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Beyond Kyoto

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THE CARBON CHALLENGE

In 1997, more than 180 countries gathered in Kyoto, Japan, in search of a coordinated international response to global warming. The provisional agreement they reached appeared to mark a significant step forward. But the Kyoto Protocol is coming unraveled. Despite nearly a decade of effort, it may not even enter into force as a binding instrument. Canada, Japan, and the European Union—the most enthusiastic advocates of the Kyoto process—are not on track to meet their commitments. And the United States has withdrawn from the agreement entirely. Those concerned with the sustainability of the earth's climate could be forgiven for feeling depressed.

Clear-eyed realism is essential. But dismay, however understandable, is a mistaken reaction. There is scope for a different and more positive view of the last seven years and of the future. First, it has become obvious that Kyoto was simply the starting point of a very long endeavor—comparable, perhaps, to the meetings in 1946 at which a group of 23 countries agreed to reduce tariffs. Those meetings set in motion a process that led to the establishment of the General Agreement on Tariffs and Trade in 1948, which, in turn, led to the creation of the World Trade Organization in the mid-1990s. Second, we have improved, if still imperfect, knowledge of the challenges and uncertainties that climate change presents, as well as a better understanding of the time scales involved. Third, many countries and companies have had experience reducing emissions and have proved that such reductions can be achieved without destroying competitiveness or

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jobs. Fourth, science and technology have advanced on multiple fronts. And finally, public awareness of the issue has grown—not just in the developed world but all around the globe.

Seven years after the Kyoto meeting, it is becoming clear that the reduction of greenhouse gas emissions is a soluble problem, and that the mechanisms for delivering the solutions are within reach. In that spirit of cautious optimism, it is time to move beyond the current Kyoto debate.

KNOWNS AND UNKNOWNS

BEFORE considering new approaches, it is necessary to distill some basic facts from the voluminous, complex, and incomplete scientific work on global warming.

Global temperatures have risen by about 0.6 degrees Celsius since the nineteenth century. Other measures of climate bolster the theory that the world is getting warmer: satellite measurements suggest that spring arrives about a week earlier now than in the late 1970s, for example, and records show that migratory birds fly to higher latitudes earlier in the season and stay later. According to the UN's Intergovernmental Panel on Climate Change (IPCC)—by far the most authoritative body of scientists working on this issue—humans are probably not responsible for all the measured warming. But the trend is undoubtedly due in large part to substantial increases in carbon dioxide emissions from human activity. Since the middle of the nineteenth century, the average concentration of carbon dioxide—a so-called greenhouse gas—in the world's atmosphere has risen from some 280 parts per million (ppm) to around 370 ppm. Burning fossil fuels account for about three-quarters of human emissions, with deforestation and changes in land use (mainly in the tropics) accounting for the rest.

There are two main reasons why it has been hard for societies to tackle climate change. First, carbon dioxide has a very long life span: it exists for hundreds of years in the atmosphere, making this a multigenerational issue. Second, reducing carbon dioxide in the atmosphere can be done only on a truly global basis, since emissions mix throughout the atmosphere much quicker than individual processes can limit their impact.

Beyond these known facts, the picture becomes murkier. For instance, nobody knows how rapidly emissions of carbon dioxide and other greenhouse gases will rise in the future. That outcome depends on the pace of global economic growth and on the impact of technology on the ways society generates and deploys useful energy. Equally, it is impossible to determine precisely how the climate will respond as greenhouse gases accumulate to ever-higher concentrations in the atmosphere. The brightness and altitude of clouds, for example, determine whether warming is amplified or diminished, yet it is not known how exactly climate change will affect cloud patterns. Nor is it known how the world's carbon cycle will respond. A warmer climate might make the planet greener—which would mean more carbon dioxide would be sucked from the atmosphere. Alternatively, climate change might impose such severe stress on the biosphere that nature's processes for removing carbon dioxide from the atmosphere would become less efficient than normal.

The most recent IPCC assessment, published in 2001, concludes that if no precautionary action is taken, carbon dioxide concentrations will rise by 2050 to between 450 and 550 ppm and will continue to increase throughout the twenty-first century. The IPCC estimates that temperatures will rise by between 0.5 degrees Celsius and 2.5 degrees Celsius by 2050, with an increase of 1.4 degrees to 5.8 degrees possible by 2100.

One of the most likely effects of global warming is a rise in sea level, as glaciers melt and warmer water expands in the oceans. The best projections suggest seas of between 5 centimeters and 32 centimeters higher by 2050; the outer limit projected for 2100 approaches one meter. These numbers seem small, but coastlines are shallow slopes, not firm walls, so a rise in water levels of just tens of centimeters would erase kilometers of wetlands and beaches.

Industrialized countries will probably be able to handle rising water levels, at least in the next few decades. London and cities in the Netherlands, for example, already have defenses to hold back surging seas. And farmers in wealthy countries can respond to changes in climate by adjusting irrigation and varying the crops they plant, in many cases with government financial support. But the developing world, home to four-fifths of humanity, is likely to fare considerably worse on both fronts. Hundreds of thousands of people have already been displaced by periodic flooding in Bangladesh, and subsistence farmers—who are far less adaptive than their richer counterparts—are already struggling at the climatic margin.

The most dramatic scenarios, although unlikely, would have grave consequences for humanity and ecosystems. Rapid changes in climate could upset the circulation of the North Atlantic, for example—which, ironically, would cause much colder regional temperatures in northern Europe by weakening the heat-rich Gulf Stream. The Amazon rain forest could deplete dramatically due to drying in the atmosphere, in turn releasing huge volumes of carbon that is stored in trees. And an accelerated rise in sea level from melting ice in Antarctica could occur. These uncertain consequences do not lead to crisp timetables for policy. But they mean that precaution and improvements in measurement and learning will be crucial.

Rapid changes in climate would have grave consequences for humanity and ecosystems.

A sober strategy would ensure that any increase in the world's temperature is limited to between 2 or 3 degrees Celsius above the current level in the long run. Focused on that goal, a growing number of governments and experts have concluded that policy should aim to stabilize concentrations of carbon dioxide in the atmosphere in the range from 500 to 550 ppm over the next century, which is less than twice the pre-industrial level.

On the basis of known technology, the cost of meeting this goal would be high. But the track record of technological progress in other fields indicates an enormous potential for costs to fall as new ideas are developed and applied. In the energy industry, for example, the costs of deep-water oil and gas development have fallen by a factor of three over the last 15 years, dramatically extending the frontier of commercial activity. There is no reason to think that research and development in the area of benign energy systems would be less successful. Predicting where that success might come will not be easy—but that means progress must be made on multiple fronts.

Many people believe that the 500–550 ppm goal would help avoid the worst calamities. But we must recognize this assessment for what it is: a judgment informed by current knowledge, rather than a confirmed conclusion to the story. Taking that judgment as the starting point, the two figures on the following page reveal the magnitude of the task ahead. Figure 1 shows an anticipated projection for emissions from industrialized and developing countries—a "business as usual" pathway that reflects the normal improvements in efficiency, the shift away from carbon-heavy fuels such as coal to carbon-light natural gas, and the expected increase in use of zero-carbon energy sources such as nuclear and wind power. Figure 2 shows the total world emissions from that business-as-usual pathway along with a "path to future stability"—an optimistic but realistic projection of what it will take to stabilize the atmosphere at 500–550 ppm by around 2100. The large gray shaded area is the difference: the wedge of emissions that must be avoided.

Almost every sensible analysis of the effort needed to stabilize carbon dioxide concentration arrives at a hump-shaped trajectory like the path to future stability in Figure 2. In other words, the long-term target of 500–550 ppm is reachable even if levels of emissions continue to rise in the short term—as long as emissions start declining thereafter. (Emissions must be progressively curtailed beyond a certain point because previously emitted carbon dioxide lingers in the atmosphere for hundreds of years.) The implication of Figure 2 is that we still have time to take measured steps. But if we are to avoid having to make dramatic and economically destructive decisions in the future, we must act soon.

EFFICIENCY AND TRANSFORMATION

Both the exact level of the peak in global carbon dioxide emissions over time and the subsequent decline are unknown. We can safely assume, however, that emissions from developing countries will keep rising as economic activity and incomes grow, as shown in Figure 1. This means that leadership must come from the industrialized world.

In the short term, the developed world can use energy much more efficiently and profitably. With a clear impetus for change, business could put new technologies and services to use: cautiously at first, but more aggressively as the best systems are identified and put into practice with the normal turnover of capital.

Figure 1

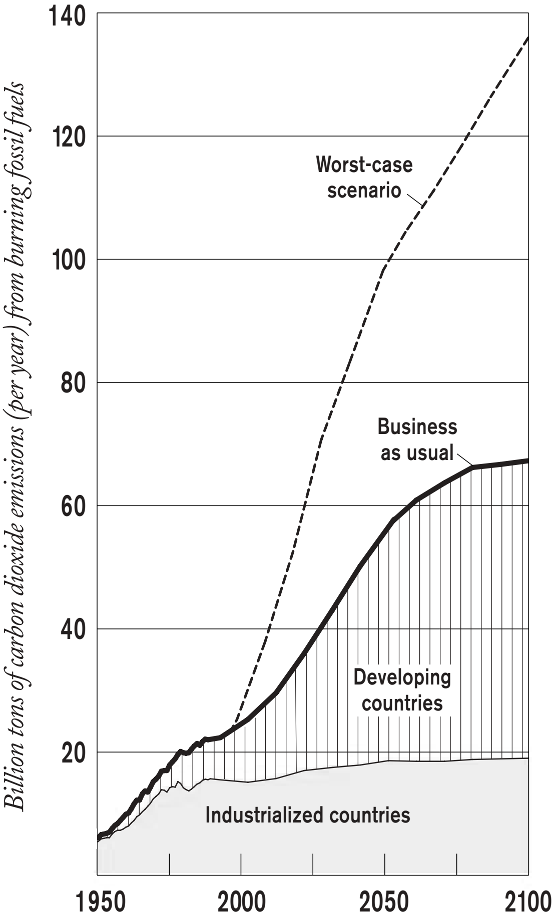

Figure 2

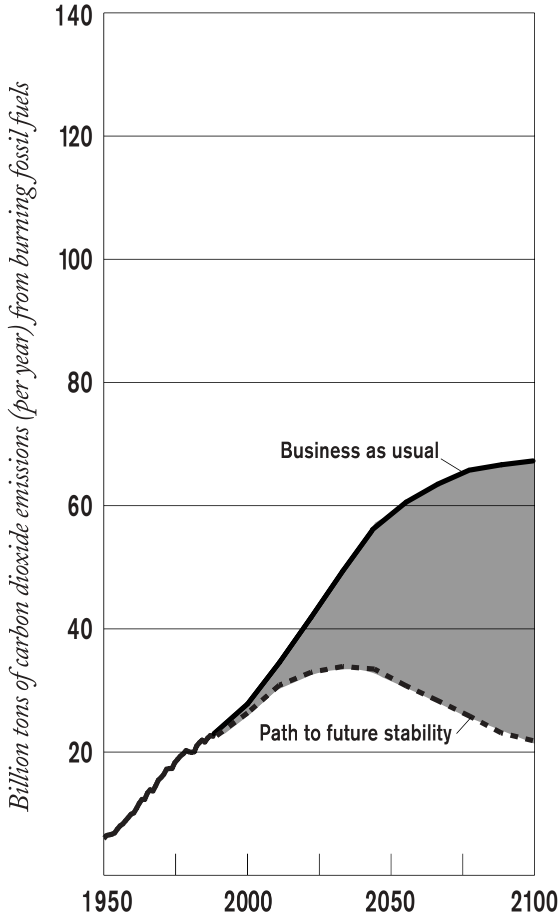

Figure 1: The "business as usual" line shows total global emissions of carbon dioxide since 1950 and the expected volume of emissions up to 2100 in the absence of significant efforts to combat climate change. These data are drawn from the central scenarios in the scientific literature compiled in Nebojsa Nakicenovic et al., eds., *Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2000). The "worst-case scenario" shown in the figure is the highest credible scenario drawn from the same source.

Figure 2: This figure contrasts the business-as-usual scenario from Figure 1 with a "path to future stability"—an optimistic but realistic projection for stabilizing the atmospheric concentration of carbon dioxide at 500–550 ppm beyond 2100. The shaded gray area shows the wedge of emissions that must be avoided. The path to future stability is based on published stabilization scenarios compiled for the IPCC report cited above.

Business has already found that it is possible to reduce emissions from its operations. Counterintuitively, BP found that it was able to reach its initial target of reducing emissions by 10 percent below its 1990 levels without cost. Indeed, the company added around $650 million of shareholder value, because the bulk of the reductions came from the elimination of leaks and waste. Other firms—such as electricity generator Entergy, car manufacturer Toyota, and mining giant Rio Tinto—are having similar experiences. The overwhelming message from these experiments is that efficiency can both pay dividends and reduce emissions.

Yet reducing emissions by the gray area in Figure 2—a reduction that amounts to around 25 billion tons per year in 2050—will require more than just efficiency improvements. Given the world's rising demand for energy, we must also transform the energy system itself, making fuller use of low-carbon fuels as well as carbon-free energy systems. Paradigm shifts must occur across the economy: transportation accounts for 20 percent of total emissions, industry contributes another 20 percent, the domestic and commercial sectors emit around 25 percent, and power-generation accounts for another 35 percent. A wide-ranging set of policies is thus called for.

> Reducing emissions by the necessary amount will require more than just efficiency improvements.

In power generation, options include switching from coal to less-carbon-intensive natural gas. For example, 400 new gas plants, each generating 1,000 megawatts, would reduce emissions by one billion tons per year. Such a reduction would be difficult within the parameters of today's electricity systems—400,000 megawatts is roughly equal to all of China's electric power capacity, or half the installed capacity in the United States. Zero-carbon fuels would also help reduce emissions. If 200,000 megawatts of coal-generated power were to be replaced with nuclear power, carbon dioxide emissions would be reduced by one billion tons per year. Progress on the nuclear front will demand investment in new technologies, as well as a viable plan for locating reactors that ensures that radioactive materials are kept out of the environment and beyond terrorists' reach.

Coal, too, could be made carbon-free, using advanced power plants that gasify the fuel and then generate power while stripping away the carbon for sequestration underground. Coal gasification could become a huge growth industry. China is among the top investors in this technology, not just because these plants are much cleaner, but also because they could be keystones in a program to synthesize clean liquid fuels for transportation needs.

More efficient buildings would also result in large energy savings, since over one-third of today's energy is used indoors. Given that electrification is a central feature of industrial and postindustrial societies, innovators must tap the potential for ultra-efficient electrical appliances. Investment in a digitally controlled power grid could aid this effort by allowing major appliances to "talk" directly with power generators so that the whole system operates closer to its optimum potential. Such a "smart grid" would reduce losses in electricity transmission while also allowing fuller use of waste heat from power generators in factories and homes.

There are efficiency savings to be made in transportation too. Given the massive advantages of gasoline over rival fuels—both in terms of its power density and its ease of storage—transport is unlikely to switch to new fuels in the near future. More promising approaches will focus on making transportation more efficient, while meeting the ever-stricter limits on other emissions that cause air pollution. For example, running 600 million diesel or gasoline cars at 60 miles per gallon (mpg) instead of 30 mpg would result in a billion fewer tons of carbon dioxide per year. Advanced ultra-efficient diesel engines, meanwhile, are so clean that even the strictest regulatory body in the world—the California Air Resources Board—is taking a second look. Advanced techniques for gasoline injection also hold promise, as do hybrid electric-gasoline cars already on the road. Such vehicles have the potential to get more than twice the mileage per gallon of their conventional counterparts. Given the increasing consumer demand for speed and flexibility in air travel, policymakers should also focus on the opportunities for cutting emissions from aircraft.

All of these efforts will require major investments. Some will also require new infrastructures. But we must begin to build and test such systems. Only with evidence from actual experience can we decide how best to direct our efforts.

DOWN TO BUSINESS

The role of business is to transform possibilities into reality. And that means being practical, undertaking focused research, and testing the different possibilities in real commercial markets. The energy business is now global, which offers a tremendous advantage: international companies access knowledge around the world and apply it quickly throughout their operations.

But the business sector cannot succeed in isolation. Harnessing business potential requires fair and credible incentives to drive the process of innovation and change. In responding to global warming, that role must fall to the government. Neither prescriptive regulations nor fiscal interventions designed to collect revenue rather than to alter behavior provide the answer. Rather, governments must identify meaningful objectives and encourage the business sector to attain them by using its knowledge of technology, markets, and consumer preferences.

Recent experience suggests that emissions trading regimes—whereby government sets a binding cap on total emissions, dividing the total into "emission credits" that are given to those who emit carbon dioxide—are the best policy for encouraging business. Policymakers (notably in the United States) have demonstrated that it is possible to design such systems for other pollutants, such as sulphur dioxide, thereby harnessing the power of innovation and the flexibility of the market to protect the environment, while avoiding crippling costs. The same insights should apply to carbon dioxide. A well-designed trading regime would include a strictly enforced cap, which would make carbon dioxide emission credits scarcer (and thus more valuable) and would thereby increase the incentive for business to control emissions. Such a system would also allow firms and households the flexibility to apply resources where they have the greatest impact, which is essential, because the best measures for controlling carbon dioxide are hard to anticipate with precision and are widely dispersed across the economy. And a credible emission trading system would create incentives to invest in radical new technologies, the kind that will be crucial in building a carbon-free energy system in the future.

Emissions trading systems need not be identical in every country, nor be applied universally from day one. The political reality is that we are unlikely to see the sudden emergence of a single regime; in scope and ambition, that would be comparable to the emergence of a single global currency. Instead, progress is much more likely to come through the gradual process of knitting together diverse national and regional efforts on the basis of their track records of experience and achievement. The key task today is to find practices that will lead to a system that will enable today's diverse and fragmented reduction efforts to be valued on a common basis. The history of trade liberalization over the second half of the twentieth century shows that gradualism can yield impressive results.

Engaging business requires fair and credible incentives to drive the process of innovation and change.

At present, the nascent European emission trading system—which will start running on a trial basis in 2005—is the most advanced example. Built on sound monitoring and verification policies, the system is the centerpiece of the European effort to implement the commitments adopted at Kyoto. Yet there are still hurdles to be cleared if it is to be fully operational by 2008, as planned. The process for allocating emission credits is not yet complete. And the system will cover only about 40 percent of Europe's emissions as it stands—mainly those from industry. The potential for extending the scope of the trading base is indeed considerable, not least through the incorporation of effective incentives that will reward businesses whose investments reduce emissions outside Europe, such as in Russia and the emerging market economies of Asia—where large and relatively low-cost reductions of emissions are possible.

Markets are emerging in other regions as well. The Chicago Climate Exchange, opened in December 2003, involves 19 North American entities that have agreed to reduce their emissions by one percent per year over four years. Canada may yet create a market for carbon dioxide as it aims to meet the Kyoto targets. And U.S. states have become laboratories for innovation and change. For example, Massachusetts, New York, and New Hampshire are adopting rules that will spur the creation of market-based emission trading systems. Voluntary systems for measuring emissions—such as one being crafted in California—may also provide further foundations for emission trading. There is a strong argument for linking these efforts. U.S. policymakers should also consider establishing a transatlantic partnership to work toward a common market-based trading system.

Offering positive incentives is one key contribution that government can make to stimulate business. Another is organizing research. It is crucial to extend our understanding of the science of climate change: monitoring key variables with sufficient precision to understand both natural variability and the climate's response to human activity. A key target of such work must be to understand the precise connection between the concentration of carbon dioxide in the atmosphere and changes in climate. Such research must also advance our knowledge of available choices: with the clock ticking, we cannot wait for definite answers before we take action.

Government intervention must take other forms too. Transforming the energy system will require new technologies with risks that will be too high (and benefits too remote) for private firms to provide all the needed investment. This is one area in which the United States, with its outstanding technical capacity, should take a leadership role. Innovation will require an across-the-board infusion of resources for basic science and technology, as well as the development of a portfolio of key demonstration projects. The priorities for such work might include photovoltaic cells (which convert sunlight into electricity), fission reactor technology, energy from biomass, and the use of hydrogen.

Given the costs and risks involved in such investment, governments with common interests and common views of the future have every incentive to combine their efforts and resources. Fortunately, there are many precedents of international partnerships in innovation—from high-energy physics to astronomy and nuclear fusion. The global warming challenge is different, in that it involves not only basic science but also the application of novel techniques through products that must withstand the test of competition. But that is why the program of research and development work should involve collaboration not just between different countries but also between governments and business.

There are examples of such collaborative work already underway. In November 2003, a ministerial-level meeting held in Washington, D.C., began the process of building international partnerships for research on the potential of the hydrogen economy. The United

States has already pledged $1.7 billion over the next five years for work in this area. A similar collaboration—the International Carbon Sequestration Leadership Forum—is built around the concept of capturing carbon and storing it geologically. Again, this scheme complements programs in the United States, such as FutureGen, a $1 billion public-private partnership to promote emissions-free coal-fired electricity and hydrogen production. These research efforts are a good start, but they must go hand-in-hand with the creation of credible caps on emissions and trading systems, which will create the incentives to transform the energy system.

DEVELOPING SOLUTIONS

It would be morally wrong and politically futile to expect countries struggling to achieve basic levels of development to abandon their aspirations to grow and to improve their people's living standards. But it would be equally wrong to ignore the fact that by 2025, energy-related carbon dioxide emissions from developing countries are likely to exceed those from the member states of the Organization of Economic Cooperation and Development. Instead of being daunted by the scale of this challenge, policymakers must recognize the scale of the opportunity: developing countries have the potential to leapfrog the developed world's process of industrialization, thereby providing an enormous opportunity to improve energy efficiency and reduce emissions.

So far, most international efforts to engage developing countries have focused on the Kyoto Protocol's Clean Development Mechanism (CDM)—a scheme that would encourage investment by awarding emission credits for the quantity of emission reductions flowing from a particular project. In principle, the CDM was a good idea. In practice, it has become tangled in red tape and has required governments and investors to do the impossible: estimate the level of emissions that would have occurred in the absence of a project and then to calculate the marginal effect of their actions. The only projects that can meet this test are small and discrete: a steel mill that uses sustainably grown wood instead of coal for coke, for example, or a tiny hydroelectric dam that averts the need to build a coal-fired power plant. Such efforts are important, but they are hardly the stuff of radical transformation.

There is no neat, off-the-shelf solution for engaging the developing world. But there are encouraging signs of the process of economic development acting as a force for modernization. In China and India, infrastructure necessary to substitute natural gas for coal is already being put in place. And in many of the oil-producing regions of the world, the spread of international technology is making it possible to capture and reinject the natural gas that is often associated with oil, rather than venting or flaring it into the atmosphere. Efforts to change the incentives that govern land use in the developing world are also encouraging. From the Congo Basin to the Amazon and the forests of Southeast Asia, practical partnerships of governments, nongovernmental organizations, and businesses are showing the way. Small amounts of money and skillfully designed incentives are stemming the tide of deforestation by creating a stake in protecting the forests.

These and other efforts reflect the determination of publics, governments, and business to transcend the harsh and unacceptable trade-off between the desire to improve living standards and allow people the freedom to use energy for heat, light, and mobility on the one hand, and the desire for a clean environment on the other.

UNFINISHED BUSINESS

The appropriate response to the faltering Kyoto Protocol is neither dismay nor fatalism. A complete international agreement on a subject of such complexity and uncertainty is still a long way off. But as those who championed the cause of liberal trade found after that first meeting in 1946, great causes acquire lives of their own. Consolidated political agreements often follow, rather than lead, the realities on the ground.

Taking small steps never feels entirely satisfactory. Nor does taking action without complete scientific knowledge. But certainty and perfection have never figured prominently in the story of human progress. Business, in particular, is accustomed to making decisions in conditions of considerable uncertainty, applying its experience and skills to areas of activity where much is unknown. That is why it will have a vital role in meeting the challenge of climate change—and why the contribution it is already making is so encouraging.