The Timing of Climate Change Policy

Over the past several decades, the scientific community has arrived at a consensus that the earth's climate is being changed by human influences, most importantly the release of carbon dioxide (CO_2) and other "greenhouse gases" (GHGs) into the atmosphere. The most recent estimates by the Intergovernmental Panel on Climate Change (IPCC) indicate that, under a "business as usual" scenario, the average global temperature will rise 2.5 to 10.4 degrees Fahrenheit by the end of the 21st century.[1] This is a significant change: the high end of this range is equal to the change in the average global temperature associated with the end of the planet's last ice age, 10,000 years ago. But, during that ice age, it took thousands of years to reach this level of warming — not just one century.

The virtual certainty that human influences are causing these significant changes in our climate naturally leads to the questions of what actions to take and when to take them. A previous Pew Center domestic policy brief, entitled *The U.S. Domestic Response to Climate Change: Key Elements of a Prospective Program*, evaluates possible policy approaches.

This "In Brief" addresses the timing of action to reduce GHG emissions. In October 2001, the Pew Center on Global Climate Change held a workshop inviting leading scientists, economists, and other analysts to discuss this question.[2] The Workshop on the Timing of Climate Change Policies revealed a consensus that action to address global climate change must *begin now* if it is to be effective. An immediate signal that initiates action is required in order to provide a smooth and cost-effective transition to a stable concentration of GHGs in the atmosphere — a challenge that will take decades, if not generations, to meet. Workshop participants identified many compelling reasons to begin taking action now, including:

- **The reality that current atmospheric concentrations of CO_2 have not been exceeded during the past 420,000 years (the period for which ice core data are available) and will soon exceed a doubling of pre-industrial levels resulting in a situation unprecedented in human history with unknown consequences;**
- **The potential for catastrophes that defy the assumption that damages resulting from climate change will be incremental, smooth, and linear;**
- **The risk of irreversible environmental impacts (as compared to the lesser risk of unnecessary investment in GHG reduction or mitigation);**
- **The need to learn about the pace at which society can begin a transition to a climate-stable economy;**
- **The likelihood of imposing unconscionable burdens and impossible tasks on future generations;**
- **The need to create incentives to accelerate technological development that will allow us to address the climate change problem; and**
- **The ready availability of "no regrets" policies that have very low or even no costs to the economy.**

This *In Brief* explores the points outlined above.

Beyond a "Doubling"

When carbon dioxide or other GHGs are emitted into the atmosphere, they remain there for a period ranging from years to centuries, and in some cases even millennia, before being removed through natural processes. Increasingly over the past century, human activities have resulted in the release of GHGs at rates faster than they can be removed. The resulting accumulation of GHGs in the atmosphere determines, in large part, the severity of changes in the earth's climate.

The average concentration of CO_2 in the atmosphere during pre-industrial times was about 270 parts per million (ppm), and it is about 370 ppm today. Most analyses of the damages that might result from climate change assume that atmospheric concentrations of CO_2 will be twice pre-industrial levels. Under the IPCC's 2001 "business as usual" emissions scenario, continuing on our current emissions path will produce concentrations of 550 ppm by 2060. However, given current emissions trends, it will be extraordinarily difficult to stabilize CO_2 concentrations at a mere doubling. Emissions would have to decline 60 to 80 percent by 2100 — and potentially decrease further in the future — in order to stabilize CO_2 concentrations at twice pre-industrial levels.

Thus, even if immediate steps are taken to limit emissions, the atmosphere's CO_2 concentration could move beyond a "doubling" to as much as a "tripling" by the end of the 21st century. This buildup will occur not only because of steady increases in CO_2 and other GHG emissions, but because the planet's most effective mechanisms for absorbing CO_2 (i.e., through carbon "sinks" that absorb and store CO_2, such as the upper ocean or forests) will become saturated.

A tripling of global atmospheric CO_2 concentrations is likely to have much more severe consequences for climate than those estimated for a doubling — from temperature increases to changes in patterns of severe weather to a centuries-long rise in global sea level. In fact, climate scientists are only beginning to consider the magnitude of impacts associated with CO_2 concentrations beyond a doubling, and remain limited in their abilities to predict the consequences with confidence.[3]

Thus, perhaps the most pressing reason to begin acting now to address climate change is that, in simplest terms, we are entering unknown climate territory. We are in danger of irreversibly causing climate change that we are only beginning to understand and that is far beyond what we have experienced to date.

The Prospect of Catastrophe

Most depictions of climate change impacts are linear and gradual, meaning that incremental changes in the environment are assumed to occur with incremental changes in climate. In most simulations of the problem, CO_2 concentrations in the atmosphere slowly rise over time; the climate system is assumed to respond like a dial that is being slowly turned up over time. This gradual change in temperature presumably yields gradual shifts in ecosystems, increases in sea levels, etc.

However, there is evidence that certain aspects of the climate system work more like a switch than a dial, and that a threshold level of warming could trigger sudden changes in the planet that would have dramatic, catastrophic consequences.[4] One example of such a change is the potential weakening or collapse of the North Atlantic Ocean's "thermohaline circulation," the ocean circulation that produces the Gulf Stream current and allows temperatures in Western Europe to rise to higher levels than those of other places of comparable latitude. This process is stable as long as sea surface temperatures remain below a critical threshold. However, climate change could gradually raise sea-surface temperatures above this threshold, resulting in the rapid destabalization of thermohaline circulation, with significant consequences to climate in the North Atlantic region. Another example of a catastrophic event that could be triggered by climate change is the potential break-up of the West Antarctic ice sheet, which would take centuries to occur but could result in catastrophic sea-level rise.

The possibility of these non-linear catastrophic events defies the way computer models traditionally have depicted climate change. Assuming these events are possible, as described in the IPCC's Third Assessment Report,[5] the benefits associated with immediate action are far greater than models using "smooth" or linear damage functions would suggest. *Immediate action offers us the best chance of avoiding the possibility of catastrophic changes in the world's climate.*

Addressing Uncertainty

Despite significant gains in scientists' understanding of climate change, significant uncertainties remain. For example, climate models cannot simulate the vast complexity of the climate system with perfection, and are based on uncertain assumptions regarding future GHG emissions. Furthermore, while climate models can make reliable projections about change in the average global climate, their projections about change in regional climate are less reliable.

Substantial uncertainty exists regarding the economic aspects of climate change as well. Some of the differences among the results of various economic models reflect differences in the structure and assumptions of those models.[6] Furthermore, the cost of limiting carbon emissions will depend on hard-to-predict factors such as how quickly technology responds or how effectively firms pursue low-cost carbon reductions around the world (perhaps through a process known as *emissions trading*).[7]

Uncertainty is sometimes cited as a reason to delay action on climate change: Why take immediate steps to reduce emissions if climate change might have only minor consequences for human societies? Economists speak of "irreversibility" — the risk that we might bear a cost that cannot be reversed. For example, society could require firms to reduce GHG emissions and subsequently learn that climate damages were less severe than imagined. Some of society's resources will have been irreversibly "sunk" into unwarranted abatement activities. Many economic models focus only on this type of irreversibility when analyzing climate change policy. Because virtually all GHGs have longer decay rates than physical capital, atmospheric GHG loadings are effectively irreversible as well. Ignoring this second irreversibility may lead us to defer action on climate change when such action is warranted.[8]

Thus, uncertainty is as much a reason to act as it is to delay — if not more so. This is particularly true in light of the economy's ongoing investment in new plants and equipment, which are usually very long-lived. Delaying action on climate raises the risk that these new investments will have to be retired or modified later at great cost once climate policies are enacted, which is another type of irreversible risk.

Given what we do know about climate change, uncertainty speaks to the need to take steps now. Delaying action may stop us from taking potentially unwarranted action, but it could preclude necessary and cost-effective actions, thus exacerbating the climate challenge and leading firms to make investments that will be obsolete under a future climate policy regime.

Sequential Decisionmaking

Given the uncertainties regarding the actual magnitude of climate change, the damages climate change will cause, and the cost of addressing those damages, it is likely that any climate policy will evolve over time, with new targets and measures replacing old ones, as we learn more about the nature of climate damages and gain experience with the costs of various approaches to reducing emissions.

An important reason to begin taking action now, therefore, is to begin learning about these uncertainties. For example, imposing immediate, moderate restrictions on CO_2 emissions would allow us to observe the costs of doing so and, in turn, gain insights into how quickly and at what cost the economy could abate emissions. Taking reasonable steps now, therefore, would allow us to learn about the costs of emissions reduction and give us a better idea of what it will take to address this pressing problem.[9]

Beginning now allows the economy a longer time to adjust. In particular, it sends firms and consumers the message that changes are coming and gives them time to anticipate the changes. Providing a "pre-announcement" — advance warning — about climate policy, in one economic experiment, reduced economic costs by as much as 40 percent.[10] *Thus, taking immediate steps to announce a climate policy that phases in GHG reductions over time and promptly pre-announcing that policy will allow us to find the best long-term "path" to climate stability.*

Impacts on Future Generations

Long-term societal problems such as human-induced climate change also raise issues regarding the impacts on future generations from polices enacted (or not enacted) today. Specifically, the use of a technique called "discounting" to value benefits of actions today over the long-term and concerns about binding future generations must be explored.

"Don't put off until tomorrow what you can do today," Ben Franklin once counseled. But, for economists, this rule is not absolute. When we spend a dollar to pursue any objective today, we don't have the use of that dollar for other purposes. So economists try to calculate what is lost and gained by doing something now as opposed to later through the use of discounting.

The discount rate is related to the interest rate. For example, if we say that the discount rate is 5 percent, we mean that a dollar today is worth $1.05 next year, because it can be invested. Alternatively, we might say that a dollar's worth of benefits next year, such as those gained by ameliorating climate change, is only worth 95 cents today. But if future values are discounted this way, what is the current value of eliminating damages that are 100 or 200 years into the future? Using a standard discount rate, they become so small as to be unimportant — a dollar's worth of benefits 100 years from now, using a 5 percent discount rate, is worth three-quarters of a cent today. While the standard discount rate makes sense for strictly financial investments, many believe that the rate should be much lower when considering long-term social issues like climate change and the protection of endangered species.

New economic research suggests that standard models of long-term costs and benefits may substantially undervalue climate damages in the distant future for another reason: the inherent uncertainty regarding what future discount rates will be.[11] Failing to recognize the implications of uncertain discount rates could lead to underestimating the effects of climate change 400 years into the future — such as a significant rise in sea level — by a factor of tens of thousands. When the entire life-cycle of climate damages is considered over 400 years, incorporating uncertainty into discounting estimates raises the value of those estimates by as much as 95 percent.

The proper treatment of discounting, therefore, puts more weight on the losses future generations will experience. Future generations will also be affected by the decisions we leave to them. Because climate change is such a long-lived problem, it will require consistency and cooperation from decision-makers in many sequential generations: whatever the policy, it will require future decision-makers to play some role. This raises the issue of whether the policies we choose require decisions or actions that future generations will be able to make or implement.

Some economic analyses have suggested that the best way to reach any given GHG concentration in the atmosphere is to continue emitting those gases for several decades until technology improves, and then suddenly and quickly drive emissions down once better technology has been developed. This path means that future decision-makers will have to make dramatic cuts in GHGs regardless of their situation. However, like a Congress that is reticent to repeal a temporary tax cut, future decision-makers may not be able to muster the political will to take the actions that have been assigned to them if the burden is too onerous, regardless of the proximity of the danger.

Another problem related to the "delay" strategy concerns technological progress. The delay strategy relies on dramatic technological breakthroughs during a period when emissions would go unabated. But if there are no restrictions on emissions, there is no obvious reason for firms to perform the necessary research; nor would they have any motivation to engage in the experimentation and learning that drives productivity gains. For all of these reasons, solutions that require future decision-makers to change their behaviors in a particular way cannot be implemented. "The only way to ensure compliance with a commitment to [climate change policy] in the long run," noted one team of economists, "is to enforce reductions in emission flows in the meantime."[12]

Thus, acting now on climate change provides the appropriate level of attention to the rights of future generations, and avoids "passing the buck" to them in ways that abrogate our own responsibilities.

Technology and Learning by Doing

The idea that technological change will underlie any long-term solution to the climate change problem is universally shared. Analyses have shown quite convincingly that, absent technological progress, the costs of any level of long-term GHG abatement are exceptionally high.[13]

However, technological progress takes a great deal of time. The production of automobiles powered by hydrogen, for example, would require developing new ways to produce, store, and distribute that fuel; new training for repair and maintenance of those vehicles; and a variety of other parallel changes. Research and development were once seen as part of a "pipeline," in which basic research at one end led to development efforts in the middle, which led to commercialization and diffusion at the other end. But a broad range of analyses of specific inventions reveals that the process is far more complex and interactive than this simple metaphor suggests. A variety of other factors appear to drive inventions and their diffusion, including procurement incentives, regulatory requirements, government research or incubation, feedback from users, and, often most importantly, the phenomenon of learning by doing. Technological progress does *not* happen because basic research is performed in one place, then carried to another for development, then subsequently brought to market.

Instead, a variety of analyses suggest that most of the nation's technological progress occurs in a swarm of minor increments related to ongoing experimentation, or "learning by doing." Leading inventions, such as the automobile, telephone, or airplane, usually have been invented by several different researchers at roughly the same time: The second application for a patent for the telephone, for example, arrived only hours after that of Alexander Graham Bell. This occurs because these epochal inventions were not truly "new," but instead took pre-existing components, parts or products and rearranged them in new and novel ways. This "component-oriented" view of innovation shows that technological progress is more directly related to experimentation and tinkering than to a pipeline of basic research results.

This view is borne out by the persistent phenomenon of "learning curves," which relate cumulative experience with a particular technology with declines in its unit costs. A survey of energy-related technologies such as photovoltaics, windmills, and gas turbines reveals that every doubling of cumulative experience with each technology led to a decline of about 20 percent in its cost of operation.[14] Thus, early experience with new technologies appears to lead to future cost reductions.

Other economic analyses note that the level of effort devoted to technology is not fixed — rather, it responds to conditions in the economy. Technological change is not simply an autonomous process, but results from complex factors including prices, consumer values, taxes and regulations, and technology policies.[15] The level of research and development, therefore, would respond to the announcement of a climate change policy. This effect is sometimes referred to as "induced technological change." When firms come to understand that a regulatory, tax, or other regime puts a premium on restraining GHG emissions, they will shift research and development efforts towards that goal. As one workshop paper points out, "We need active training not relaxation to get into shape to run a marathon."[16] This lowers the cost of complying with a GHG reduction mandate, but also means that society's R&D resources must be shifted from other purposes so long as science and engineering workers are in scarce supply.

A number of leading corporations have set targets to reduce their own GHG emissions, finding that acting now gives them a competitive advantage through learning by doing. As they set and meet their targets, these companies are finding low-cost emissions reduction opportunities; ancillary safety, efficiency, and environmental benefits; and competitive advantage in becoming more climate-friendly.[17] Any climate policy must lead firms to begin this process in earnest — to induce technological change — if it is to lower the cost of abating GHG emissions. *The very long times required to bring technologies on line, and the prospect for rising atmospheric GHG concentrations in the interim, suggest strongly that action be taken now to begin developing and diffusing those technologies.*

"No Regrets" Options

"No regrets" options are steps to reduce GHGs that would pay for themselves even without a climate change policy. Some studies, for example, note that information-oriented programs that make buyers aware of energy-saving products and opportunities, such as the federal government's "Energy Star" program, generate substantial energy and cost savings, simply by filling a gap in the market's awareness.[18]

The U.S. tax code contains features that are viewed by some analysts as subsidies for inefficient energy use. Eliminating these subsidies could have important effects on energy use and emissions of conventional pollutants. For example, efforts to reduce or eliminate CO_2 emissions often also result in lower levels of so-called "criteria pollutants," such as sulfur dioxide, nitrogen oxides, or particulates. These have their own effects on health and economic activity. Thus, reducing CO_2 may have other benefits that reduce the societal cost of abating these emissions, conceivably to the point of making them "free" on a societal basis. While there is often debate as to the extent of these essentially free options, there is broad agreement that they should be pursued.

Another type of cost that bears on the true societal cost of carbon abatement concerns our nation's strategic vulnerability to imported oil. Economists have long recognized that U.S. dependence on foreign oil poses costs to the economy greater than those that can be mitigated by maintaining strategic oil stockpiles. Shifting the economy away from fossil fuels and towards sustainable technologies to reduce dependence on foreign oil would generate benefits even before climate effects were considered.

A far wider range of policies that abate GHG emissions, therefore, can be justified on a "no regrets" basis, once the full social costs and benefits of those actions are taken into account.

Conclusions

The scientific community has arrived at a consensus that human activities are driving dramatic changes in our planet's climate. This naturally raises the question of when we should begin to respond to this challenge. Some have argued that society, given the uncertainties and costs associated with climate change, would best be served by relying on voluntary measures to reduce GHG emissions while waiting until more is known regarding the science and economics of climate change.

However, as the scientific literature makes clear, we do not need to know more in order to conclude with confidence that the trend towards a warmer global climate is real. Waiting to take action to reduce GHG emissions ignores the strong scientific evidence that GHG concentrations in the atmosphere will soon exceed a doubling of their pre-industrial levels. We currently have limited abilities to predict the specific, long-term consequences that these escalating GHG concentrations will have on the earth's climate as well as the related effects they will have on economic activity, human health and quality of life, biodiversity, and many other areas. However, a number of trends, such as the inundation of low-lying areas, a pole-ward shift in agricultural production, and a general reduction in biodiversity, can be predicted with confidence. Moreover, economists understand that a strategy of delaying direct action and relying on laboratory science alone cannot produce the broad-based experimentation and learning that in the past has led to technological progress.

Establishing a clear path for emissions reductions would begin the process of a timely and efficient response to the climate challenge. It would lead the private sector into a long-term transition towards a low-GHG economy, inducing technological progress and wide-scale experimentation. Such action would allow us to learn as we gather experience with implementing climate change policy, and would give future generations the tools to manage the problem without insurmountable burdens.

In short, the argument that delay is the best strategy for addressing global climate change runs counter to what we understand about technology, the economy, and climate science itself. It risks allowing significant escalation of the problem while providing little in the way of momentum towards a long-term solution. In contrast, moving forward with a real and rational program to reduce GHGs allows us to address this challenge in a way that is timely, consistent, meaningful, and cost-effective. *Our response to the challenge of global climate change should begin now.*

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[2] The Pew Center Workshop on the Timing of Climate Change Policies, held at The Westin Grand Hotel in Washington, D.C. October 11-12, 2001. A summary of proceedings is available on the Pew Center website, www.pewclimate.org/events/timing_proceedings.cfm.

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