Chapter 2

Responding to Climate Change: Mitigation

I. Introduction (p. 49)

After introducing the substantial potential impacts from climate change in chapter 1, both chapter 2 (mitigation) and chapter 3 (adaptation) introduce the range of policy options available to respond to climate change. This chapter addresses mitigation, or those policies that are aimed at reducing greenhouse gas (GHG) emissions, enhancing GHG sinks or otherwise avoiding climate change. Chapter 3 focuses on adaptation, which are those policies aimed at managing and reducing the impacts of climate change.

This chapter first provides a theoretical discussion of the various regulatory approaches that can be taken, including command-and-control, cap-and-trade, carbon taxes, and others, to avoid or reduce climate change. Certainly, the mitigation policy that receives the most attention is cap-and-trade. Cap-and-trade dominates the Kyoto Protocol, the European Union's emission trading system, and the proposed Waxman-Markey legislation that passed the U.S. House of Representatives in 2009. Students will understandably be anxious to learn how cap-and-trade and the associated carbon market works, but it is also important to emphasize that cap-and-trade is only one policy tool that can be, and is being, used to address climate change. Indeed, other policies and measures can be found in the Kyoto Protocol, in European Union legislation, in proposed U.S. federal legislation and in state and local approaches. In part, this chapter is thus meant to introduce students to the wide variety of tools available to reduce GHG emissions or enhance carbon sinks.

Given the startling impacts of climate change, students must also be introduced to what is at stake in the regulation of GHGs. Fossil fuels form the primary energy base of our industrial economy, and regulating them will carry significant costs. Everything any one of us does in our day-to-day lives adds to climate change in significant ways. Addressing climate change requires us to balance potentially catastrophic and inequitable environmental and social impacts on the one hand with the fundamental energy and agricultural base of the modern economy. The stakes can't get much higher!

Teaching Point. To focus students on how individual activities contribute to climate change, we recommend that they find and use one of the many climate change calculators available on the internet to determine their climate impact and steps they can take to reduce their carbon footprint. *See*, for example, http://www.newdream.org/climate/resources.php, the website for the Center for a New American Dream which provides citations to several carbon calculators and other resources for individuals; or http://www.safeclimate.net/calculator/, which is published by the World Resources Institute.

II. General Mitigation Approaches (p. 50)

A. Climate Change as a Market Failure (p. 51)

Responding to climate change will ultimately require an interrelated set of complex laws and policies, but it is nonetheless valuable for students to understand that on some levels climate change is no different than any other form of pollution. One way to illustrate this is to discuss climate change as a basic market failure, just like local water pollution. This can demystify the problem of climate change and allow students to begin building a basic framework from which to address the tremendous complexities of the issue.

GHG emissions like any pollution are a market failure in that they are a form of external costs not readily reflected in free market pricing. As the text describes, externalities are the costs actually incurred in making a particular product that are not reflected in its market price. For example, externalities are the costs of acid rain, smog, GHGs, and other pollutants borne by society, neighbors, communities, as well as wildlife, among others but not actually incurred by the manufacturer or individual supplying the product, unlike labor or operation costs. The short David Pearce excerpt (p. 52) explains how these external environmental costs are never incorporated into the actual price of the product. Thus, the wider social costs are never accounted for, which makes the market price an inaccurate reflection of the actual cost to society of the product. The excerpt concludes that the market works best when the market price is corrected to reflect both social and production costs and, in the pollution context, makes the polluter actually pay for the amount of pollution that they create. This amounts to the internalizing of external environmental costs. Of course, the difficult question is how to best accomplish internalization accurately and credibly. The next section of the text takes up this issue in the context of GHG pollution and climate change.

Questions and Discussion (p. 53)

This question is meant to highlight how, despite its inherent complexity, climate change is just like other forms of environmental pollution. Climate change is just one example of an externality, albeit one with global repercussions. Viewed from the perspective of a market failure, the actual, social costs from burning fossil fuels, deforestation, or poor land-use practices are not reflected in the market costs of the underlying energy, forests, or agricultural products. For economists, this means the principal challenge in responding to climate change is to establish a policy that effectively internalizes the costs of greenhouse gas pollution. In theory, virtually all forms of environmental regulation help to internalize costs, although market-based instruments such as taxes and tradable permits hold the promise of doing so more efficiently.

As described in the text, climate change can also be seen as a "tragedy of the commons," where at least in theory the failure of private ownership leads to a lack of sustainable management. Cap-and-trade systems are based in part on the theory that they will create a

limited property right in the atmosphere—or at least the right to pollute a certain amount into the atmosphere.

B. Internalizing External Costs: Cures for Market Failure (p. 53)

This section is meant to introduce briefly different categories of regulatory or policy responses to respond to pollution (i.e. to internalize the external costs of GHG emissions). The section is not intended to address specific climate-related approaches as much as it is meant to introduce the theoretical differences, strengths and weaknesses of different general approaches to pollution. The categories addressed, include traditional regulation, emissions trading (or cap-and-trade), pollution (carbon) tax, information-based approaches, and investment and technology-based approaches. Other policy approaches such as the use of green subsidies or procurement policies are covered in the Questions and Discussion.

1. Traditional Regulation (p. 55)

Although traditional, command-and-control approaches to curbing pollution are often maligned as bureaucratic, inefficient and costly, they are still important and necessary approaches for addressing greenhouse gas emissions. More attention will be placed on the "exciting" and "glamorous" emissions trading, but in the end approaches that require certain efficiency standards, pollution control technology or that ban certain practices may be even more important for addressing climate change. Renewable portfolio standards, auto emission or efficiency standards, and the phase-out of certain industrial gases such as HCFCs are just a few of the command-and-control regulations that play an important role in mitigating climate change.

2. Emissions Trading (p. 55)

During the course, the students may be exposed to four different GHG emissions trading systems: the European Union emissions trading system, the Kyoto Protocol's emissions cap and flexibility mechanisms, the cap-and-trade systems being debated in the U.S. Congress, and the Regional Greenhouse Gas Initiative for the New England states. Students thus need a framework for understanding why emissions trading has become such a central policy approach in the climate change area, and the tools to critically evaluate these various systems. This section is meant as a general introduction to emissions trading as a first step in providing the framework for the students. It is designed to raise more questions than it answers, leaving the details of various GHG emissions trading systems to later chapters.

Questions and Discussion (p. 58)

1. Self-explanatory.

2. Self-explanatory.

3. Self-explanatory. The first three questions and discussion notes together can be used to raise the importance of design in making a "cap-and-trade" or emissions trading system work effectively to reduce emissions cost-effectively. This may be the most important point for students to gain from the reading: that a cap-and-trade system has the potential to provide for cost reductions in gaining the same amount of pollution reduction as traditional regulation, but it requires a good design and strong implementation.

4. Administrative costs of any regulation are often ignored by students as they think about the design and implementation of various policy proposals. As this note points out, the administrative costs of both emissions trading and traditional regulation are significant and roughly comparable over time.

5. This note highlights the issue of how to allocate the initial rights to pollute under a cap-and-trade permitting system. For those professors who choose to discuss cap-and-trade systems in relative detail at this point in the class, this note can give you a point of departure for discussing some of the experience with the EU system as well as whatever legislation ahs been proposed or enacted in the United States. Both the EU Emissions trading system (at least thus far) and the Waxman-Markey bill passed by the U.S. House of Representatives give most of the initial permits away for free. In both cases, the decision not to auction off permits was basically a political compromise to counter serious opposition to auctions from powerful utilities and fossil fuel companies.

6. Driesen's article excerpted in this note forces students to understand the complexity inherent in environmental regulation. Cap-and-trade and other market-based systems are regularly described as superior to traditional regulation because they are supposed to encourage greater technological innovation. Driesen's article suggests that it is more complex and, at the very least, how we design and implement a cap-and-trade system will be critical as to whether we provide adequate incentives for technological innovation.

This is a good article to revert back to throughout the course. Students should be asked to consider Driesen's arguments as they read about the Kyoto Protocol, the Clean Development Mechanism and any arrangements established in the Copenhagen negotiations, as well as the structure of any domestic cap-and-trade system.

7. The arguments for the emissions trading provisions, also known as the flexibility mechanisms, under the Kyoto Protocol are primarily that the lower the cost of achieving a given amount of GHG emissions reduction, the less political opposition there will be to reductions and the greater the reductions will be. Detractors of this approach are concerned, as suggested by Driesen, that cheap reductions or "offsets" may reduce the price signal needed to spur technological innovation. Evidence discussed in later chapters also supports the view that offsets under the Clean Development Mechanism may have been too cheap and was one factor that suppressed any meaningful price incentive in the initial stage of the EU emissions trading system.

3. Carbon Taxes (p. 63)

Taxes on pollution are a direct and straight-forward way to internalize the social costs of the product or activity. Thus, in the climate context, a per-ton tax on carbon-equivalent emissions would have different impacts on different energy sources depending on their relative emissions of GHGs: coal and oil would face a higher tax than natural gas, for example, and this would make natural gas relatively more price competitive in the energy market (incentivizing the switch from coal and oil to natural gas).

The market impact of a tax is more direct and easier to understand than the market impact of emissions trading, for example. This is one of several reasons why academics and many observers favor a carbon tax over a cap-and-trade system for addressing climate change. The Metcalfe excerpt identifies many of the potential advantages of a GHG tax over cap-and-trade, including greater revenue generation, lower administrative costs, and fewer abilities to manipulate the system for one set of industries over another.

Questions and Discussion (p. 66)

1. In the past year, as the U.S. Congress has debated its response to climate change, many academics, bloggers and other opinion makers have supported a carbon tax. Many reasons exist for why a carbon tax might advantageously replace a cap-and-trade system, or at least be an integral part of a comprehensive U.S. climate policy. But taxes of any sort have proven difficult to pass or even to debate openly in the U.S. Congress over the past decades, as reflected in tax revolts, Boston "tea parties" and other anti-tax sentiment. Taxes are a lightning rod for the broader debate over the size and role of the government, with conservatives largely opposing tax increases as a way of ensuring a smaller government role. Democrats meanwhile are unwilling or unable to form a sufficient majority to risk being seen as "tax-and-spend" liberals. This general debate over the level of taxes infects debates on carbon taxes, with the added feature of strong opposition by powerful fossil fuel interests and some consumer groups. The net result is that even though a cap-and-trade system may act similar to a carbon tax, politically it is far safer to debate and support. Indeed, one strategy for defeating the Waxman-Markey cap-and-trade legislation was to try to characterize it as a "hidden" carbon tax.

2. Self-explanatory.

3. This discussion note addresses the differences between a carbon tax and an emissions trading system. Although several differences are noted, we highlight the relative areas of uncertainty in each system. Most importantly, with a carbon tax the policymakers can be pretty certain what the maximum cost will be on society (the amount of current emissions x the cost of a ton of emissions)—but they cannot be certain about what level of emissions reductions they will achieve with a given amount of costs. The opposite is true with respect to a cap-and-trade system. The policymakers set the emissions cap and thus are more certain about total emissions; what they can not be certain about is the cost of achieving the cap, or more precisely what will be the price of a marginal cost of reducing a ton of emissions. In this way, the choice between a tax and emissions trading can be seen as a trade-off between what policymakers view as being the most important thing to get right from the outset—the cost or the amount of emissions reductions. In practice, one

would hope that either system would allow for flexible adaptation over time to ensure an appropriate balance between costs and benefits.

4. Imposing liability for costs caused by pollution is another way of ensuring that companies internalize the external costs of their activities. In theory, liability regimes act as do pollution taxes to increase the cost of pollution and to send a price signal incentivizing more pollution control. Liability regimes necessarily entail difficult *post hoc* demonstrations of causation and other potentially expensive administrative costs that in practice make them less direct in their internalization function. For example, liability is imposed after damage has occurred and the damage may be separated both by time and space from the polluting activity. Moreover, liability is typically implemented through case-specific adjudications, which makes it less efficient than an economy-wide preventive regulation or tax. The administrative costs of imposing liability (of proving causation, of measuring compensation, etc.) may be too high to impose it in a sufficient number of cases to create economy-wide price incentives for pollution control.

4. Information-Based Approaches (p. 67)

Although often viewed as a "softer" regulation, requirements to gather and distribute information about GHG emissions can be important for catalyzing reductions in emissions. The old saying "that which gets measured, gets done" is somewhat true. Requiring companies to measure their emissions can often lead companies to be more conscious of their impacts and to take voluntary steps to reduce emissions. Public embarrassment or derision resulting form the public disclosure of large scale emissions can also lead to changes in behavior. Perhaps most importantly, policies that require reporting and monitoring of GHG emissions are necessary components for effectively implementing many of the other regulatory approaches (including taxes and emissions trading).

5. Investment & Technology Approaches (p. 68)

The government also has a role in creating and stimulating technological advances that can help us address climate change. Examples can include providing subsidies for research and development of clean energy technologies, using the purchasing power of the government to create markets for new technologies through procurement standards, lowering barriers to the transfer of technology internationally, and removing subsidies for fossil fuels.

Questions and Discussion (p. 68)

1. Because energy supply is seen as so critical to economic growth and national security, broad support can be developed for fossil fuel and related energy subsidies. In addition, students must acknowledge the political power fossil fuel and related energy companies wield not only in the United States, but throughout the world. A discussion with students about the major impediments to eliminating subsidies may range from international trade

and competitiveness issues, to consumer demands for cheap energy, to national security interests, to the political influence of moneyed energy interests in domestic politics.

You may also want to ask a follow-up question of why students think renewable subsidies may not be so common or substantial. Smaller, renewable and energy efficiency companies do not yet have the resources or political networks to influence national and global policy. Moreover, until renewables and energy efficiency are scaled up to provide more significant portions of our energy, arguments over energy security or lowering consumer costs are not as supportable. This means that renewables and energy efficiency industries have had to rely on climate change arguments for justifying broader subsidies (although in recent years, the call for "green jobs" has provided an additional argument for subsidies to renewables and energy efficiency).

2. Self-explanatory.

3. Self-explanatory.

4. Self-explanatory. Note that any federal climate legislation passed in the United States is likely to take a multi-faceted approach to climate change. The Waxman-Markey American Clean Energy and Security Act passed by the U.S. House of Representatives in 2009, for example, included renewable performance standards, money for research and development, new efficiency standards for lighting and appliances, as well as an emissions trading scheme.

III. Mitigation Policies at the Sectoral Level (p. 69)

A. Mitigation Measures (p. 69)

Questions and Discussion (p. 74)

The questions and discussion notes in this section put the focus on scaling up four different approaches to mitigating climate change: a solar revolution, carbon capture and sequestration (CCS), "carbon negative" technologies, and the use of biochar. Each of these approaches would require advances in technological innovation and each might have significant externalities of their own. Ultimately, we may need to pursue each of the four (and other) approaches on a massive scale to reduce greenhouse gas concentrations sufficiently.

1. Self-explanatory. Solar power is a well known technology to most students, at least on a small scale. The Zweibel article mentioned in this note is provoking because it suggests solar can be scaled up to provide a majority of U.S. electricity needs. Solar on this level would require significant public and private investments and would involve some significant impacts on public lands.

2. CCS technology remains controversial. It is clear that we have yet to demonstrate CCS technology will be cost-effective at the scale necessary. More importantly, coal

companies around the world have been promoting "CCS-ready" power plants as a way to continue building coal-fired power plants even in the face of concerns over climate change. These "CCS-ready" plants are designed to allow easier retrofitting to capture carbon emissions, if and when locations are identified to sequester the carbon underground. By promoting new coal-fired plants in this way, industry effectively mutes opposition while gambling that CCS will be possible in the future.

3. Self-explanatory.

4. Self-explanatory.

B. Stabilization Wedges: Mitigation One Step at a Time (p. 75)

The Pacala and Sokolow article is now a bit dated, but it still serves two important purposes: it makes solving the climate change challenge more accessible by breaking down the solution into smaller pieces and it also shows students that solving climate change will require a mixture of mitigation approaches and technologies. No one approach can be implemented on a scale massive enough to solve the problem on its own, but multiple mitigation steps taken at the same time can bend our GHG emissions downward over time.

Questions and Discussion (p. 80)

1. Self-explanatory.

2. One of the virtues of the Pacala and Sokolow approach is that it allows us to determine what additional steps can be taken to make even more progress on mitigating climate change. Thus, as the consensus target for acceptable climate risk drops from 550 ppm GHGs in the atmosphere to 450 ppm GHGs, the approach can be expanded to incorporate additional technologies or wedges.

3. Students can be asked what policies are best for technological innovation and what the proper role of government is in forcing technology through regulation or in developing technology cooperatively in public-private partnerships.

4. Pacala and Sokolow do not present a cost-effectiveness analysis of the different wedges, so it is impossible from the information given to compare costs or benefits of different approaches. Nonetheless, students can be encouraged to explore their own opinions and the potential biases that they bring. For example, some students may want to pursue proven technologies such as nuclear power and ignore the potential externalities that are associated with the uranium cycle and nuclear power. Others may want to invest in CCS technologies or other cutting-edge approaches that may or may not prove effective in the future.

5. Self-explanatory. Students may raise the issue of individual responsibility or the role that individual lifestyles and consumer choices have on the effort to address climate

change. On the one hand, individual choices appear to have little effect on an issue as massive and global as climate change, but on the other hand it is the cumulative impact of individual choices that has fueled climate change—and lead to its resolution. When confronting this question of the utility of individual actions (such as driving less or eating less beef), we often emphasize that "every little bit counts" and that the climate change challenge is a "matter of degrees." We need to stabilize GHG concentrations at levels that will lower the ultimate temperature increase. Two degrees is better than three degrees, but so is 2.9 degrees. This reminds students that it is a continuum and not an "on or off" issue. The ultimate level at which we are able to stabilize GHG concentrations depends on how early and how pervasive our switch is to low-carbon lifestyles. Thus, local and individual decisions to reduce carbon footprints today can only help to contribute to lower the level at which we stabilize GHG concentrations.

IV. The Benefits and Costs of Climate Mitigation (p. 81)

This section introduces macro-economic analysis into the discussion of climate change, by presenting studies that analyze the costs of climate impacts (or the benefits of avoiding climate change) as well as the costs of mitigating climate change. Cost-benefit analysis (CBA) is an important tool that can provide important insights into questions of what type of activities we should take to respond to climate change. The influential study issued by Nicholas Stern that forms the basis of Part IV.A. was widely viewed as a credible study of the costs and benefits of climate mitigation. The Stern report concluded that climate change could lead to permanent loss of "at least 5% of GDP now and forever," and taking into account concerns of equity, non-market impacts, and the uncertainty surrounding climate change, the report claims that the costs of climate change could be as high as 20% of global GDP when compared with a world without climate change. Other studies have concluded costs of climate change mitigation at between 2% and 8% of GDP. The Stern report also concluded that the benefits from acting now to mitigate climate change would exceed the costs of trying to adapt subsequently.

Students should also understand the limits of CBA for making specific policy decisions about climate change mitigation. Part IV.B. highlights many of the critiques of BCA, drawing primarily from Douglas Kysar's article, *Climate Change, Cultural Transformation, and Comprehensive Rationality.* According to Kysar, the four shortcomings of CBA analysis are: (1) the difficulty in reflecting the tremendous uncertainty surrounding climate change; (2) the inability of valuation methodologies to reflect appropriately the anticipated losses of human life and environmental resources; (3) the intergenerational inequity of using exponential discounting within CBA to resolve decisions regarding the intertemporal distribution of costs and benefits; and (4) the inherent orientation of CBA toward the status quo.

Parts A and B, taken together, provide the basis for leading students in a discussion about the strengths and limitations of monetizing all costs and benefits from climate change mitigation. This discussion could be held in the context of current policy debates over federal cap-and-trade legislation. A flurry of competing cost estimates have been published in the past year, estimating the costs associated with various legislative

proposals for reducing GHG emissions in the United States. The Congressional Budget Office (CBO), for example, estimates that the U.S. cap-and-trade program under the Waxman-Markey bill will cost $22 billion annually, or about $175 per household, by 2020. This figure includes the cost of restructuring the production and use of energy and of payments made to foreign entities under the program. The CBO did not analyze or account for the benefits from reducing GHG emissions. *See* Cong'l Budget Off., *The Estimated Costs to Households from the Cap-and-Trade Provisions of H.R. 2454* (June 19, 2009).

A. The Stern Review of Climate Economics (p. 82)

Questions and Discussion (p. 85)

1. Self-explanatory. Analyses of costs and benefits do not easily take into account considerations of equity or fairness across regions or countries. Any potential moral responsibility of industrialized countries for reducing the impacts on small island states, for example, is hard to reflect in an analysis of costs and benefits.

2. Self-explanatory. Students may have heard of other estimations of costs of climate change (or of climate change mitigation), or students may be given a research assignment to try to find more recent estimates of various types of climate change impacts or mitigation options.

3. The range in the social (external) costs of carbon (ranging from $7.50 per ton in Lomborg and $85 per ton in the Stern report) helps to illustrate to students how much the outcome in an economic analysis reflects the assumptions of the study. One difficulty is that such assumptions are rarely exposed or publicized so that all policymakers or the public focus on is the quantitative number. Reducing the complexity of climate change to one figure—the social cost of carbon—is fraught with difficulties and students should be able to see the danger in relying too heavily on this approach. The ability to manipulate underlying assumptions that go into an economic study makes it particularly prone to *post hoc* rationalizations of pre-existing positions. In fact, both Lomborg and Stern had particular views about climate change before their economic analyses were released (Lomborg was a known climate-skeptic and Stern has long advocated stronger climate policies in the UK), and their economic analyses generally back up their viewpoints. This may not discredit their studies entirely, but it does show the importance of learning how to unwrap and analyze the assumptions that underlie any BCA.

4. The argument that we will be better able to afford climate impacts later when they are scheduled to occur, so therefore we should allow them to occur is on its face controversial. To some extent, however, it is this view that is supposed to be reflected in the choice of a discount rate (discussed further in Question 1 on page 92). Moreover, Lomborg's and related arguments are usually based on the most conservative estimates of climate change impacts along with the highest estimates of mitigation costs. Even if the economic analyses suggested that we will be so much wealthier in the future that we needn't worry about climate change now, however, the questions of equity, uncertain

impacts, and un-quantifiable costs identified in the Kysar excerpt all argue against the economic argument for doing no mitigation now. Incidentally, these arguments to do nothing now were a primary reason why the Stern report studied the cost-effectiveness of immediate mitigation actions; that report concludes that immediate mitigation actions are justified from a cost-benefit viewpoint.

B. The Critique of Cost-Benefit Analyses (p. 87)

The Kysar article is a thoughtful critique of CBA. We encourage students to read the entire article in order to understand the various concerns raised over the use of CBA in the climate context.

Questions and Discussion (p. 92)

1. This note demonstrates how important discount rates are to the ultimate outcome of any CBA. Vastly different estimates of the costs and benefits from climate change mitigation result from changes in the discount rate. And selection of the appropriate discount rate is somewhat subjective as suggested by the different approaches highlighted by the Stern, Lomborg and Kysar articles.

2. This note is meant to focus the students on the difficulty of monetizing costs and benefits associated with climate change. The imperfections and uncertainties in valuation methodologies are one of the primary shortcomings in CBA, although it is also a shortcoming of how we use CBA. The complexities, uncertainties and qualities associated with environmental issues are simply lost when we reduce our policy debates to a focus on monetized costs and benefits.

3. Self-evident.

4. By exploring the use of scenarios as an alternative to CBA for aiding decision makers, the discussion note is meant to further demonstrate how simplistic (i.e. reductionist) CBA can be. Again, CBA has its uses, but students should be able to discern how much more robust and nuanced a discussion of climate change is possible when one moves beyond only thinking in terms of CBA.