean warmth approximating values prevailing around 1950 to

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4 Houghton, et al, eds, Intergovernmental Panel on Climate Change, Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change ch 3 (Cambridge 2001) (hereinafter Climate Change 2001).

5 Bette L. Otto-Bliesner, Esther C. Brady, and Christine Shields, *Late Cretaceous Ocean: Coupled Simulations with the National Center for Atmospheric Research Climate System Model*, 107 J Geophysical Res (Atmospheres) ACL 11-1 (2002).

temperatures about six degrees colder during the major Ice Ages.[6] Simulations of global mean warming associated with a doubling of carbon dioxide lie in the range of two to four degrees Centigrade,[7] with no guarantee that the higher figure truly represents the worst possible case. At the high end of this range, we are talking about a climate change two-thirds as big as the transition to an ice age but with this important difference: the expected warming would be added on top of the maximum temperatures experienced in the past two million years. Therefore, we have no natural analogues to tell us how the complex web of physical and biological interactions would respond to such a drastic climate change. We are driving into unknown territory, and, given the present imperfect state of physical and especially ecological simulations, with a windshield heavily encrusted with mud.

Third, and most significant, the excess carbon dioxide we put in the atmosphere today is removed exceedingly slowly, meaning that the carbon dioxide we emit in the next half century will alter the climate for millennia to come; even if we wholly ceased using fossil fuels after fifty years, the harm could not be undone. The lifetime of carbon dioxide in the atmosphere is often mistakenly quoted as being on the order of a hundred years; this figure is actually the result of a fallacious and largely meaningless method of aggregating the many physical processes that operate on widely differing time scales into a single number which is supposed to represent the amount of time some extra added carbon dioxide will stay in the atmosphere. The fact is that for each kilogram of carbon dioxide put into the atmosphere today, only a small portion will be rapidly absorbed into the ocean. After five hundred to one thousand years of slow uptake by the ocean, fully a quarter of that kilogram will remain in the atmosphere. A portion of that will be taken up by the ocean over the next ten thousand years by slow processes related to ocean sediments, but fully 7 percent of our initial kilogram will stick around for hundreds of thousands of years.[8] It has been estimated that fossil fuel exploitation could eliminate the natural ice age cycle for the next half-million years, with presently unforeseeable consequences for the storing and catastrophic release of exotic methane-bearing ices in the ocean.[9] The long reach of our actions over the eons gives us unprecedented power over the future, and with that power comes unprecedented responsibility.

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6 Thomas J. Crowley and Gerald North, *Paleoclimatology* 110–32 (Oxford 1991).

7 *Climate Change 2001* at ch 9 (cited in note 4).

8 David Archer, *Fate of Fossil Fuel CO_2 in Geologic Time*, 110 J Geophysical Res C09S05 at 5 (2005).

9 David Archer and Andrey Ganopolski, *A Movable Trigger: Fossil Fuel CO_2 and the Onset of the Next Glaciation*, 6 Geochemistry, Geophysics, and Geosystems Q05003 (2005), available online at <http://www.agu.org/journals/gc> (visited Nov 11, 2005).

An innocuous-sounding two to four degree Centigrade increase in average global temperature carries along with it much larger regional changes in temperature and precipitation, which can in turn have profound consequences. Polar regions warm more than the average, and already, at the present early stage of warming, one-fifth of Arctic summer sea ice has disappeared. Arctic summer ice may be gone in fifty years,[10] which will have dire consequences for polar bears and other marine mammals. The opening of arctic ports and shipping routes may well prove to be a boon for the market economy (as well as a source of political conflict and territorial disputes), but the increasingly intensive exploitation of the area is hardly likely to be good for natural ecosystems. We are learning, too, that land ice can respond more rapidly to climate than previously thought. The Greenland summer melt zone has expanded dramatically and many of the Greenland glaciers are surging into the ocean. At the opposite pole, the Larsen B ice shelf in the Antarctic has collapsed for the first time in ten millennia.[11] The success of the documentary film *March of the Penguins*, a straightforward account of a year in the life of the Antarctic's emperor penguins, is a testament to the deep affinity people feel for these brave creatures. Emperor penguins adapted over millions of years to life on the ice. Their life cycle is intimately tied up with the long inland march along sea ice and shelf ice, undertaken to protect their newborns from oceanic predators. The penguins would struggle mightily to undo ten million years of evolution in a century.

In the tropics, temperature changes little in the normal course of the year. How will the Amazon ecosystem respond to the extensive warming and drying predicted by some models? Warm water holds less oxygen than cold water. Throughout the world, then, global warming will stress sensitive freshwater fish living in shallow streams; coastal saltwater shellfish will likely also be affected by the heat. Agricultural diseases, human diseases, and parasite infestations (including potato blight, bark beetles, West Nile, and malaria) can expand their range with warming. Summer heat waves will become more severe, placing particular stress on places that are already barely tolerable during the summer. Some regions will experience extensive droughts, and if the monsoons should cease, the results will be catastrophic for countries such as India. Also, hurricanes draw their energy from warm water, so the intensity (and perhaps also the number) of hurricanes is likely to increase in the future. There are indications that the expected increase in the destructive power of hurricanes is already

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10 J. Overpeck, et al, *Arctic System on Trajectory to New Seasonally Ice-Free State*, 86 EOS 309, 309 (Transactions of the American Geophysical Union 2005).

11 Paul R. Epstein and James J. McCarthy, *Assessing Climate Stability*, 85 Bull Am Meteorological Soc 1863, 1863–70 (2004).

underway.[12] The impact in low-lying coastal regions may be exacerbated by a sea level rise even greater than currently forecast, if glaciers should prove more responsive to temperature increases than conventionally thought.

Major ocean circulations are also likely to change, with uncertain consequences for the Earth's climate and its oceanic ecosystems. Carbon dioxide becomes an acid when it dissolves in water; the resulting acidification of the ocean will make it harder for coral to form their skeletons. While carbon dioxide in the air acts as a fertilizer for many kinds of plants, meaning that an increase in its concentration could have limited beneficial effects on agricultural plants, this increase could also have adverse and unexpected consequences for land ecosystems (just as dumping phosphate and nitrate fertilizer into the Gulf of Mexico has not proved beneficial for the environment).

In addition, historical evidence shows that the climate system has abrupt switches built into it, and that climate changes in fits and starts rather than along a smooth, gentle curve.[13] Notwithstanding the movie *The Day After Tomorrow*, this does not mean that global warming risks bringing on an ice age. Rather, what we risk is a switch to a climate that has much more dramatic swings in it from one decade to the next, making adaptation much more difficult. The last ten thousand years, which embrace the entire history of civilization, have had an unusually steady climate, and we are uncertain about what it would take to disrupt this happy state of affairs.

Many of the above impacts are in the realm of the possible rather than the probable, and it is presently difficult to say how large such impacts would be, or even how probable they are. However, a cogent case has been made that one should pay more attention to low-risk but potentially catastrophic events, as opposed to the current focus on the "most probable" case.[14] Those who would sneer that such an application of the "precautionary principle" would lead to paralysis are relying on an extreme caricature of the principle that has little resemblance to the way it is used in practice. For example, if one is thinking about driving down a mountain road at night and has faulty headlights, knows that the ravine ahead has a rickety bridge over it, and has heard that there has been a storm that may have washed the bridge away, one would be quite justified in driving slowly or perhaps even postponing the trip, even if it was not known for certain that the bridge had been swept away. No doubt, those who disdain the "precautionary principle" would be quite happy to load their whole family in the car and put the pedal to the floor.

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12 K.A. Emanuel, *Increasing Destructiveness of Tropical Cyclones over the Past 30 Years*, 436 Nature 686, 686–88 (2005).

13 R.B. Alley, et al, *Abrupt Climate Change*, 299 Science 2005, 2005–10 (2003).

14 See Richard Posner, *Catastrophe: Risk and Response* (Oxford 2004); Jonas, *Imperative* (cited in note 2).

The global nature of the climate change problem has some novel policy implications and also creates some opportunities. The atmosphere is well-mixed with regard to carbon dioxide. From the standpoint of climate change, carbon dioxide released in Sydney, Australia is in every regard interchangeable with carbon dioxide released in Beijing, China or Edmonton, Canada. The atmosphere truly is a global commons with respect to carbon dioxide, making emissions trading schemes far more benign than would be the case for pollutants, such as mercury, which have locally lethal impacts. The harm caused by the emission of carbon dioxide in Edmonton is not felt primarily, if at all, in Edmonton. This scenario means that one is confronted with an especially severe form of the free rider problem. A particularly unstable situation is created when a major emitter like the United States perceives (foolishly) that it will suffer minimal harm from the impacts of climate change and perceives (also foolishly) that actions taken to reduce emissions will derail its economy.

Because of the extremely long-term impact of each additional year's carbon dioxide emissions, the calculus of delay is completely changed as compared to other pollution problems. Ordinarily, in the face of uncertainty, a certain amount of delay could be justified; technology improves so as to make abatement cheaper, and one could wait to get a peek at the growing impacts to see just how deleterious they actually are. For many kinds of pollution, bad decisions are, to some extent, reversible. For example, suppose that at some point society has decided that it can no longer afford stringent restrictions on particulate emissions by power plants. It holds to this decision despite the possibility that a rather modest rollback in tax cuts for the wealthy could easily cover the costs. Such a society, in essence, places a higher value on the ability of wealthy individuals to afford new Hummers than it does on the health of children and other vulnerable populations. A future generation with different values may ultimately have to live with the guilt of a large number of preventable deaths of children from asthma and other respiratory ailments. However, a feeling of guilt is all that future generations are burdened with since the adverse impacts will disappear within a few years of action taken by more enlightened leaders. We do not have even this dubious luxury with respect to global warming. If we wait forty or fifty years before taking serious action, the die will have been cast and a thousand generations of our descendants will have to live with the consequences of the climate we bequeathed them.

The problem of long-term consequences is compounded by the long lead time for developing new energy infrastructure and technology and by the long capital life—well over a half century—of newly built electric power plants. Investments being made today, investments that the coming generation will be reluctant to write down, are committing the world economy to another half century of runaway carbon dioxide emissions. We are, in fact, rapidly running out of time to act.

III. FRAMEWORKS FOR DECISION: THE BANKRUPTCY OF COST-BENEFIT ANALYSIS

Analyses of market-based economic impacts of doubling carbon dioxide suggest that losses could amount to perhaps a few percent of the world's gross domestic product ("GDP") annually. If that were the whole story, there would be little cause for alarm. The most comprehensive studies are those carried out by Nordhaus,[15] but the Intergovernmental Panel on Climate Change Second Assessment Report (Working Group III) quotes similar figures for aggregate damage to the market economy.[16] How can it be that the enormous and consequential changes to the Earth wrought by global warming appear to be a matter of at best mild concern when seen through the lens of the typical well-meaning economist's analytical apparatus? An estimate like this coming from the office of Senator Inhofe, or from Bjorn Lomborg, would obviously be suspect, but here we have no case for liberal or conservative bias; Nordhaus was the same economist who concluded that the economic costs of the Second Iraq War could run to nearly a trillion dollars. Rather, what we have is a case of a typical economist's biases with regard to methodology and valuation, and a certain hubris and unsalutary lack of skepticism regarding the precision of the field's tools, both with regard to estimating the economic harm wrought by global warming and the economic cost of abatement.[17] The projected economic harm is low because the world economy is dominated by the developed world and only a small proportion of market traded goods and services in the economies of developed nations are directly affected by climate. Agricultural goods comprise under 1 percent of the United States's GDP, so even if the United States's entire agriculture output were utterly wiped out by global warming, it would amount to hardly a blip in the market-based cost estimates.

One should not draw much comfort from Nordhaus' numbers, though, because of the many factors that have been excluded from the analysis. Some of these factors are left out because they are hard to quantify with current scientific

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15 See generally William D. Nordhaus and Joseph Boyer, *Warming the World* (MIT 2000); Rudiger Dornbusch and James M. Poterba, eds, *Global Warming: Economic Policy Responses* (MIT 1991).

16 J.P. Bruce, et al, eds, *Intergovernmental Panel on Climate Change, Climate Change 1995: Economic and Cross-Cutting Issues. The Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change* ch 9 (Cambridge 1996).

17 To be fair, Nordhaus himself has never oversold the implications of his analysis. It is those, such as Lomborg, who have uncritically quoted his numbers as representing the full impact of global warming, who are at fault. It should also be noted that despite the limitations of his damage analysis, Nordhaus nonetheless concludes that substantial carbon taxes would more than pay for themselves in damage averted. His principal criticism is of the inefficiency of the Kyoto Protocol as a mechanism for buying climate protection, not of the general necessity of taking action to combat global warming.

tools. Such factors include extreme events such as hurricanes, floods, droughts, and heat waves; the spread of agricultural pests and human diseases; large regional changes in temperature and precipitation; abrupt climate changes; and sea level increases that may be larger than expected because of surprises lurking in glacial dynamics.[18] One can imagine the possibility of someday incorporating these factors accurately into a framework like Nordhaus's, even if the present state of the art is not up to the task. This more comprehensive approach would align the estimates more with the considerations that Posner favors, which give weight to the extremes of possible harms, even if such harms may have a small (or unknown) probability of actually occurring.[19]

More troublesome are the problems found at the conceptual foundations of market-based analysis and traditional monetized cost-benefit analysis ("CBA"). Amartya Sen has mounted a polite but ultimately devastating critique of the utility of such analyses in the environmental domain.[20] The basis of Sen's criticism is that the space of social states, and the nature of the valuations of relative desirability of these states, is far too large and complex to be adequately represented by a reduction to the one-dimensional continuum known as money. One aspect of this criticism is the distributional issue. For example, the situation where climate change increases the value of North American agricultural output (by a few percent of US GDP) but reduces the value of Indian agriculture by a similar dollar value (representing perhaps a quarter of India's GDP and half of what Indians eat), does not, as a social state, have equal value to the present situation, and as a matter of social choice is not equally desirable.[21] A related but more general aspect of the CBA problem is the question of additivity. Additions to and withdrawals from a bank account sum up nicely, but more general harms and benefits are not necessarily as conducive to aggregation. A situation with a large harm and an equally large benefit is not equivalent to a social state with neither harm nor benefit. The aggregation of monetized equivalents of environmental benefits and harms ignores this critical insight.

Third, there is the problem of assigning monetary value to things that are not, and probably could not be, traded on any market. This is an important issue

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18 Nordhaus, *Warming the World* at 69–98 (cited in note 14). The damage function used by Nordhaus does make a crude attempt to incorporate some of these effects, but with so little empirical or physical basis as to inspire little confidence.

19 Posner, *Catastrophe* at 3–14 (cited in note 14).

20 Amartya Sen, *Rationality and Freedom* chs 18, 19 (Belknap 2002).

21 In common with other neoclassical economists, Nordhaus optimizes a convex welfare function that assigns more marginal value to change in consumption in poor economies. However, this is used only in the determination of how the world economy adjusts to damage caused by climate. The actual global damages computed from the model are reported as straight linear aggregates, discounted back to the present.

because many of the major effects of global warming involve the disruption of natural ecosystems. How is one to value the survival of polar bears or penguins in the wild? And what about various insects that individuals, on whom valuation surveys are contingent, may never have even heard of, but are creatures that expert ecologists know play some critical role in the ecosystem? Or worse, all those things in the ecosystem that provide some essential ecosystem service of which we are currently unaware? As Sen argues, the assignment of market values to such things involves insurmountable foundational difficulties. He states in conclusion: "The very idea that I treat the prevention of an environmental damage just like buying a private good is itself quite absurd."[22]

Sen's formulation in essence invites a consideration of moral and ethical values when it comes to decision-making concerning the environment, just as Peter Singer's treatment of environmental issues is based on rights and justice rather than costs and benefits.[23] As Sen notes, "The particular variant of cost-benefit approach that is most commonly used now is, in fact, extraordinarily limited, because of its insistence on doing the valuation entirely through an analogy with the market mechanism. This admits only a narrow class of values."[24] In the professedly value-laden Bush administration, no such consideration of moral values is admitted into the judgment of those proposing federal regulations. John Graham, an advocate of rigidly monetized CBA, has been placed at the helm of the Office of Information and Regulatory Management, which was set up as the bottleneck through which all proposed regulations must pass.[25] To take a small but illuminating example, one of Graham's early actions was to block the ban on snowmobiles in Yellowstone National Park on the ground that the benefits were not quantified. In a related decision, Graham demanded a monetized analysis of the health improvements that would result from EPA regulation of the noisy and highly polluting two-stroke spark engines that typically power snowmobiles and jet-skis. But can anybody really believe that the debate over snowmobiles in Yellowstone is about the money to be made from snowmobile tourism versus some fictitious market worth assigned to wildlife?

This perspective misses the point entirely. What is really at stake is the question of the rights of people who wish unrestricted use of the park for motorized tourism versus the rights of people to have places to visit that are undisturbed by urban noise and air pollution. It is the debate about "what is

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22 Sen, *Rationality* at 540 (cited in note 20).

23 See Peter Singer, *One World* 14–50 (Yale 2002).

24 Sen, *Rationality* at 553 (cited in note 20).

25 J. Keiser, *Harvard Professor Shakes up Regulatory Policy*, 294 Science 2277, 2277–78 (2001).

wilderness for?"—just as global warming engages us in a debate about "what is the Earth for?"

Another severe conceptual problem with CBA is the aggregation of intergenerational effects, which is treated by applying a discount rate to future harms. As Singer notes, the concept of a discount rate is of dubious applicability with respect to environmental goods.[26] Unlike computers or washing machines, we tend to value environmental goods more as we become wealthier. Most of us would pay incomparably more to see (or taste) a Moa than could have been imagined by the Maori who decided to eat the last one. Posner, while recognizing the moral ambiguity of discounting, notes that discounting must be used with CBA since otherwise a harm that persists forever yields an infinite cost.[27] However, this fact may actually be telling us that such harms deserve special consideration that CBA cannot give them.

The fallacy of discounting becomes particularly apparent when one tries to discount human life. To take a well-known example, suppose that by an expenditure of $1000 we could either save one life this year or take an action that would prevent the extermination of the entire human race in five hundred years time. At a 5 percent discount rate, the value of ten billion lives discounted to the present over 500 years is the same as the value of one-fourth of a life currently.[28] CBA, then, clearly tells us to save the one person today and let the future take care of itself, even if the action we forego represents a one-time opportunity to save the human race. The situation just described is really not so farfetched in light of the nature of global warming. We have already seen that actions we take in the next century have the possibility of causing major climate changes that could last four hundred thousand years, with unforeseeable and potentially catastrophic consequences for humanity. What does CBA tell us about how much we should care about such long-term impacts?

Let us be generous to CBA and apply only a 1 percent discount rate, and assume that climate changes risk extinguishing ten billion members of the human race after one hundred thousand years. Continuing in the spirit of generosity to CBA, let us put a value of one billion dollars on a human life, far in excess of the value (typically on the order of several million dollars) used in practice. How much should we be willing to spend over the next four centuries to prevent this catastrophe? The answer is unimaginably small; it is so small that the value of a single atom in a single US penny is still unimaginably greater than the amount we should be willing to spend to prevent the far off catastrophe. In fact, to get the correct value that CBA tells us to spend, you would have to take

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26 Singer, *One World* at 25–26 (cited in note 23).

27 Posner, *Catastrophe* at 152–53 (cited in note 14).

28 This figure is calculated by taking 10 billion divided by 1.05, repeated 500 times.

that poor single atom and divide it into ten parts, take a single one of those parts and divide it in 10 again, and repeat the process 363 times, taking only a single one of those unimaginably small parts at the end.

In short, the application of discounting tells us that the fact that global warming can cause potentially dangerous changes in climate lasting over one hundred thousand years is utterly irrelevant to our decision-making.

Proponents of CBA seem to view the appearance of such absurdities as just a matter to be ironed out through minor refinements of the method's technical details. Aristophanes' character Strepsiades would no doubt take a different view, one that I think is the correct one:

> PHEIDIPPIDES: Well, now, Misery Loves Company, they say. So I'll give you some company. I'll horsewhip Mother.
>
> STREPSIADES: You'll *WHAT??? HORSEWHIP YOUR OWN MOTHER?* But this is worse! Ten thousand times worse!
>
> PHEIDIPPIDES: Is that so? And suppose I prove by Sokratic logic the utter propriety of horsewhipping Mother? What would you say to that?
>
> STREPSIADES: What would I *say*?
>
> By god, if you can prove *that*,
> then for all I care, you heel,
> you can take your stinking Logics
> and your Thinkery as well
> with Sokrates inside it,
> and damn well go to hell![29]

The obvious conclusion that an observer unburdened by preconceptions would arrive at is that there is something irreparably broken about the methodology of CBA itself. As Sen concludes, referring to the parsimony of market-based CBA, "[b]ut when the result of that parsimony is to neglect those features of social states to which individuals as citizens would attach importance, the formulation of the problem cannot but be deeply defective."[30]

Society has limited financial resources, so what can be wrong with the notion that one ought to expend the resources where they will accomplish the most good and not fritter them away in meeting pointless requirements? As pursued by the more well-intentioned advocates, cost-benefit analysis has no other goal than this, and it is entirely laudable.[31] These people, however, have been snookered. Cost-benefit analysis is the Marxism of the twenty-first century. The principles of Marxism may sound lofty, but an examination of how Marxist

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29 Aristophanes, The Clouds, in *Four Plays by Aristophanes* 139–40 (Meridian 1994).

30 Sen, *Rationality* at 547 (cited in note 20).

31 See Cass R. Sunstein, *Risk and Reason* (Cambridge 2002) (discussing the benefits of a cost-benefit state).

states operate in practice belies the lofty ideals. Similarly, a look at cost-benefit analysis as actually applied suggests that it is principally a means of denying to progressives the policies that they want enacted. Those wanting peace, quiet, and clean air to breathe while vacationing in Yellowstone have to justify their desires in terms of dollars and cents. Meanwhile the expensive things that powerful (and typically conservative) interest groups desire are never submitted to a cost-benefit test—including the Second Iraq War, tax cuts concentrated on the wealthy, Social Security privatization, ballistic missile defense, development of bunker-busting nuclear weapons, development of a new generation of "suitcase" nuclear weapons, and the trillion dollar push to close a "missile gap" that in fact never existed.[32]

None of my arguments should be construed as meaning that quantitative analysis has no legitimate role in public debate. Numbers matter, and, if anything, we need more of them and better ones—numbers that tell us what our policies really cost and what their effects are in terms of diseases prevented, lives saved, species rescued, and precious ecosystems preserved. When we have imperfect knowledge about consequences that may have low, unquantifiable probabilities but dire effects, these consequences should not be excluded from the analysis, as they too often are. The implication of my criticism is that in cases where substantial out-of-market or long-term effects are at stake, the information in these hard-won numbers should not be discarded through largely meaningless aggregation in cost-benefit analyses. In coming to a judgment on the balancing of values, there is no magic formula that can substitute for the messy apparatus of politics and democracy.

IV. COAL: A STUDY IN INSTITUTIONAL FAILURE

Nowhere is the failure of current institutions more apparent, or the need for new institutional structures more pressing, than in the area of coal-fired electric power plants. Coal is popularly considered the outmoded fuel of the nineteenth century, but it is rapidly becoming the fuel of choice for the twenty-first century and beyond. Figure 1[33] shows that while Europe has had some success in reducing its reliance on coal (through fuel switching, replacement of outmoded East German plants, and some reduction in economic activity in the former East Germany), US coal usage is growing explosively, and has done so through both Republican and Democratic administrations. In the developing world, both Chinese and Indian coal use have grown exponentially. On a per-

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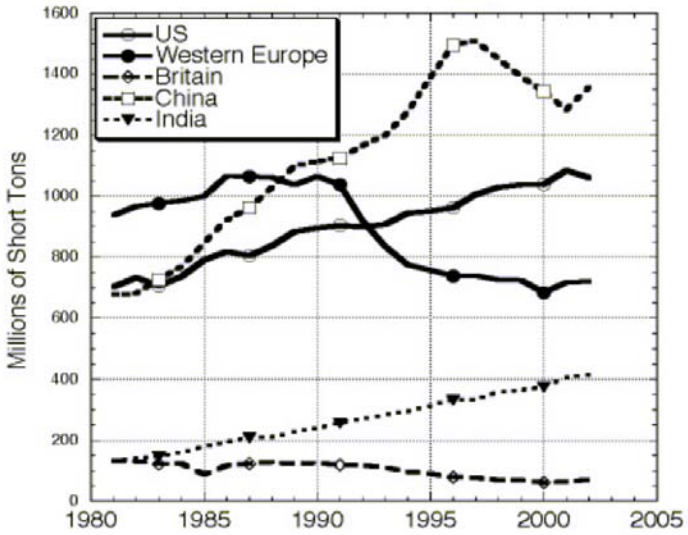
32 The sad tale of the "missile gap" debacle is recounted in Stephen I. Schwartz, ed, *Atomic Audit* 17, 184–95, 294–98, 495 (Brookings 1998).

33 Figure 1 is based on data from the US Energy Information Agency online database, available online at <http://www.eia.doe.gov/emeu/international/coal.html> (visited Nov 11, 2005).

nation basis (though not on a per capita basis), China is now the world's chief coal-burner, though there is a chance that the US may soon overtake it. In the data for China, one can see that the replacement of old coal-fired electric power plants with more modern and relatively efficient plants has decreased coal usage. It remains to be seen whether and when the growth in China's coal usage resumes.

FIGURE 1. ANNUAL COAL USAGE, 1980–2005



Coal is the main threat to climate because there is not enough carbon in conventional oil or natural gas reserves to double the atmosphere's carbon dioxide. We can only double the atmospheric concentration of carbon dioxide through a considerable amount of coal-burning, which is what we seem to be headed toward doing. In fact, it is estimated that potential coal resources are sufficient to enable us not just to double the amount of carbon dioxide in the atmosphere, but to quadruple or nearly octuple the pre-industrial value.[34] With continued reliance on fossil fuels, continued economic growth, and an approach to parity between developing and developed countries, we could easily burn that much coal in two hundred to four hundred years.

Coal is a particularly pernicious fuel because, even burned efficiently, it puts fully a third more carbon dioxide into the air than natural gas for a given amount of energy released. In practice, the figure is even worse than this since the cheapest ways of burning coal waste a large amount of the energy, meaning

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[34] H-H. Rogner, *An Assessment of World Hydrocarbon Resources*, 22 Ann Rev Energy Envir 217, 247, 256–57 (1997).

that yet more coal has to be burned to produce the desired quantity of electricity. Coal is cheap, so there is little incentive to invest capital in its efficient use unless the environmental costs of burning it are somehow internalized. As an environmental problem, oil may take care of itself through rising prices or supply limitations, but coal will not—there is simply too much of it.

The situation is about to become much worse. In China, India, and the US combined, there are currently 850 new coal-fired power plants on the drawing board,[35] and these will annually add some 681 million tons of carbon to the atmosphere in the form of carbon dioxide.[36] By way of comparison, the signatories of the Kyoto Protocol (an agreement that the US declined to sign) will reduce their annual carbon emissions by only 131 million tons if they meet their targets.[37] The 850 planned coal-fired plants almost irrevocably foreclose future opportunities to reduce carbon emissions.

Because of the long lifetime of carbon dioxide in the atmosphere, and because projected business-as-usual emissions in the next fifty years take us a substantial way towards doubling the atmosphere's carbon dioxide, we cannot write off what happens in the next fifty years and hope that the future thereafter provides more benign means of generating power. Yet coal-fired power plants have a capital life well in excess of a half century. For example, the Crawford power plant in Chicago was built in 1958, but it is still running and there are no plans to phase out its operations. What is still more tragic is that investors currently have no incentive to spend the modest additional sums necessary to make coal plants less threatening to future climate. Standard current technology uses pulverized coal, either burned in a subcritical reactor (cheaper and more polluting) or a supercritical reactor (more expensive and less polluting). To meet minimal air pollution requirements, pollutants are scrubbed out from the effluent gas, which is a witches brew of nitrogen oxides, sulfur compounds, particulate soot, mercury, and carbon dioxide. It is essentially impossible to retrofit most current coal-fired power plants to effectively sequester carbon dioxide.

The preferred technology, if one must build coal plants, is Integrated Gasification Combined Cycle ("IGCC"), which first turns the coal into gas, leaving virtually all pollutants behind. IGCC plants can be configured to burn coal in a self-generated pure oxygen stream, resulting in zero emissions of nitrogen oxides and an effluent stream of pure carbon dioxide. These plants can be retrofitted for carbon dioxide sequestration quite cheaply when reliable

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35 Mark Clayton, *New Coal Plants Bury 'Kyoto,'* Christian Sci Monitor, Planet 1 (Dec 23, 2004). The breakdown by country is: 562 in China, 213 in India, and 72 in the US.

36 Id.

37 Id.

sequestration technologies become available. Even without sequestration, IGCC plants produce less carbon dioxide per unit of energy produced since they burn coal more efficiently than pulverized coal plants. In addition, an IGCC plant is not particularly expensive to build; it costs perhaps 10 percent more than a state-of-the-art supercritical pulverized coal plant and maybe 20 percent more than a subcritical plant equipped with scrubbers to meet minimal air pollution requirements. IGCC plants also have the important collateral benefit of producing hardly any conventional pollutants (namely pollutants other than carbon dioxide).

However, hardly any IGCC plants are being built. On the national, state, and local levels, where ample mechanisms exist to foster a more sensible coal policy, the record is outright discouraging. Stringent limits on conventional pollution could help favor IGCC technology. However, the Bush administration is attempting to weaken the Clean Air Act[38] and has gutted New Source Review, the main tool for providing an incentive to shutter old, inefficient coal-fired plants. We should not imagine that a change of regime would miraculously sweep aside the problem, for the political dynamic on the Democratic side offers as much of an impediment to an enlightened coal policy as that on the Republican side. Heavily Democratic Illinois actually spends $20 million per year promoting the use of coal, and when recently faced with a similar-sized shortfall in public transit funding, the state chose to retain the coal promotion program (subsidizing a nineteenth-century industry) and imposed a tax on the twenty-first century software industry. The Democratic governor of Illinois, Rod Blagojevic, has been a heavy promoter of coal, largely because of its appeal to traditional Southern Illinois mining unions and economic development constituencies. The governor's verbiage about "clean coal" has not translated into actual implementation of state-of-the-art technology. His administration recently approved the fifteen thousand megawatt Prairie State Coal Plant, which uses conventional pulverized coal technology and is so filthy that its operations threaten air quality in the Mingo State Wildlife Refuge.[39] Worse, essentially no action is being taken to clean up the nine ancient coal-fired plants owned by Midwest Generation. These plants, which encircle Chicago, are grandfathered

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38 Act of July 14, 1955, 69 Stat 322, codified as amended at 42 USC § 7401 et seq (chapter created was subsequently named the Clean Air Act. Act of Dec 17, 1963, Pub L No 88-206, 77 Stat 392, 401). The attack on this act has been carried out via both regulatory means (new guidelines on the enforcement of New Source Review) and legislative means (promoting the weaker "Clear Skies" bill, S 131, 109th Cong, 1st Sess (Jan 24, 2005), in 151 Cong Rec S 319–48 (Feb 8, 2005), as a replacement of the Act).

39 Michael Hawthorne, *Planned Illinois Coal Plan Could Haze Over Refuge*, Chi Trib CN 1 (Mar 21, 2005).

under the Clean Air Act so that they are not required to meet even the inadequate current pollution standards.

The situation is no more encouraging on the local level. Two of those antiquated coal-fired power plants, Crawford and Fisk, are located within Chicago's city limits, in the struggling Hispanic immigrant neighborhood known as Pilsen/Little-Village. Democratic mayor Richard M. Daley has attempted to position himself as America's "greenest" mayor, and has indeed taken a number of small but worthwhile steps to reduce the city's adverse environmental impact. However, he has been shamefully silent when it comes to these power plants, which surely constitute Chicago's most egregious affront to the environment. These power plants cause severe local and regional health effects,[40] including asthma attacks and premature deaths, which alone would justify cleaning them up. Turning Crawford and Fisk into showcases for modern clean-power technologies would have immediate health benefits, and such actions would also meaningfully contribute to a reduction of Chicago's greenhouse gas emissions. The attempted introduction of the Chicago Clean Power Ordinance by Alderman Edward Burke should have served as a stimulus to action in this direction, but the bill was allowed to languish in City Council. If the will existed, the Mayor and City Council could also exert pressure on the owners of Crawford and Fisk through the imposition of coal excise taxes. On this matter, the Mayor, a man not generally known for timidity,[41] has abdicated leadership.

Any attempts to make coal burning more expensive by internalizing the environmental damage of coal burning and coal mining will favor not only natural gas and renewable energy plants, but also nuclear power plants. This is not an overly adverse consequence. Nuclear power is not without its problems, and much research is needed on three issues: the decommissioning of old power plants, nuclear waste disposal, and fuel cycles that reduce nuclear weapons proliferation. However, solving the problems of nuclear power is arguably more tractable than solving the problems of burning coal safely—especially safely sequestering the highly mobile carbon dioxide that is the inevitable consequence of coal burning.

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40 See Jonathan I. Levy, et al, *Using CALPUFF to Evaluate the Impacts of Power Plant Emissions in Illinois: Model Sensitivity and Implications*, 36 Atmospheric Environ 1063 (2002). But see also Micahel R. Ames, et al, *Comments on: Using CALPUFF to Evaluate the Impacts of Power Plant Emissions in Illinois: Model Sensitivity and Implications*, 36 Atmospheric Environ 2263–65 (2002) (criticizing Levy's model) and Levy, et al, *Authors' Response*, 36 Atmospheric Environ 2267–70 (2002) (responding to Ames's critiques).

41 Mayor Daley's decision to close the Meigs Field airport by a surprise midnight bulldozing raid is testament to the kind of action he is willing to take when an issue is at the top of his agenda. A year after the bulldozing, he described the decision to act as "one of the best" he had made as Mayor. Gary Washburn and Hal Dardick, *Daley Boasts about Closing Meigs; New Group Says Mayor Is a Liar*, Chi Trib C1 (Mar 31, 2004).

V. INTERNATIONAL INSTITUTIONS, REAL AND IMAGINED

Having identified the scope of the problem in the previous sections, I will now consider the international institutions available for dealing with the problem and assess the extent to which these institutions are equal to the task. Before dealing with the more problematic issues, it is worth noting that one role international institutions have served admirably in is that of information brokers. Making the "right" decision (whatever one's criteria) requires a good understanding of consequences of the candidate policies, and determining consequences requires good information. As noted by Hans Jonas, it is the combination of foresight (however imperfect) with the unprecedented scope of the consequences of human action that expands the domain of human endeavors to which ethical considerations apply.[42] If I am thinking about punching somebody, I do not need a panel of experts to determine the physical consequences of my act; prediction of physical consequences is the least part of the consideration of the ethical justification for this type of act, since everyone has a pretty reliable idea of what happens when fist impacts flesh. The situation is quite different if, instead, I am thinking about putting a ton or two of carbon dioxide into the atmosphere. It is here that honest information brokerage becomes critical. The Intergovernmental Panel on Climate Change ("IPCC"), formed in 1988 under the auspices of the United Nations Environment Program, has played a central role in evaluating and interpreting the vast and sometimes arcane scientific literature on climate change. Without actively engaging in either advocacy or policy formulation, the IPCC has been the key player in forming a consensus that action is necessary. The success and integrity of the IPCC process must be cherished and protected. Various other international and national energy agencies have also served as exemplary information brokerages, namely by collating and verifying information on worldwide fossil fuel usage. Such data provide a firm basis for determining the scope of the problem and for monitoring compliance with any future emission targets.

However, there still remains the difficulty of persuading nations to take concrete action based on this information. The international scope of the global warming problem is evident in that all nations share the atmosphere as a global commons for the disposal of carbon dioxide. An international entity addressing this pressing problem must fairly allocate the use of the commons to each nation (along the lines discussed by Singer)[43] and internalize the environmental damage caused by carbon dioxide emissions so as to provide markets an incentive not to

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42 Jonas, *Imperative* at 1–22 (cited in note 2).

43 Singer, *One World* at 26–48 (cited in note 23).

over-utilize the commons. The enterprise inherits all the usual problems of international law stemming from lack of a true police authority; enough parties must be persuaded to sign on, through perception of moral imperative or self-interest, in order to make the agreement work. What is needed is conceptually rather simple: an international agreement creating either a global market in carbon emission rights or a global tax on carbon emissions. In either case, the price of emissions, or tax on emissions, needs to be set high enough to provide a real incentive to invest in more efficient technologies, the sequestration of carbon dioxide, or the use of carbon-free energy sources. The revenue raised by the creation of emission rights, or by a carbon tax, would be ploughed back into the economy to pay for research on carbon abatement technology, and these revenues would be a substitute for other taxes so as to provide the right market signals while being fiscally neutral.

The challenge is not very different from that surmounted by other international treaties that have been successfully negotiated and have performed with varying degrees of success. One can point to treaties covering organophosphate pesticides, world fisheries, whaling, ozone-destroying chemicals, nuclear non-proliferation, and arms limitations. One can also point to international trade agreements (the General Agreement on Trades and Tariffs and the World Trade Organization) as examples where nations have in essence ceded some sovereignty to international adjudicatory organizations because of perceived self-interest. The global warming problem differs chiefly in the scope of the adjustment it demands of societies and in the somewhat abstract, theoretical, and far-off nature of the harms to be averted. The problem is not so much a lack of suitable international institutions as the difficulty of convincing the principal players to sign on. A conspicuous problem, and the primary impediment to progress at present, is the intransigence of the United States in the face of the need to control carbon emissions. If the world's wealthiest nation and greatest emitter of carbon dioxide is unwilling to submit to the rather mild mandatory targets in the Kyoto Protocol—or even the milder targets in the McCain-Lieberman Climate Stewardship Act[44]—there would appear to be little moral basis for persuading the developing world to reduce carbon dioxide emissions. Then, too, the current US administration's demonstrated contempt for international treaties is far from helpful; in the past few years, the US has run roughshod over the Antiballistic Missile Treaty,[45] the Comprehensive Nuclear

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44 S 139, 108th Cong, 1st Sess (Jan 9, 2003), in 149 Cong Rec S 167–73 (Jan 31, 2003) (failed to pass the Senate).

45 Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems (1972), 23 UST 3435 (1973). This treaty went into force Oct 3, 1972, but the US withdrew from the treaty in 2002 in order to pursue development of "Star Wars" ballistic missile defenses.

Test Ban Treaty,[46] the Biological Weapons Treaty,[47] the International Criminal Court,[48] and of course, the Kyoto Protocol itself. International law is an imperfect and fragile vehicle, but it offers the only hope of solving major worldwide problems like global warming. International law is based on respect, cooperation, and a perception of mutual self-interest, so if one of the world's major forces repudiates it, the mechanism is cut off at the knees. The problem of convincing the US and other developed nations to submit to sufficiently stringent carbon taxes is all the more daunting in light of the fact that the reductions called for by the Kyoto Protocol represent a rather small down payment on the degree of carbon reduction that will be needed over the next fifty to one hundred years, if substantial protection of the climate is to be won.

Waiting in the wings is the still more problematic issue of how to involve the developing world—principally China and India—in the effort to control carbon emissions. The central difficulty here is that the developed world has in some sense "colonized" the atmospheric commons in that it has far higher per-capita emissions than the developing world. As Singer notes, a target of strict global parity in per-capita emissions may be inappropriate since this scheme provides no incentives for population control.[49] Nonetheless, achieving some semblance of equity between the developing and developed world dictates that the developed world would have to give up a fair proportion of its property rights (or, more strictly speaking, squatter's rights) in the global atmospheric commons. This may be the just course of action to follow, but nations rarely act against their short-term economic interests merely out of a sense of fairness, however compelling.

Global warming has an intergenerational as well as an international dimension. Solving the problem will require making and abiding by agreements that span decades to centuries. Solving the problem of global warming demands a long-term focus that is not a natural match for the way political institutions operate. Religious institutions are more accustomed to the role of acting as long-

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46 Comprehensive Nuclear Test Ban Treaty, 35 ILM 1439 (1996). This treaty is not currently in force. It was never ratified by the US Senate and the Bush administration is not pursuing ratification. It cannot come into force until all forty countries with nuclear capabilities have ratified it.

47 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (1975), 26 UST 583 (1976). This treaty went into force March 26, 1975, but without any monitoring or enforcement mechanism. At present, the US has abandoned negotiations aimed at strengthening the treaty by adding an enforcement provision.

48 Rome Statute on the International Criminal Court, 37 ILM 999 (1998). This treaty is in force, but without the participation of the US, which was withdrawn from the treaty by the Bush administration.

49 Singer, *One World* at 26–48 (cited in note 23).

term custodians of values, namely by supporting programs over many generations, despite the uncertainty of an ultimate payoff. The mission of halting global warming demands the kind of concerted attention that, over centuries, accomplished the building of Notre Dame in Paris. It is an encouraging sign that the human spirit is, in fact, capable of such accomplishments. One must find some way to bring the same spirit to bear on the problem of climate change. Awareness of the long-term consequences of our present actions engages a new type of intergenerational law that aims to codify the rights of future generations. Notions of rights, justice, and ethics do not automatically derive from utilitarianism, and still less from the extreme, constrained, artificial, and procrustean form of utilitarianism known as "cost-benefit analysis." The starting point must be to acknowledge those rights and to begin a dialogue on defining their scope and reconciling them with the needs of the present generation.

At this point, the problem seems hopeless because it has been framed as a matter of nations giving up a substantial degree of well-being. If it remains so framed, present generations are likely to continue blithely ahead and hope future generations will find some way to live with a vastly altered climate. However, two plans of action can make the outlook less bleak. They share the theme of convincing nations that quality of life can be improved at the same time that economies become less reliant on energy sources that emit carbon. The first plan involves the promotion of technology. It would encourage nations to develop energy efficient measures and renewable energy of all sorts, but would also advocate the expanded use of nuclear energy as an interim solution. Another technological advance endorsed by the plan would be the utilization of IGCC coal plants in conjunction with sequestration of the carbon dioxide effluent. Clean energy offers collateral air quality and health benefits that are already appearing attractive to the ascending economies of environmentally stressed nations like China. Once the world agrees that such a path is desirable, a suitable combination of technology transfer, development subsidies and carbon taxes can be agreed upon by way of implementation. The second plan of action involves lifestyle choices and environmental aesthetics. Gross domestic product is not itself a measure of welfare, but rather a rigorously measurable statistic that is crudely correlated with welfare. It is not a law of nature that human happiness must derive from the consumption of material goods that require a significant amount of energy to produce. One can imagine many societal changes that could improve quality of life while reducing energy usage. Compact urban developments with less sprawl offer a greater sense of community and less lost time to commuting and shuttling children to lessons and activities. High-speed trains are more pleasant than traffic jams or interminable waits in airports. It is not clear that people living in expensively heated McMansions in the barren exurbs are happier than people living in small apartments in Paris and deriving their pleasure from sharing excellent food with a network of close friends. As a

matter of fact, if US citizens lived more like the French, US per capita carbon dioxide emissions would plummet to one-fourth of their present value. To be sure, part of this difference is attributable to France's greater utilization of nuclear power, but the rest is largely a matter of lifestyle choices. Even if China takes a path of development that is more like France than the US, its emissions will rise by a factor of three once it reaches the prosperity of France. This scenario is troubling enough, but not nearly as dire as the one that would arise if the Chinese adopted present US norms as their development path.

As a bridge to a full-scale global carbon taxation and trading regime, the world needs something better than the Kyoto Protocol ("Kyoto"). Kyoto may not be as costly as some of its critics fear, but it is undeniable that it buys little actual climate protection. The main arguments in favor of Kyoto are that it might stimulate appropriate technology development and put the developed world in a better moral position to demand participation of the developing world. An improvement on Kyoto should retain the goal of helping to convince the developing world to sign on eventually, and also the goal of forcing the pace of technology development. However, it should be made more economically efficient by according a central role to emission trading or carbon taxes, and in such a way as to provide the developing world with an incentive to participate. Further, through more involvement of the developing world, the proposed agreement should buy more substantive climate protection than Kyoto does. Coal burning is the most immediate problem; market signals must be put into place very soon to curtail the investment in plants that will lock the Earth into a half century of elevated emissions. Other fossil fuels will soon have adequate price incentives for conservation without any interference. Therefore, finding a way to take tentative steps on redirecting worldwide coal-related investment should be the prime target.

The idea of promoting any kind of coal or nuclear energy will no doubt seem unpalatable to many on the more Green side of the political spectrum. Therefore, I propose the "Coal/Nuclear Covenant," which views coal and nuclear energy as equally necessary evils whose use should be minimized. As part of the covenant, all new coal power plants would use IGCC technology, with carbon dioxide sequestration to the extent that technology allowed. Nuclear plants would be viewed on par with coal plants insofar as they present solvable but currently unsolved problems of a nature comparable to that of carbon dioxide sequestration. Under my proposed covenant, the building of coal and nuclear capacity would be ameliorated by an aggressive conservation and renewable energy program: every five hundred megawatts of power saved by conservation, or produced by new renewable means, would allow one planned coal or nuclear plant to be taken off the books.

The central challenge facing our generation, in its quest to establish a regime that can head off a perilous degree of climate change, is that the difficult

trade-offs must be threshed out in the political forum, but most of the beneficiaries of our policies will have no direct voice in the debate. These unfranchised parties either do not exist (the future generations) or have no ability to assert their interests (the natural ecosystems). Whatever basis in a broader conception of rights may be found, and whatever rights we accord to the future and to the biosphere, it is humans of the present who need to be convinced that action against global warming is necessary. The other affected parties cannot speak for themselves. Like the Lorax,[50] we must speak for the trees.

[50] See Theodor Seuss Geisel ("Dr Seuss"), ***The Lorax*** (Random House 1971).