1

Introduction

Scientific opinion has coalesced around the view that human activity, through the emission of greenhouse gases, makes a major contribution to global warming, even though natural forces are also at work.[1] In 2006 a team led by the English economist Sir Nicholas Stern issued a striking report that sized up the economic dimensions of global climate change and called for immediate collective action to reduce greenhouse gas emissions. According to the Stern report, the danger of huge future costs can be reduced by incurring relatively modest costs over the next few decades.[2] In this vein, at the United Nations Climate Change Conference in Bali, Indonesia, in December 2007, representatives of 187 countries agreed on the so-called Bali Roadmap, which promises talks over the next two years

1. "Radiative forcing" measures how the energy balance of the earth-atmosphere system is influenced by various factors that affect climate. The Intergovernmental Panel on Climate Change (IPCC) has found that radiative forcing resulting from factors that are affected by human activity has been much larger than the radiative forcing resulting from natural processes. For more details, see IPCC (2007a). The report is also available at www.ipcc.ch (accessed on January 12, 2009).

2. The Stern report argued that the risk of the worst effects of climate change can be substantially reduced if greenhouse gas levels in the atmosphere are stabilized between 450 and 550 parts per million (ppm) CO_2 equivalent (CO_2e). The current level is 430 ppm CO_2e, and the concentration is rising at more than 2 ppm each year. Stabilization in the range advocated by Stern (450 to 550 ppm CO_2e) would require a drop in emissions at least 25 percent below current levels by 2050. Ultimately, annual emissions would need to be brought down by more than 80 percent below current levels. The report estimated annual costs of about 1 percent of global GDP to achieve stabilization between 500 and 550 ppm CO_2e if strong action is taken now. The full Stern (2006) report is available at www.hm-treasury.gov.uk (accessed on January 12, 2009).

to develop a new treaty that would replace the Kyoto Protocol after 2012.[3] At the United Nations Climate Change conference held in Poznan, Poland in December 2008, countries reaffirmed their commitment to the post-Kyoto regime and asserted that the economic downturn should not be an excuse for delaying action on climate change. While countries addressed technical details and presented proposals for elements in a post-Kyoto agreement, the Poznan conference failed to address key issues such as bound targets for emissions reduction by developing countries and technical and financial assistance from developed countries. Moreover, the current financial turmoil raises doubts that countries will reach agreement on a comprehensive new international climate regime in Copenhagen by December 2009.

In the midst of the climate change debate, the United States has been roundly criticized for its reluctance to take action. Although the United States ranked among the largest emitters of greenhouse gases, the US Senate passed the Byrd-Hagel Resolution by a 95–0 vote in 1997, effectively rejecting the Kyoto Protocol.[4] The Bill Clinton administration signed the Kyoto Protocol in 1998, but it never submitted the protocol to the Senate, acknowledging the force of the resolution. The George W. Bush administration rejected the Kyoto Protocol in 2001 and only grudgingly agreed to the Bali Roadmap.[5] However, some state governments (notably Califor-

3. The United Nations first called for collective action on climate change when it adopted the Framework Convention on Climate Change (UNFCCC) in 1994. After years of talks, in 1997, the Kyoto Protocol, which requires developed countries to reduce their greenhouse gas emissions below levels specified for each of them in the treaty, was adopted at the third Conference of the Parties to the UNFCCC in Japan. The Kyoto Protocol is scheduled to expire in 2012.

4. The Byrd-Hagel Resolution (S. Res. 98) stated: "Whereas the Senate strongly believes that the proposals under negotiation, because of the disparity of treatment between Annex I Parties and Developing Countries and the level of required emission reductions, could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof; and…. That it is the sense of the Senate that (1) the United States should not be a signatory to any protocol to, or other agreement regarding, the United Nations Framework Convention on Climate Change of 1992, at negotiations in Kyoto in December 1997, or thereafter, which would—(A) mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period, or (B) would result in serious harm to the economy of the United States…." The full text of the resolution is available at http://thomas.loc.gov.

5. In a statement following the Bali conference, the White House expressed its dissatisfaction: "The United States does have serious concerns about other aspects of the Decision as we begin the negotiations…. Accordingly, for these negotiations to succeed, it is essential that the major developed and developing countries be prepared to negotiate commitments, consistent with their national circumstances, that will make a due contribution to the reduction of global emissions. A post-2012 arrangement will be effective only if it reflects such contributions" (quoted from the statement by White House Press Secretary Dana Perino on December 15,

nia) have enacted their own measures over the past six years, and several bills are now on the congressional agenda. Box 1.1 discusses core elements of current US climate policy.

While scientific and economic uncertainties are often cited in climate change debates, another enormous obstacle to collective action is the chasm between competing conceptual standards for setting greenhouse gas limits.[6] The chasm would exist even if all countries agreed on target levels for global greenhouse gas concentrations—which, of course, they do not. Even if a target for global levels could be agreed upon, however, a debate would still rage: Should national limits be based on "per capita comparability" or "carbon price equivalency"? Per capita comparability rests on the argument that the United States, Europe, and Japan emitted billions of tons of CO_2 on their path to industrialization and that China, India, and Brazil should not now be denied the same route. An approach based on "historic emissions," often advocated by developing countries arguing that targets should reflect cumulative emissions, draws on the same tenets. If per capita comparability or a historic emissions approach is to be the accepted standard, then developed countries would have to enforce tremendous reductions, while developing countries could vastly increase their greenhouse gas emissions (see table 1.1).

The argument for carbon price equivalency rests on the proposition that an additional billion tons of CO_2 does the same damage to the globe whether it comes from New York or New Delhi. If bygones are bygones, and the standard for collective action is to be carbon price equivalency, then a short list of major nations would need to impose very similar limits (see table 1.2, panel b). The explicit or implicit tax on greenhouse gas emissions, per ton of CO_2 equivalent (CO_2e) emissions, would then reach roughly the same high level in all major countries.[7]

Based on the debates surrounding the original Kyoto Protocol and the Bali Roadmap, US climate negotiators have harbored grave doubts that important developing countries (notably China and India) will accept carbon price equivalency as the working standard. In turn, the US Congress is very worried that, by taking the lead and imposing national

2007, www.whitehouse.gov [accessed on January 12, 2009]).

6. Climate change skepticism has diminished but not disappeared, as uncertainties still exist in climate change science and economic analysis. Michaels (2006) of the Cato Institute, for example, argues that many studies on climate change are seriously flawed and exaggerate the negative impact of global warming. Appendix A discusses four major uncertainties that are embedded in climate change debates.

7. An unmentioned but powerful undertone in the debate between per capita comparability and carbon price equivalency is the footprint of damage caused by climate change. All countries will be adversely affected, but some much more than others. As the science of climate change improves, and severe as opposed to modest losers are identified, that will influence the lineup between countries advocating one standard or the other.

Box 1.1 Core elements of current US climate policy

Ethanol subsidies. At both the federal and local levels, the United States has subsidized ethanol (mostly corn-based) and other biofuels. The federal government currently provides a 51 cent tax credit per gallon of ethanol, and the states provide a wide array of policies to support ethanol and other biofuel industries. Economists have criticized the cost of ethanol and biofuel production, and scientists have questioned the environmental benefits, especially when CO_2 emissions from cleared land are taken into account. Issues related to biofuels are discussed in appendix B.

Energy standards. In December 2007 President George W. Bush signed an energy bill establishing higher fuel economy standards for new cars and light trucks and other conservation measures. New vehicles are mandated to increase their fuel efficiency by 40 percent, setting a standard of an average of 35 miles per gallon (mpg) by 2020, instead of the prior target of 25 mpg.

State climate policy. States have enacted tougher state laws to regulate greenhouse gas emissions. California became an environmental pioneer among states when Governor Arnold Schwarzenegger signed the Global Warming Solution Act into law on September 26, 2007. This is the first statewide cap on greenhouse gas emissions, mandating a 25 percent cut by 2020. Despite the denial by the Environmental Protection Agency in December 2007 of California's petition to adopt its own CO_2 guidelines, California has pledged to go further in a green direction. Other states have engaged in cooperative efforts by initiating regional programs such as the Regional Greenhouse Gas Initiative, the Western Climate Initiative, and the Midwestern Greenhouse Gas Reduction Accord (the Midwest Accord).

limits on greenhouse gas emissions, affected US industries will suffer a severe competitive disadvantage in the global marketplace. This would happen if China, India, and other developing countries were to insist on a per capita comparability or an historic emissions standard and impose few if any limits on their own carbon emissions.[8] To address this concern, several US climate bills introduced in the 110th Congress contain competitive provisions that, in one way or another, extend domestic greenhouse gas policies to US merchandise imports and foreign greenhouse gas control systems.

8. While China has pushed historic emissions or per capita comparability standards in international negotiations over the past several years, China has also aggressively pursued a combination of measures to control air, water, and soil pollution, using industrial and energy policies, among others. See Leggett, Logan, and Mackey (2008).

Table 1.1 CO_2 emissions from fuel combustion, 2006 (millions of tons)

Fuel type/sector	United States	China	EU-27	Russia	Japan	India	Brazil	Total	World total
Total	5,697	5,607	3,983	1,587	1,213	1,250	332	19,669	28,003
Percent change, 1990–2006	17	154	–2	–27	13	112	73		33
By fuel type									
Coal	2,090	4,641	1,263	445	431	844	47	9,761	11,686
Oil	2,411	864	1,682	321	587	339	246	6,450	10,768
Gas	1,169	101	999	805	190	67	40	3,371	5,445
Other[a]	27	n.a.	40	17	5	n.a.	n.a.	89	103
By sector									
Electricity and heat	2,421	2,796	1,461	913	459	702	34	8,786	11,509
Manufacturing industries and construction	633	1,764	656	222	292	284	98	3,949	5,477
Transportation	1,809	367	952	227	245	101	141	3,842	6,453
Residential	309	247	476	123	63	72	16	1,306	1,860
Other[a]	524	434	439	102	153	90	44	1,786	2,705
CO_2 per unit of GDP (kg/2000 US dollars)	0.51	2.68	0.42	4.25	0.24	1.78	0.43		0.74
CO_2 per capita (tons/capita)	19.00	4.27	8.07	11.14	9.49	1.13	1.76		4.28
Cumulative CO_2 emissions, 1950–2004 (percent of world total)[b]	26.70	9.90	21.70[c]	9.40	4.80	2.60	1.00	76.10	100

n.a. = not available

a. "Other" includes industrial waste and nonrenewable municipal waste.
b. Cumulative CO_2 emissions (energy) data for the period of 1950–2004 from World Resources Institute, Climate Analysis Indicators Tool (CAIT) Version 5.0, 2008.
c. Figure for EU-25.

Note: The Organization for Economic Cooperation and Development noted that CO_2 emissions are calculated using International Energy Agency energy balances, the sectoral approach of the Intergovernmental Panel on Climate Change, and the default emissions factors from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The calculations may differ from the national communication submitted by the parties to the UN Framework Convention on Climate Change.

Sources: International Energy Agency, *CO_2 Emissions from Fuel Combustion*, 2008; Organization for Economic Cooperation and Development; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Version 5.0, 2008.

Statistical Overview

Before discussing US climate policy options and their consistency with the World Trade Organization (WTO), this section takes a quick look at some statistical evidence. Yes, climate change is happening. Scientists have found that since the mid-1970s, the average surface temperature has warmed about 1ºF (Fahrenheit) and that the earth's surface is currently warming at a rate of about 0.32ºF per decade, or 3.2°F per century. The top 10 warmest years in recorded history have all occurred since 1990.[9]

According to the IPCC, most of the observed increase in globally averaged temperatures since the mid-20th century likely reflects the observed increase in anthropogenic greenhouse gas concentrations.[10] Greenhouse gas concentrations in the atmosphere have historically varied as a result of natural processes. However, when industrialization accelerated after the Second World War, the human use of fossil fuels added great amounts of greenhouse gases to the atmosphere.

Tables 1.1 through 1.4 summarize greenhouse gas emissions by the largest emitters in the world—namely, the United States, European Union, China, Russia, Japan, India, and Brazil. In 2000 the United States ranked first among large greenhouse gas emitters (table 1.2, panel a), accounting for more than 20 percent of total world greenhouse gas emissions, and China and the European Union took the second and the third places, respectively. China probably surpassed the United States in total tonnage in 2007. Among the six major greenhouse gases—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluocrocarbons (PFCs), and sulfur hexafluoride (SF_6)—emissions of carbon dioxide accounted for about 73 percent of world total greenhouse gas emissions in 2000 (table 1.2, panel a). In terms of sectors, the production and use of energy represents the largest source of total greenhouse gas emissions, contributing about 76 percent to the world total in 2000 (table 1.3, panel a).

Table 1.1 illustrates just CO_2 emissions from fuel combustion in 2006. Electricity and heat are the largest source of CO_2 emissions, accounting for about 41 percent of such emissions worldwide. In 2006 CO_2 emissions from the manufacturing sectors that lie at the center of the US competitive-

9. For more details, see annual climate reports by the National Oceanic and Atmospheric Administration's (NOAA), available at www.ncdc.noaa.gov, and surface temperature analysis by the National Aeronautics and Space Administration (NASA), available at http://data.giss.nasa.gov/gistemp.

10. The atmospheric concentration of carbon dioxide (CO_2) in 2005 was recorded at 379 ppm (estimated to be about 455 ppm CO_2e), which exceeds the natural range over the last 650,000 years (180 to 300 ppm), as determined from ice cores. The annual growth rate of CO_2 concentration was faster during the last decade than earlier, with an annual average increase of 1.9 ppm. The primary source of the increase since the preindustrial period is the growing use of fossil fuels. For more details, see IPCC (2007a, 2007c).

Table 1.2 Greenhouse gas emissions by gas and hypothetical carbon taxes

Gas	Equivalent factors (GWP)[a]	United States	EU-25	China	Russia	Japan	India	Brazil	World total
a. By gas, 2000 (million metric tons of CO_2 equivalent; percent of world total in parentheses)									
CO_2	1	5,791 (22)	3,843 (15)	3,400 (13)	1,533 (6)	1,266 (5)	1,034 (4)	337 (0)	26,351
CH_4	21	546 (9)	444 (7)	788 (13)	307 (5)	21 (0)	499 (8)	366 (6)	6,020
N_2O	310	396 (13)	408 (13)	645 (21)	55 (2)	37 (1)	67 (2)	241 (8)	3,114
HFCs	140 to 11,700	101 (39)	39 (15)	42 (16)	4 (2)	34 (13)	5 (2)	4 (2)	259
PFCs	6,500 to 9,200	14 (18)	10 (13)	6 (7)	8 (10)	6 (8)	1 (1)	2 (2)	81
SF_6	23,900	19 (48)	3 (7)	2 (5)	2 (5)	2 (5)	1 (2)	1 (2)	40
Greenhouse gas total		6,868 (19)	4,747 (13)	4,883 (14)	1,909 (5)	1,366 (4)	1,607 (5)	950 (3)	35,865
b. Hypothetical carbon taxes (billions of dollars)									
CO_2		158.1	104.9	92.8	41.9	34.6	28.2	9.2	719.4
CH_4		14.9	12.1	21.5	8.4	0.6	13.6	10.0	164.3
N_2O		10.8	11.1	17.6	1.5	1.0	1.8	6.6	85.0
HFCs		2.8	1.1	1.1	0.1	0.9	0.1	0.1	7.1
PFCs		0.4	0.3	0.2	0.2	0.2	0.0	0.1	2.2
SF_6		0.5	0.1	0.1	0.1	0.1	0.0	0.0	1.1
Greenhouse gas total		187.5	129.6	133.3	52.1	37.3	43.9	25.9	979.1

a. All emissions are expressed in CO_2 equivalents using 100-year global warming potentials (GWP), found at the website of the United Nations Framework Convention on Climate Change (http://unfccc.int). For HFCs and PFCs, GWPs are shown in range values, since HFCs and PFCs include several gases that differ in their GWP values.

Note: Table excludes CO_2 emitted through changes in land use. Hypothetical carbon tax equivalent amounts in panel b calculated based on greenhouse gas emissions by gas in panel a. The table uses an arbitrary price of $100 per metric ton of carbon equivalent, which converts to about $27 per metric ton of CO_2 equivalent (based on the conversion method used by the Environmental Protection Agency and the IPCC, which derives the quantity of carbon by multiplying the quantity of CO_2 by the factor 12/44).

Source: World Resources Institute, Climate Analysis Indicators Tool (CAIT) Version 5.0, 2008.

Table 1.3 Greenhouse gas emissions by sector and hypothetical carbon taxes

Sector	United States	EU-25	China	Russia	Japan	India	Brazil	World total
a. By sector, 2000 (million metric tons of CO_2 equivalent; percent of country total in parentheses)								
Electricity and heat[a]	2,685 (39)	1,477 (31)	1,466 (31)	917 (48)	466 (35)	556 (35)	50 (5)	11,582 (33)
Transportation[a]	1,714 (25)	879 (19)	219 (5)	176 (9)	257 (19)	92 (6)	126 (13)	5,098 (14)
Manufacturing and construction[a]	661 (10)	649 (14)	903 (19)	218 (11)	270 (20)	225 (14)	94 (10)	4,748 (13)
Industrial processes	208 (3)	226 (5)	377 (8)	32 (2)	87 (7)	57 (4)	31 (3)	1,369 (4)
Residential and other fuel combustion[a]	720 (11)	780 (17)	463 (10)	210 (11)	202 (15)	139 (9)	45 (5)	3,964 (11)
Agriculture	444 (7)	493 (10)	1,041 (22)	110 (6)	34 (3)	375 (24)	549 (58)	5,729 (16)
Fugitive emissions[a] and waste	416 (6)	225 (5)	290 (6)	243 (13)	10 (1)	150 (9)	47 (5)	2,958 (8)
Greenhouse gas total	6,846	4,730	4,759	1,906	1,326	1,595	942	35,440
Memorandum: Energy generation and use (percent of country total)	88	82	67	90	90	66	34	76
b. Hypothetical carbon taxes (billions of dollars)								
Electricity and heat	73.3	40.3	40.0	25.0	12.7	15.2	1.4	316.2
Transportation	46.8	24.0	6.0	4.8	7.0	2.5	3.4	139.2
Manufacturing and construction	18.0	17.7	24.7	6.0	7.4	6.1	2.6	129.6
Industrial processes	5.7	6.2	10.3	0.9	2.4	1.6	0.8	37.4
Residential and other fuel combustion	19.7	21.3	12.6	5.7	5.5	3.8	1.2	108.2
Agriculture	12.1	13.5	28.4	3.0	0.9	10.2	15.0	156.4
Fugitive emissions and waste	11.4	6.1	7.9	6.6	0.3	4.1	1.3	80.8
Greenhouse gas total	186.9	129.1	129.9	52.0	36.2	43.5	25.7	967.5

a. Sector included in "Energy generation and use" in the memorandum row.

Note: Table excludes CO_2 emitted through changes in land use. Hypothetical carbon tax equivalent amounts in panel b calculated based on greenhouse gas emissions by sector in panel a. The table uses an arbitrary price of $100 per metric ton of carbon equivalent, which converts to about $27 per metric ton of CO_2 equivalent (based on the conversion method used by the Environmental Protection Agency and the IPCC, which derives the quantity of carbon by multiplying the quantity of CO_2 by the factor 12/44).

Source: World Resources Institute, Climate Analysis Indicators Tool (CAIT) Version 5.0, 2008.

ness debate accounted for under 11 percent of total CO_2 emissions by the United States.[11] Also, the last row of table 1.1 shows the historical share of cumulative world CO_2 emissions by country from 1950 to 2004. The United States and the EU-25 accounted for about 27 and 22 percent of cumulative emissions, respectively, while China and India accounted for about 10 and 3 percent, respectively. These figures support the argument made by developing countries as to who is most responsible for climate change, since warming is generated by the cumulative stock of greenhouse gases in the atmosphere. On the other hand, if positive as well as negative contributions to human well-being are going to be tallied in a fanciful exercise to settle historical scores, the developed countries can list many technological innovations that benefited the developing world free of charge.

Compared with the 1990 level, total world CO_2 emissions increased by about 33 percent in 2006. China and India, two of the fastest industrializing countries, show huge increases in their CO_2 emissions of about 154 and 112 percent, respectively (table 1.1). In coming decades, these two countries are expected to continue on a path of faster growth in CO_2 emissions (table 1.4).

Serious limits on greenhouse gas emissions—of the sort proposed by Peterson Institute economist William Cline, Yale economist William Nordhaus, and Nicholas Stern—will entail heavy costs.[12] While estimates vary across a wide range depending on baselines and assumptions, experts agree that costs will sharply rise if actions to tackle greenhouse gas emissions are delayed. A principal reason is that valuable time will be lost both in implementing relatively easy control measures and in spurring new technologies that will enhance energy efficiency.

Panel b in tables 1.2 and 1.3 illustrates the cost/value implication if moderate measures are taken in the near future. These tables use an arbitrary price of $100 per metric ton of carbon equivalent, which converts to about $27 per metric ton of CO_2 equivalent. This figure can be interpreted as a "cost" if a uniform carbon tax is imposed on all emission sources. Alternatively, it can be interpreted as a "value" if emissions are rigorously capped and tradable emissions permits are distributed free of charge to established firms. A price of $100 per metric ton of carbon equivalent is well within the range of estimates made by the economists mentioned above. However, it is above the current value of EU emissions permits.[13] A control system that,

11. The figure of 11 percent includes emissions from both manufacturing industries and the construction sectors. Therefore, the manufacturing sector alone would account for less than 11 percent.

12. For references to these economists and others, see Stern (2006) and Cline (2004). The latter paper is available at www.copenhagenconsensus.com (accessed on January 12, 2009).

13. In December 2008 and January 2009, the EU allowance unit (EUA) contract for December 2009 delivery was traded at prices around €15 per metric ton of CO_2 in the European over-the-counter market (about $20 per metric ton of CO_2). The price of EUA can be found at

Table 1.4 CO_2 emissions projections by selected countries, 2005–30
(million metric tons of CO_2)

Country/region	2005 actual	2010	2020	2030	Average annual percent change (2005–30)
United States	5,982	6,011	6,384	6,851	0.5
OECD Europe[a]	4,383	4,512	4,760	4,834	0.4
China	5,323	6,898	9,475	12,007	3.3
Russia	1,696	1,789	1,984	2,117	0.9
Japan	1,230	1,196	1,195	1,170	–0.2
India	1,164	1,349	1,818	2,238	2.6
Brazil	356	451	541	633	2.3
Memorandum:					
World	28,051	31,100	37,035	42,325	1.7

OECD = Organization for Economic Cooperation and Development

a. Includes 23 countries: Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

Source: US Energy Information Administration, *Annual Energy Outlook 2008*.

in terms of effect, equates to $100 per metric ton of emitted carbon-equivalent would generate costs/values of around $190 billion annually for the United States alone, at current emission levels. For the European Union or China, the costs/values would be around $130 billion annually.

Issues in Controlling Greenhouse Gas Emissions

Ramp Up Speed

While there is general agreement that world greenhouse gas emissions should be reduced to slow global warming, other important questions in addition to the "per capita" versus "carbon price" debate need to be answered, and these involve both economics and science. The critical question is how much emissions should be reduced and along what time path. Fundamentally, the answer must balance costs and benefits and give due weight to very low-probability but very high-damage scenarios. Using various models, economists have estimated the implied costs of reducing

www.pointcarbon.com (accessed on January 12, 2009).

emissions to defined levels on prescribed paths. These economists generally agree that if the emission targets are either quite modest or extremely ambitious, the policies adopted would be severely suboptimal—either the costs incurred would fall far short of the likely benefits from reducing the extent of climate change, or the costs would vastly exceed the likely benefits.[14]

Other participants in the debate argue that reasonable reductions in greenhouse gas emissions will only be accomplished with the creation of new technologies and their active deployment; therefore, severe public action to tackle climate change should be delayed until new technologies emerge or barriers to existing technologies (e.g., nuclear power plants, electric cars) are swept aside. In that way, the decline in emissions could be structured in a manner consistent with technological availability and public action could be implemented at lower cost. In a recent study, the respected McKinsey & Company strongly emphasized the new technology angle and suggested that dramatic reduction of greenhouse gas emissions may not be as costly as frequently cited if tested approaches and high-potential emerging technologies are implemented.[15]

While the importance of new technologies is not arguable, other studies have voiced strong calls for immediate international action with tough targets. In a report commissioned by Australia's federal, state, and territory governments and released in September 2008, distinguished economist Ross Garnaut (2008) warned that the world is heating up faster than previous climate models suggested because of rapid economic growth in developing countries—led by China and India—and that this growing amount of emissions makes mitigation both more urgent and more costly.[16] Damon H. Matthews and Ken Caldeira (2008) argue in the journal *Geophysical Research Letters* that holding the world's climate constant at present average temperatures will require near-zero future carbon emissions. According to these scientists, any future anthropogenic emissions will commit the climate system to warming that is essentially irreversible on a centennial time scale.[17]

14. See Cline (2004), Stern (2006), and Nordhaus (2007).

15. McKinsey & Company (2007) concluded that the United States could reduce greenhouse gas emissions by 2030 by 3.0 to 4.5 gigatons (1 gigaton equals 1 billion metric tons) of CO_2e using tested approaches and high-potential emerging technologies. These reductions would involve a wide array of abatement options available at marginal costs less than $50 per ton of CO_2e, with the average net cost to the economy being much lower if sizable gains in energy efficiency are achieved. This report even suggested that about 40 percent of abatement could be accomplished at "negative" marginal costs, meaning that investing in the options would generate positive economic returns from energy saved over the relevant life cycle.

16. The *Garnaut Climate Change Review* is available at www.garnautreview.org.au (accessed on January 12, 2009).

17. See Juliet Eilperin, "Carbon Output Must Near Zero To Avert Danger, New Studies Say," *Washington Post*, March 10, 2008, www.washingtonpost.com (accessed on January 12, 2009).

Competitiveness

A major US objection to taking stringent action on emissions controls is a fear that heavy costs would weaken the position of US producers, leading to the "leakage" of production and jobs to foreign firms. US measures might inflict competitive damage on the country's manufacturing firms, especially by comparison with China and India. A related concern is that, in the end, US controls will make no difference to climate change if emissions activity simply migrates to other countries. Moreover, US legislation would miss an opportunity if it does not create maximum leverage so that China, India, and other developing countries feel obligated to reduce their own emissions not only in the manufacturing sector but throughout the economy.[18] In the absence of parallel international commitments that result in approximately the same implicit tax per ton of CO_2e emissions, mandatory US programs would impose heavier costs on US industries than their foreign competitors. The extra costs in turn would put US producers at a price disadvantage.[19]

To level the playing field for vulnerable manufacturing firms, policymakers have tried to include specific provisions in climate bills, such as the allocation of free allowances, special exemptions, and border measures. The political parallel with trade legislation is obvious, in that compensatory measures for severely impacted industries may be required to forge a coalition prepared to enact controls on greenhouse gas emissions. To address leakage and leverage concerns—both of which are aspects of the broader competitiveness agenda—trade-related rules in the form of border adjustment schemes have gained political support. On the down side, however, trade measures could easily interrupt the broad agenda of trade liberalization that has proven enormously successful in boosting world economic growth since the Second World War and could also hinder international negotiations to design a global climate framework. At the Bali Roadmap conference in December 2007, US Trade Representative Susan Schwab expressed worries that efforts to address climate change

18. According to the *New York Times,* "In an alliance of denial, China and the United States are using each other's inaction as an excuse to do nothing [on climate change issue]." See "Warming and Global Security," *New York Times,* April 20, 2007, www.nytimes.com (accessed on January 12, 2009).

19. A competing line of thinking is that actions to reduce carbon emissions will reduce production costs through a more efficient and sustainable use of energy and the development of new technologies. From this perspective, the US government should require substantial domestic reductions in carbon emissions to further its own economic interests, regardless whether major developing countries reciprocate. The logical implication of this view is that no trade or border measures are needed to protect US competitiveness because a strong climate policy enhances rather than undermines US competitiveness.

through trade measures could lead to tit-for-tat trade restrictions and reduce global economic growth.[20]

Besides, any performance standards that the United States imposes on foreign firms, and any "comparability" tests it imposes on foreign greenhouse gas control systems, can be turned around and imposed on the United States. An example will illustrate. The United States might impose its own carbon tax or performance standards on imports of steel rebar products from India, citing an exceptionally high level of carbon emissions per ton of Indian rebar production. In turn, India might impose a duty on all imports from the United States, citing the exceptionally high figure of US per capita CO_2 emissions compared with the world average (table 1.1).

In addition, trade data show that the largest foreign suppliers to the United States of carbon-intensive goods are countries such as Canada and those of the European Union, and these countries emit considerably less carbon than the United States either on a national basis or a per capita basis. Moreover, restrictive US trade measures might serve as an excuse for other countries to erect barriers against imports from the United States but not serve as an effective incentive to convince developing countries to reduce their own greenhouse gas emissions. In 2007 imports from China made up an average of about 11 percent of US carbon-intensive imports in five main product groups combined, accounting for 15 percent of US steel imports, 6 percent of US aluminum imports, practically no US chemical imports, 12 percent of US paper imports, and 19 percent of US cement imports (see table 1.5).[21] It is not obvious that these trade shares create substantial leverage for the United States to shape Chinese greenhouse gas policies. Regarding leakage concerns, the International Energy Agency (IEA 2008b) found no meaningful changes in trade flows and production patterns in EU sectors affected by the first phase (2005–07) of the EU Emission Trading Scheme. However, emission controls during the first phase were relatively light.

Major Bills Introduced in the 110th Congress

The major bills introduced to the 110th Congress are summarized in tables 1A.1 and 1A.2 at the end of this chapter.[22] The legislative proposals embody two main incentive approaches: carbon taxes and cap-and-trade

20. Schwab warned that countries should not restrict imports based on the carbon intensity of production, because such measures easily lead to covert protectionism. See *Inside US Trade* 25, no. 49, December 14, 2007.

21. Table 1.5 does not show US import data from China for chemicals. The value of US imports of chemicals from China in 2007 was small, only $13 million.

22. New climate bills are being introduced in the 111th Congress.

Table 1.5 US imports by origin of selected carbon-intensive products, 2007

Steel[a]

Rank	Country	Value (millions of US dollars)	Percent share
1	Canada	5,430	17.6
2	China	4,473	14.5
3	Mexico	2,530	8.2
4	Japan	1,794	5.8
5	Germany	1,704	5.5
6	Korea	1,610	5.2
7	Brazil	1,415	4.6
8	Taiwan	1,324	4.3
9	India	1,227	4.0
10	Italy	1,076	3.5
Memorandum:			
EU-27		7,643	24.7
OECD		19,728	63.8
Total imports from world		30,909	100.0

Cement[b]

Rank	Country	Value (millions of US dollars)	Percent share
1	Canada	387	29.2
2	China	246	18.6
3	Korea	121	9.1
4	Mexico	116	8.8
5	Colombia	105	7.9
6	Taiwan	99	7.5
7	Brazil	39	2.9
8	Greece	36	2.7
9	Thailand	33	2.5
10	Sweden	25	1.9
Memorandum:			
EU-27		111	8.4
OECD		751	56.7
Total imports from world		1,324	100.0

Paper[c]

Rank	Country	Value (millions of US dollars)	Percent share
1	Canada	9,509	53.1
2	China	2,093	11.7
3	Finland	1,063	5.9
4	Germany	906	5.1
5	Mexico	858	4.8
6	Japan	502	2.8
7	Korea	443	2.5
8	Indonesia	299	1.7
9	United Kingdom	219	1.2
10	Brazil	210	1.2
Memorandum:			
EU-27		3,231	18.0
OECD		14,769	82.4
Total imports from world		17,917	100.0

Aluminum[d]

Rank	Country	Value (millions of US dollars)	Percent share
1	Canada	7,769	55.7
2	Russia	1,467	10.5
3	China	826	5.9
4	Germany	655	4.7
5	South Africa	344	2.5
6	Brazil	336	2.4
7	United Arab Emirates	317	2.3
8	Venezuela	190	1.4
9	Argentina	184	1.3
10	Bahrain	174	1.2
Memorandum:			
EU-27		1,246	8.9
OECD		9,716	69.6
Total imports from world		13,958	100.0

systems. Each of these approaches has several nuances. While both approaches will impose costs on the US economy, one major difference in approaches is whether permits are assigned to private companies, thereby conferring valuable "quota rents" on the recipients, or whether limits are imposed by way of auction or taxes so that the government collects substantial revenues. Another major difference is the choice of activity where

Table 1.5 US imports by origin of selected carbon-intensive products, 2007 *(continued)*

		Chemicals[e]	
Rank	Country	Value (millions of US dollars)	Percent share
1	Trinidad & Tobago	1,033	22.6
2	Canada	919	20.1
3	Korea	556	12.1
4	Brazil	405	8.8
5	Venezuela	285	6.2
6	Netherlands	230	5.0
7	Equatorial Guinea	207	4.5
8	India	129	2.8
9	Argentina	110	2.4
10	Mexico	95	2.1
Memorandum:			
EU-27		459	10.0
OECD		2,047	44.7
Total imports from world		4,579	100.0

OECD = Organization for Economic Cooperation and Development

a. Standard International Trade Classification (SITC) 3-digit (672, 673, 674, 675, 676, 677, 678, 679).
b. SITC 4-digit (6612).
c. SITC 3-digit (641,642).
d. SITC 4-digit (6841, 6842).
e. SITC 5-digit (51111, 51112, 51113, 51122, 51123, 51124, 51211, 52251).

Note: US general imports based on general customs value. US general imports represent goods that arrive in the United States from foreign countries, whether such goods enter consumption channels immediately or are entered into bonded warehouses or foreign trade zones under customs custody.

Source: US International Trade Commission, Interactive Tariff and Trade Database, available at http://dataweb.usitc.gov (accessed on September 17, 2008).

limits are designed to "bite"—for example, on power generation and refineries, or also on transportation and manufacturing. Other parameters also differ between approaches, including the trading of permits, domestically and internationally; banking and borrowing of permits; and special auctions to curtail price spikes.

Carbon Tax Systems

These systems would levy charges in proportion to the carbon content of fuels and products. Economists generally favor carbon tax systems for three reasons. First, by contrast with cap-and-trade systems, which typically target only the larger sources of CO_2 emissions, a carbon tax would curtail emissions throughout the economy—importantly including elec-

tricity generation and transportation (the two US sectors that account for about three-quarters of total CO_2 emissions; see table 1.1). Second, in principle a carbon tax system can be fairly simple, easing the administrative burden. Third, the revenue raised through carbon taxes can be used to enlist the support of recalcitrant publics—for example, by financing Medicare.[23]

Offsetting these arguments is a powerful liability: the fact that a carbon tax is literally a "tax." This is the main reason why carbon tax systems have gained little political support in Congress. Moreover, a uniform tax per ton of carbon emitted would exert a highly differential price impact in percentage terms, depending on the fuel. For example, a tax of $100 per metric ton of carbon equivalent would increase the cost of residual fuel from petroleum by around 12 percent and the cost of bituminous coal by about 74 percent (table 1.6).[24]

Another argument against carbon taxes, perhaps unpersuasive to economists but often compelling to politicians, is that taxes do not set hard limits either on annual emissions or the stock of atmospheric CO_2. Environmental groups, inspired by apocalyptic visions and drawing on some scientific reports,[25] believe the time to enact hard limits is now, and anything less will pave the road to disaster.

Among the major bills listed in tables 1A.1 and 1A.2, two are based on carbon tax systems. One is the Save Our Climate Act (H.R. 2069), sponsored by Representative Fortney Pete Stark (D-CA); the other is the America's Energy Security Trust Fund Act (H.R. 3416), sponsored by Representative John Larson (D-CT). Both bills address the competitiveness concern by requiring equivalent taxes on imported goods (table 1A.2). Later we will examine the international dimension of the proposed border tax adjustments.

Cap-and-Trade Systems

Cap-and-trade systems enjoy far more support in Congress than carbon taxes, and the majority of bills reflect this fact. There are two reasons for this preference. First, cap-and-trade systems can be advertised as

23. As a similar inducement, former Vice President Al Gore has argued that carbon tax revenue can be used to lower payroll tax rates. See "Al Gore Suggests Carbon Tax Replace Payroll Taxes," Tax Foundation, December 19, 2006, www.taxfoundation.org (accessed on January 12, 2009).

24. For this comparison, as a baseline price of coal, we used the spot price of Illinois basin coal—$83 per short ton on August 29, 2008 (table 1.6). However, since electric utilities typically purchase on long-term contracts, the average delivered coal price in 2008 is likely to be lower than the spot price. Therefore, the 74 percent increase in the cost of bituminous coal due to a tax of $100 per metric ton of carbon equivalent is very likely an understatement.

25. For one example, see Matthews and Caldeira (2008).

Table 1.6 Carbon emissions and projected carbon taxes, by selected types of fuel

Fuel	Amount of CO_2 per unit[a] (pounds)	Amount of carbon per unit		Carbon tax per unit (in dollars) for following arbitrary tax amounts (assuming the same tax rate per metric ton of carbon emitted)			
		In pounds[b]	In metric tons[c]	$50	$100	$200	$400
Petroleum products (per barrel)							
Aviation gasoline	771	210	0.10	4.77	9.54	19.08	38.16
Distillate fuel	940	256	0.12	5.82	11.63	23.27	46.53
Jet fuel	886	242	0.11	5.48	10.96	21.93	43.85
Kerosene	905	247	0.11	5.60	11.19	22.39	44.77
Liquified petroleum gases	538	147	0.07	3.33	6.65	13.31	26.62
Motor gasoline	823	224	0.10	5.09	10.18	20.37	40.73
Petroleum coke	1,356	370	0.17	8.39	16.79	33.57	67.14
Residual fuel	1,093	298	0.14	6.76	13.53	27.06	54.12
Coal (per short ton)							
Anthracite	5,685	1,550	0.70	35.17	70.35	140.69	281.39
Bituminous	4,931	1,345	0.61	30.51	61.02	122.04	244.08
Subbituminous	3,716	1,013	0.46	22.99	45.98	91.96	183.93
Lignite	2,792	761	0.35	17.27	34.54	69.09	138.18

(table continues on next page)

Table 1.6 Carbon emissions and projected carbon taxes, by selected types of fuel *(continued)*

Memoranda:	
US price per unit (dollars)	
Petroleum, barrel (crude oil, as of August 29, 2008)	$110
Coal, short ton, spot price (Illinois basin, as of August 29, 2008)[d]	$83
CO_2 per million BTU used for electricity generation	
Petroleum (residual fuel)	174 pounds[e]
Coal (bituminous)	205 pounds[f]
Natural gas (pipeline)	117 pounds

a. Emission coefficients from US Energy Information Administration (EIA), available at www.eia.doe.gov.
b. To convert a quantity of CO_2 to a quantity of carbon, multiply by 12/44 (by definition used by the Environmental Protection Agency and the Intergovernmental Panel on Climate Change). See www.epa.gov.
c. 1 metric ton = 1.102 short ton = 2,204 pounds.
d. Spot price data from the EIA website at www.eia.doe.gov (accessed on September 8, 2008). Since electric utilities typically purchase on long-term contracts, the average delivered coal price in 2008 is lower than the spot price.
e. 1 metric ton of crude oil = 42.5 million BTU of crude oil.
f. 1 metric ton of coal = 23 million BTU of coal.

Sources: US Energy Information Administration, www.eia.doe.gov; US Environmental Protection Agency, www.epa.gov; Copenhagen Consensus Center, www.copenhagenconsensus.com. All websites accessed on January 12, 2009.

relatively painless, entailing little sacrifice from the general public. Second, meaningful caps will ripen into very valuable licenses, eventually worth hundreds of billions of dollars (see panel b in tables 1.2 and 1.3), and firms that are potentially affected want to claim part of the "quota rent," rather than see it entirely collected by the US Treasury in the form of carbon taxes or auctioned permits.

Under cap-and-trade systems, the federal government would establish a cap on total emissions and either assign or auction CO_2 and other greenhouse gas permits. Industrial holders of rights could emit annually at the specified levels. Moreover, holders could buy and sell permits. The core idea is that firms that are less able to cut greenhouse gas emissions will use all of their assigned rights and buy additional rights on the market; meanwhile, firms that are better able to cut emissions will sell some of their assigned rights.

Among the current climate bills, the Climate Security Act (S. 2191) sponsored by Senators Joe Lieberman (I-CT) and John Warner (R-VA) has received the most attention in Congress. In its original form, this bill was introduced in October 2007; after several amendments, it was reported favorably by the Senate Environment and Public Works Committee in December 2007. The Lieberman-Warner bill, based on a cap-and-trade system, requires a 70 percent reduction (from 2005 levels) in greenhouse gas emissions from covered sources by 2050. While the bill envisages the auction of some allowances, it includes transition assistance in the form of free allowances to certain industries, such as power plants and manufacturing firms, for the period between 2012 and 2030. The bill addresses concerns over the possible price volatility of allowances by including three provisions: auctioning some allowances; allowing firms to borrow permits from future periods; and establishing an "international reserve allowance" program. After adding a measure to ensure budget neutrality, the version of the act reported by the Environment and Public Works Committee was introduced in the Senate as S. 3036 on May 20, 2008. Shortly after, the Boxer substitute amendment to S. 3036 was introduced, but a cloture motion to limit debate on the Boxer amendment failed in June 2008.

In October 2008 House Energy and Commerce Chairman John Dingell and Energy and Air Quality Subcommittee Chairman Richard Boucher released their 461-page draft climate change bill. The draft proposed an 80 percent greenhouse gas emissions cut compared with 2005 levels by 2050. It covers roughly 88 percent of US emissions, including those from power plants, petroleum producers, and other major industrial polluters. As with many other proposed bills, the Dingell-Boucher bill would enable the Environmental Protection Agency (EPA) to regulate industrial emissions. Box 1.2 discusses the EPA and climate change. Table 1A.2 summarizes the draft.

The Lieberman-Warner bill and other cap-and-trade systems have

Box 1.2 The Environmental Protection Agency and climate change

In April 2007 the US Supreme Court ruled 5-4 in favor of petitioners in the case of *Massachusetts vs. EPA*.[1] In 1999 private organizations petitioned the Environmental Protection Agency (EPA) to regulate emissions of four greenhouse gases, including CO_2, from new motor vehicles, citing the EPA's duty described in Section 202 (a)(1) of the Clean Air Act.[2] However, in 2003 the EPA denied the Section 202 petition, asserting that it was not given the authority under the Clean Air Act to regulate CO_2 or other greenhouse gases, claiming they do not fall within the statutory definition of pollutants; moreover, even if the EPA had the authority to set greenhouse gas emissions standards, it would be "unwise to do so" owing to the scientific uncertainty in linking greenhouse gases to global warming. In response to the EPA's denial, Massachusetts along with other states, cities, and organizations sued the EPA.

Disagreeing with the EPA's assertions, the Supreme Court held: (1) EPA's action was not in accordance with law; (2) the Clean Air Act authorizes the EPA to regulate emissions from new motor vehicles based on their possible impact on climate change; and (3) Section 202 constrains EPA discretion once it determines that greenhouse gases contribute to climate change.

This ruling is very important in that it admonished the EPA to determine whether greenhouse gases are a dangerous pollutant to public health or welfare under the current law. Despite the court's ruling, however, the Bush administration and the EPA delayed the rule-making process. In July 2008 the EPA released an Advanced Notice of Public Rule-Making (ANPR), the first formal response to the Supreme Court's ruling in the *Massachusetts vs. EPA* case.[3] In the ANPR, the EPA stated that the Clean Air Act is "ill-suited" for the task of regulating greenhouse gases and urged Congress to enact comprehensive climate change legislation. Rather than making an "endangerment" finding that would in turn lead to regulating greenhouse gas emissions, the EPA in its ANPR further delayed the rule-making process by calling for a 120-day public comment period.

Despite the reluctant attitude of the Bush administration and the EPA, many discussions on Capitol Hill have centered on using the EPA and the Clean Air Act to regulate greenhouse gas emissions. In September 2008 the Senate Environment and Public Works Committee held a full committee hearing entitled "Regulation of Greenhouse Gases under the Clean Air Act." Several climate change bills introduced in the 110th Congress proposed to amend the Clean Air Act to regulate greenhouse gas emissions. Moreover, the Obama administration may use the Clean Air Act to regulate CO_2 emissions, a possibility expressed during the presidential campaign.[4]

Box 1.2 The Environmental Protection Agency and climate change

1. For more details on this case, see the syllabus and opinion of the US Supreme Court on the case (549 U.S. 497), available at www.supremecourtus.gov (accessed on January 12, 2009), and the summary report on the case by the Congressional Research Service, available at www.earthscape.org (by subscription).

2. The forerunner of the current Clean Air Act was the Air Quality Act of 1967. The Clean Air Act was amended in 1970, 1977, and 1990.

3. For more details and full text of ANPR, visit the EPA website at www.epa.gov (accessed on January 12, 2009).

4. See Jim Efstathious, Jr., "Obama to Declare Carbon Dioxide Dangerous Pollutant," Bloomberg News, October 16, 2008, www.bloomberg.com (accessed on January 12, 2009).

evolved in the direction of hybrid systems with various market-based measures (notably auctions). They promise to be complex for three reasons:

- They guarantee a series of intense lobbying battles over initial permit allocations, subsequent renewals, and systems for auctioning licenses.
- How they would interact with state and regional limits on greenhouse gas emissions is not clear.
- How they would interact internationally with the climate policies of other nations is far from obvious.

A central concern of this study is the international dimension of cap-and-trade systems.

Appendix 1A

Table 1A.1 Major climate change bills of the 110th Congress (without competitiveness provisions)

	S 485: Global Warming Reduction Act	HR 1590: Safe Climate Act
Sponsor	Senators John Kerry and Olympia Snowe	Representative Henry Waxman
Status in Congress	Introduced on February 1, 2007	Introduced on March 20, 2007
Scope	All six greenhouse gases economywide	All six greenhouse gases economy-wide
First year of emissions cap	2010	2010
Emissions reduction targets	Mandatory caps ■ 2010: 2010 level ■ 2020: 1990 level ■ 2021–30: reduce by 2.5 percent per year ■ 2031–50: reduce by 3.5 percent per year ■ 2051: 62 percent below 1990 levels Long term: 2°C or less above preindustrial temperature level	Mandatory caps ■ 2010: 2009 levels ■ 2011–20: reduce by 2 percent per year ■ 2021–50: reduce by 5 percent per year ■ 2050: 80 percent below 1990 levels Long term: no targets
Allowance allocation	The president determines allocation/ auction split	The president determines allocation/ auction split
Offset provisions	■ Banking permitted and no specific provision on borrowing ■ Offsets generated from biological sequestration	■ No explicit provision on use of domestic and international offsets ■ Banking permitted and no specific provision on borrowing
Technology incentives	■ Funds and incentives for technology R&D, consumer impacts, and adaptation ■ Standards for vehicles, efficiency, and renewables	■ Standards for vehicles, efficiency, and renewables
Other key provisions	■ Establishes a Climate Reinvestment Fund and a national Climate Change Vulnerability and Resilience Program ■ Periodic evaluations	■ Establishes a Climate Reinvestment Fund and Renewable Portfolio Standards ■ Periodic evaluations

Table 1A.1 Major climate change bills of the 110th Congress (without competitiveness provisions) *(continued)*

	S 280 (related to HR 620): Climate Stewardship and Innovation Act	S 317: Electric Utility Cap and Trade Act
Sponsor	Senators Joseph Lieberman and John McCain	Senators Diane Feinstein and Tom Carper
Status in Congress	Introduced on January 12, 2007	Introduced on January 17, 2007
Scope	■ All six greenhouse gases economywide ■ Upstream for transportation sector; downstream for electric utilities and large sources[a]	All six greenhouses, electricity sector cap (only power plants)
First year of emissions cap	2012	2011
Emissions reduction targets	Mandatory caps ■ 2012: 2004 level ■ 2020: 1990 level ■ 2030: 20 percent below 1990 level ■ 2050: 60 percent below 1990 level Long term: no targets	Mandatory caps ■ 2014: 2006 levels ■ 2015: 2001 levels ■ 2016–20: reduce by 1 percent per year ■ After 2020: reduce by 1.5 percent per year Long term: no targets
Allowance allocation	Administrator determines allocation/auction split	■ 85 percent free to industry, based on generation (updated annually), and phased out by 2036
Offset provisions	■ 30 percent limit on use of international credits and domestic reduction or sequestration offsets ■ Borrowing for five-year periods with interest; banking permitted	■ International offsets up to 25 percent of cap ■ Extensive domestic biological offsets ■ Banking and limited borrowing of allowances permitted
Technology incentives	■ Funds for research and development (R&D) on advanced coal, renewable electricity, energy efficiency, advanced technology vehicles, etc. ■ Incentives for mitigating impact on poor	■ Funds for technology programs, including a low-carbon technologies program; a clean coal technologies program; and an energy efficiency technology program ■ Funds for adaptation and mitigation activities
Other key provisions	■ Establishes a Climate Change Credit Corporation to reduce costs to consumers and a Climate Technology Financing Board ■ Periodic evaluations to determine whether emissions targets are adequate	■ Establishes a Climate Science Advisory Panel; a safe climate level; and a Climate Action Trust Fund to carry out this act ■ Periodic evaluations

(table continues on next page)

Table 1A.1 Major climate change bills of the 110th Congress (without competitiveness provisions) *(continued)*

	S 309: Global Warming Pollution Reduction Act
Sponsor	Senators Bernard Sanders and Barbara Boxer
Status in Congress	Introduced on January 16, 2007
Scope	All six greenhouse gases economywide
First year of emissions cap	2010
Emissions reduction targets	Mandatory caps ■ 2010–20: reduce by 2 percent per year to 1990 level ■ 2030: 27 percent below 1990 level ■ 2040: 53 percent below 1990 level ■ 2050: 80 percent below 1990 level Long term: stable at 450 ppm
Allowance allocation	■ Cap and trade permitted but not required ■ Allocation criteria include transition assistance and consumer impacts
Offset provisions	■ No limit on use of domestic biological sequestration ■ No specific provisions on borrowing and banking
Technology incentives	■ Funds for R&D on geologic sequestration ■ Standards for vehicles, power plants, efficiency, renewables, and bio sequestration
Other key provisions	■ Establishes a task force on international clean, low-carbon energy cooperation; a renewable portfolio standard and credit program; and a new low-carbon generation requirement and trading program ■ Periodic evaluations

a. An upstream approach is the one that requires fuel producers to submit allowances or pay a tax for emissions attributable to their products. By contrast, a downstream approach requires the final emission source (e.g., a manufacturing firm) to submit allowances or pay a tax.

Sources: Pew Center on Global Climate Change, "Economy-wide Cap-and-Trade Proposals in the 110th Congress as of October 20, 2008" (available at www.pewclimate.org); Resources for the Future, "Summary of Market-Based Climate Change Bills Introduced in the 110th Congress" (available at www.rff.org); Lieberman and Beach (2007); GovTrack website (www.govtrack.us); Congressional Research Service (2008). All websites accessed on January 12, 2009.

Table 1A.2 Major climate change bills of the 110th Congress (with competitiveness provisions)

	S 1766: Low Carbon Economy Act	HR 6316: Climate Matters Act of 2008
Sponsor	Senators Jeff Bingaman and Arlen Specter	Representative Lloyd Doggett
Status in Congress	Introduced on July 11, 2007	Introduced on June 19, 2008
Scope	■ All six greenhouse gases economywide ■ Upstream for natural gas and petroleum; downstream for coal	■ All six greenhouse gases economywide ■ Upstream for transport fuels and natural gas; downstream for large sources and large coal users
First year of emissions cap	2012	2012
Emissions reduction targets	Mandatory caps ■ 2012: 2012 level ■ 2020: 2006 level ■ 2030: 1990 level	Mandatory caps ■ 2012: 2012 level ■ 2020: 1990 level ■ 2050: 80 percent below 1990 level
Allowance allocation	■ Increasing use of auctions: 24 percent from 2012–17, rising to 53 percent in 2030 ■ Sector allocations are specified, including 9 percent to states, 53 percent to industry, declining 2 percent per year starting in 2017 ■ 5 percent set-aside of allowances for agriculture	■ Increases use of auctions: 85 percent at beginning and rising to 100 percent in 2020 ■ Beginning in 2012, 5 percent of allowances to power plants and 10 percent to energy intensive manufacturers, phased out by 2020
Offset provisions	■ President may implement use of international offsets subject to 10 percent limit ■ $12 per ton of CO_2 equivalent "technology accelerator payment" starting in 2012 and increasing 5 percent per year above inflation ■ Banking permitted and no specific provision on borrowing	■ Limits on use of offsets: 10 percent domestic offsets; 15 percent international allowances; and 15 percent international forest allowances ■ Banking permitted; the Carbon Market Efficiency Board may permit borrowing
Technology incentives	■ Bonus allocation for carbon capture and storage ■ Funds and incentives for research and development (R&D)	■ Funds for energy efficiency and transportation

(table continues on next page)

Table 1A.2 Major climate change bills of the 110th Congress (with competitiveness provisions) *(continued)*

Other key provisions	■ Establishes an Energy Technology Deployment Fund; a Climate Adaptation Fund; and an Energy Assistance Fund ■ Periodic evaluations	■ Amends the Internal Revenue Code to establish a system for accounting of greenhouse gas emission allowances ■ Establishes a Carbon Market Efficiency Board to analyze information on the greenhouse gas emission allowance market ■ Establishes the Deficit Reduction Trust Fund and the Citizen Protection Trust Fund
Competitiveness provisions	■ Establishes an interagency group to review comparable action by foreign countries with respect to greenhouse gas emissions ■ Beginning in 2019, requires a US importer of greenhouse gas–intensive goods from a country that does not take comparable emission reduction action to buy these allowances, unless the importer proves a sufficient number of "international reserve allowances" (denominated in units of metric tons of CO_2 equivalent), or the importer shows that the goods are not subject to the program	■ Directs the Secretary of the Treasury to establishes an International Reserve Allowance Program and requires a US importer of greenhouse gas intensive goods to buy and submit required amount of allowances ■ Establishes the International Climate Change Commission to determine annually whether a World Trade Organization (WTO) participant country has taken certain action to limit its greenhouse gas emissions ■ Under the international reserve allowance program, allowance sales proceeds shall be used to mitigate the negative impacts of global change on disadvantaged communities in WTO participant countries
	HR 2069: Save Our Climate Act	**HR 3416: America's Energy Security Trust Fund Act**
Sponsor	Representative Fortney Pete Stark	Representative John Larson
Status in Congress	Introduced on April 26, 2007	Introduced on August 3, 2007
Scope	Economywide tax: fossil fuels taxed by CO_2 content at the point of production and import	Economywide tax: fossil fuels taxed by CO_2 content at the point of production and import
Emissions regulations	■ Amends the Internal Revenue Code to impose a tax on primary fossil fuels based on their carbon content ■ Imposes carbon tax at $10 per ton of carbon content when the fuel is either extracted or imported ■ The tax would increase $10 per ton every year until the Energy Department and Internal Revenue Service determine that US emissions of CO2 have dropped 80 percent from 1990 levels	■ Amends the Internal Revenue Code to impose an excise tax on any taxable carbon substance sold by a manufacturer, producer, or importer ■ Imposes taxes at $15 per ton in its first year for every ton of carbon dioxide emissions from the oil, gas, and coal industries, with the tax rising 10 percent annually faster than the cost of living adjustment each year

Table 1A.2 Major climate change bills of the 110th Congress (with competitiveness provisions) *(continued)*

Allowance allocation	100 percent revenue to US Treasury	1/6 of revenues to R&D, 1/12 to industry transition assistance with phase-out, remainder to payroll tax rebates
Offset provisions	Tax refunds for fuel CO_2 sequestered downstream: carbon capture and storage[a] or used to make plastics	Tax refunds for domestic sequestration and HFC destruction projects
Technology incentives	No provisions	1/5 of tax revenues up to $10 billion annually goes to clean technology R&D
Other key provisions	No provisions	Creates a trust fund (known as America's Energy Security Trust Fund) in the Treasury
Competitiveness provisions	■ Imposes equivalent taxes on imported products ■ No tax shall be imposed on the sale by the manufacturer or producer of any taxable fuel for export	■ Imposes equivalent taxes on imported products ■ No tax shall be imposed on the sale by the manufacturer or producer of any taxable fuel for export
	S 3036: Lieberman-Warner Climate Security Act of 2008	**Discussion Draft: Dingell-Boucher Bill (as released on October 7, 2008)**
Sponsor	Senator Barbara Boxer	Representatives John Dingell and Richard Boucher
Status in Congress	■ Introduced in the Senate on May 20, 2008 ■ Replaced S 2191: S 2191 was introduced on October 18, 2007 and the version was passed by the Senate Environment & Public Works Committee on December 5, 2007 ■ Cloture motion on the Boxer substitute was rejected on June 6, 2008	■ A discussion draft released on October 7, 2008
Scope	■ All six greenhouse gases economywide ■ Upstream for transport fuels and natural gas; downstream for large coal users; separate cap for hydrofluorocarbons (HFC) consumption	■ All six greenhouse gases plus NF_3, economywide ■ Upstream for transport fuels and natural gas; downstream for electric utilities and large sources
First year of emissions cap	2012	Not specified
Emissions reduction targets	Mandatory caps ■ 2012: 4 percent below 2005 level ■ 2020: 19 percent below 2005 level ■ 2050: 71 percent below 2005 level	Mandatory caps ■ 2020: 6 percent below 2005 level ■ 2030: 44 percent below 2005 level ■ 2050: 80 percent below 2005 level

(table continues on next page)

Table 1A.2 Major climate change bills of the 110th Congress (with competitiveness provisions) *(continued)*

Allowance allocation	■ Increasing use of auctions: 24.5 percent in 2012 (includes 5 percent early auction), rising to 58.8 percent from 2032–50 ■ Free allowances totaling 75.5 percent in 2012 are specified, including 18 percent to power plants and 11 percent to manufacturers (both transition to zero in 2031), 12.75 percent to electricity and natural gas local distribution companies for consumers, and 15 percent to states ■ 4.25 percent set-aside of allowances for domestic agriculture and forestry	Four options for allocating allowance value: 1) most value to regulated entities; 2) less value to regulated entities and more value to complementary greenhouse gas reduction programs; 3) some value to adaptation and international programs; 4) most value to consumer rebates
Offset provisions	■ International offsets up to 15 percent and domestic offsets up to 15 percent ■ Banking permitted and borrowing up to 15 percent per company	■ Increasing use of offsets, including both domestic and international offsets: 5 percent initially, rising to 35 percent by 2024 ■ Borrowing up to 15 percent per company
Technology incentives	■ Funds and incentives for zero- or low-carbon energy technologies, advanced coal and sequestration technologies, production of fuel from cellulosic biomass, advanced technology vehicle manufacturing, and sustainable energy	■ Funds for energy efficiency and clean technologies, including carbon capture and storage and renewables
Other key provisions	■ Establishes a domestic offset program to sequester greenhouse gases, the Bonus Allowance Account for carbon capture and sequestration projects; the Carbon Market Efficiency Board; Climate Change Credit; and the Deficit Reduction Fund ■ Establishes and provides for the deposit of auction proceeds to and allocations from the (1) Energy Assistance Fund; (2) Climate Change Worker Training Fund; (3) Adaptation Fund; (4) Climate Change and National Security Fund; (5) Bureau of Land Management Emergency Firefighting Fund; (6) Forest Service Emergency Firefighting Fund; and (7) Climate Security Act Management Fund ■ Performance and targets subject to three-year National Academy of Sciences review	■ Establishes Bonus Allowance Accounts for carbon capture and storage, renewables projects ■ Establishes a Renewable Energy Worker Training Program; an Industrial Energy Engineer Apprenticeship program to provide industrial energy efficiency expertise; and a Natural Resources Adaptation Program ■ Establishes several funds such as the Climate Change Management Fund; National Energy Efficiency Fund; Low-Income Consumer Climate Change Rebate Fund; Consumer Climate Change Rebate Fund; Supplemental Greenhouse Gas Reduction Fund; Green Jobs Fund; National Climate Change Adaptation Fund; and International Clean Technology and Adaptation Fund

Table 1A.2 Major climate change bills of the 110th Congress (with competitiveness provisions) *(continued)*

Competitiveness provisions	■ Establishes an interagency group to review comparable action by foreign countries with respect to greenhouse gas emissions and an Interagency Climate Change Task Force ■ Establishes an International Reserve Allowance Program during the one-year period beginning on January 1, 2019 ■ Beginning in 2019, requires a US importer of greenhouse gas–intensive goods to buy and submit required amount of allowances. The proceeds from sales of such allowances to be used to mitigate the negative impacts of climate change on other countries' disadvantaged communities ■ Requires a US importer to submit, in lieu of international reserve allowances issued under the section, a foreign allowance or similar compliance instrument distributed by a foreign country pursuant to a cap-and-trade program that represents a comparable action, or a foreign credit or a credit for an international offset project that the administrator has authorized ■ Not later than January 1, 2023, and annually thereafter, the president shall prepare and submit to Congress a report that assesses the effectiveness of the applicable international reserve allowance requirements under section 6006 with respect to the covered goods of each covered foreign country	■ Establishes an International Climate Change Commission to review comparable action by foreign countries with respect to greenhouse gas emissions, on an annual basis starting no later than 2013 ■ Establishes an International Reserve Allowance Program ■ Requires a US importer of covered products to buy and submit required amount of allowances, or cash, bonds or other security in an amount sufficient to cover purchase of the required amount of international reserve allowances; the proceeds from sales of such allowances to be used to mitigate the negative impacts of climate change on other countries' disadvantaged communities ■ Requires a US importer of covered product to declare to US Customs and Border Protection either that the imported products were not produced or processed in any foreign country on the covered list, or that the imported products are subject to the international reserve allowances requirements ■ Requires a US importer of covered product to submit, in lieu of international reserve allowances issued under the section, a foreign allowance or similar compliance instrument distributed by a foreign country

a. Carbon capture and storage refers to technologies that remove carbon from the exhaust streams of fossil fuel burning plants and store the carbon underground indefinitely.

Sources: Pew Center on Global Climate Change, "Economy-wide Cap-and-Trade Proposals in the 110th Congress as of October 20, 2008" (available at www.pewclimate.org); Resources for the Future, "Summary of Market-Based Climate Change Bills Introduced in the 110th Congress" (available at www.rff.org); Lieberman and Beach (2007); GovTrack website (www.govtrack.us); Congressional Research Service (2008). All websites accessed on January 12, 2009.