CAP-AND-TRADE VERSUS CARBON TAX
TWO APPROACHES TO CURBING GREENHOUSE GAS EMISSIONS

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Policymakers evaluating strategies for reducing greenhouse gas (GHG) emissions have two general approaches to consider. A **cap-and-trade** system curbs emissions by limiting the *quantity* of a pollutant (e.g., carbon dioxide [CO_2]) that can be emitted and then allocating a corresponding number of tradable emissions permits to sources covered by the program. A **carbon tax** curbs emissions by raising the *price* of fossil fuels based on their carbon content. Each approach has advantages and disadvantages, and a well-designed system of either type will be more effective than a poorly designed system of the other type.

CAP-AND-TRADE

With this approach, a regulatory body (e.g., the federal government) sets a cap on emissions of a particular pollutant (e.g., CO_2) from a designated group of polluters (e.g., power plants). The total emissions allowed under the cap are divided into individual permits, each representing the right to emit a certain quantity of the pollutant (e.g., one ton of CO_2). The permits are then allocated to the sources covered by the program. (There are a variety of allocation methods, including free distribution to the capped entities, an auction, or some combination of the two.) At the end of the compliance period (e.g., one year), each regulated source must report all emissions and surrender an equivalent number of permits, to be retired from the system.

Since the total number of permits is limited by the cap, the permits take on financial value and can be traded on the open market. Companies that are able to reduce their emissions at low cost can sell their surplus permits to companies for whom the cost of reducing emissions is high. Each company has the flexibility to choose how to meet its emissions target, but market incentives encourage companies to invest in new technologies or employ conservation measures to lower the cost of reducing emissions. Over time, the emissions cap is tightened to achieve more aggressive pollution-reduction targets, requiring companies to adjust their strategies to comply with the new levels.

Acid Rain Program: An example of cap-and-trade

The most successful cap-and-trade system to date is the Acid Rain Program created under the 1990 Clean Air Act Amendments. It set a permanent cap on the total amount of sulfur dioxide (SO_2) that could be emitted by electric power plants across the country. At full implementation in 2010—after increasingly stringent emissions limits have been imposed—the program is expected to have reduced annual SO_2 emissions to one-half the amount emitted in 1980.[1]

Regulated sources (electric power plants) are allocated allowances (permits) based on historic fuel consumption and emissions rates prior to the start of the program. At the end of each year, every source must hold enough allowances to cover its emissions for the year. The allowances needed to match its emissions are deducted from the utility's compliance account and retired from the system. Sources that have excess allowances may sell them or bank them to use or sell in future years. Emissions trading gives each source the flexibility to design its own compliance strategy. Monitoring and stiff penalties promote compliance.

Design Considerations—Scope and Point of Regulation[2]
Designing an effective cap-and-trade program to reduce GHG emissions is far more complex than was creating a system to reduce emissions of SO_2. The Acid Rain Program covered just one sector—electric power plants, the principal source of SO_2 emissions. Major sources of CO_2 and other GHGs, on the other hand, include electric power plants, transportation, industry, residential and commercial sectors, and agriculture.

Deciding which GHGs and emissions sources to include and where in the fossil fuel supply chain the point of regulation will occur are key issues for policymakers.

Upstream cap-and-trade. An upstream program is implemented where carbon enters the economy. It requires *producers and importers* of fossil fuels to submit allowances equal to the carbon emissions released when their fuel is burned. The producers pass along the cost of the allowances to fuel consumers, and the higher prices in turn encourage adoption of fuel- and energy-saving technologies and practices. An upstream program can cover virtually all fossil-fuel-based emissions while keeping administrative costs low because only a relatively small number of firms need to be regulated.[3]

Downstream cap-and-trade. A downstream program is implemented where GHGs are emitted. It can apply *economy-wide* to all GHG emissions sources, which would involve regulation of large stationary sources as well as vehicles, small industrial and commercial sources, and the residential sector—presenting huge administrative challenges. Or the program can apply only to *large stationary sources*, such as electricity generators and large industrial facilities. Although more manageable administratively, this latter approach would cover only about 50 percent of GHG emissions.[4]

Upstream/downstream cap-and-trade. This approach combines downstream regulation of large stationary sources of emissions with upstream regulation of fossil fuels used by other sectors (e.g., transportation fuels, natural gas). The design challenge is to ensure that each ton of emissions is counted only once in the system. Upstream fuel suppliers, for example, would be required to hold permits covering the carbon content of their fuels—except for those fuels to be delivered to electricity generators, who would be required to hold permits for their emissions. This would increase the administrative complexity of the program.

Sectoral hybrid program. This option combines downstream regulation of large stationary sources with upgraded efficiency standards for smaller sources, such as vehicles, appliances, and residential and commercial buildings. It builds on existing efficiency standards programs and would achieve coverage of roughly 80 percent of energy-related CO_2 emissions without the problem of the potential double-counting of emissions. On the other hand, efficiency standards do not provide incentives to reduce usage, and it would take time for the more efficient products to penetrate the system.[5]

Emissions reductions from sources that are not easily covered by a cap-and-trade program (e.g., methane emissions from landfills and from the agricultural sector) can be encouraged through complementary measures such as an offset program.[6]

Design considerations—Method of Allowance Distribution[7]
Allowances are extremely valuable assets, worth tens, perhaps hundreds, of billions of dollars a year, so the way they are distributed has important implications for the equity of the program.

Free distribution. Allowances could be given free of charge to the capped entities according to one of several allocation methods—based on their historic emissions ("grandfathering"), their current level of emissions, or some environmental performance "benchmark." This approach is meant to compensate regulated firms, in whole or in part, for the cost of the emissions reduction program. Research indicates, however, that most of the cost of meeting the emissions cap would be passed on to consumers in the form of higher prices, leaving the regulated entities with substantial profits.[8]

Auction. Alternatively, the government could sell the needed allowances to the regulated entities through an auction. This method would generate sizable revenues that could then be used to achieve other desired goals. Among the options: help consumers cope with higher energy prices by rebating auction proceeds to every citizen (*cap-and-dividend*); target the dividends to lower-income households (*cap-and-buffer*); fund low-income weatherization programs (*cap-and-caulk*); invest auction revenues in the development of clean energy technologies and energy efficiency improvements (*cap-and-invest*); and/or reduce existing taxes that dampen economic activity (e.g., payroll or income taxes).

Hybrid. A mix of free distribution and auction of allowances could also be used. A portion of the allowances could be distributed free for the first few years, for example, to sectors and/or regions of the country that would be more adversely affected by the emissions cap. Over time, the free allocations could be phased out entirely.

Design considerations—Flexibility and Cost Controls[9]

Most cap-and-trade proposals include provisions to address the potential volatility in the price of allowances and/or to contain costs. Some features help limit price volatility by providing firms with flexibility as to when and where to achieve their emissions reductions. Others provisions provide assurance that the cost of compliance will not climb beyond a specified level.

Banking. This feature adds flexibility by allowing capped entities to save unused allowances for use in future years. Firms would have an incentive to bank allowances when the cost of making larger-than-needed emissions reductions is lower than they expect costs to be in the future. Banking would boost demand for permits when the price was relatively low (because of a mild winter, for example), helping to maintain incentives for investment in low-carbon technologies. And it would encourage larger emissions reductions in the near term, resulting in earlier progress towards environmental goals.

Borrowing. This provision would allow companies to borrow allowances from future years and pay them back (perhaps with interest) by reducing emissions more sharply in the future. It would provide relief if permit prices spiked unexpectedly and would give firms more time to modify their operations. (Multi-year compliance periods would provide similar flexibility.) Limiting the amount of borrowing and the length of the payback period could help preserve the integrity of the cap over the long term. Safeguards would be needed to ensure repayment.

Offsets. These are GHG reductions from sources not covered by the cap-and-trade program and that regulated entities can use to meet their compliance obligations. Firms could cover some of their emissions by purchasing credits created through offset projects, such as methane capture at a landfill or avoided deforestation. An offset program can significantly reduce compliance costs by providing access to lower-cost emissions reduction options. The program could be limited to domestic projects or could include international projects as well. The quantity of offsets could also be limited so as to maintain incentives for investment in new clean-energy technologies.

Care must be taken to ensure that only high-quality offset projects are included—lest the environmental goals of the cap-and-trade program be compromised. Emissions reductions must be real, additional (beyond what would have occurred anyway), verifiable by an independent third party, permanent, and enforceable.

Safety valve. This cost-containment provision would establish a "ceiling" on the price of allowances. If the permit price rose to this pre-determined level, the government could sell additional permits at this ceiling price—or firms could be allowed to pay into a fund instead of acquiring additional permits—thus allowing emissions to exceed the cap. By ensuring that the price of allowances would not exceed a certain level, this feature could reduce firms' incentives to invest in more expensive clean-energy technologies, which might be needed to achieve emissions-reduction goals. And by permitting firms to purchase additional allowances rather than make emissions reductions, it would allow firms to delay action into the future, thereby undermining the environmental effectiveness of the cap.[10]

Circuit breaker. This mechanism would freeze a gradually declining emissions cap if the permit price rose above a predetermined level. It would offer firms some protection from high compliance costs if the development of new technologies lagged behind the pace of the cap's decline. Such a feature, however, could undercut incentives to invest in low-carbon technologies and delay achievement of environmental goals.

CARBON TAX

As typically envisioned, a carbon tax would be imposed on fossil fuel suppliers at a rate that reflects the amount of carbon that will be emitted when the fuel is burned. The tax would be included in the price of the coal, oil and natural gas supplied to wholesale users and ultimately passed on to consumers in the price of electricity, gasoline and other energy-intensive products. Coal, which generates the greatest amount of carbon per unit of energy (BTU), would be taxed at a higher rate per BTU than oil or natural gas.[11] By raising the price of carbon-based energy, the tax would create incentives to reduce energy use, stimulate demand for more energy-efficient products, and promote a shift to cleaner fuels and renewable energy.

A federal carbon tax would affect all sectors of the economy. Tax proponents suggest that it be levied at the wholesale stage as far "upstream" as practicable—namely at the point at which the fossil fuel passes from the producer (e.g., the coal mine, oil tanker, or natural gas wellhead) to the next entity in the supply chain. Electric power generators, for example, would pay the tax on the coal, oil, or natural gas they purchase and then pass the cost on to retail electric utilities "downstream," which in turn would pass it along in the rates they charge their customers.[12]

A carbon tax could be revenue-neutral: all revenues could be rebated directly to every citizen (*tax-and-dividend*) or could be used to reduce existing taxes (*tax-and-shift*). Alternatively, revenues could be invested in development and deployment of new clean-energy technologies (*tax-and-invest*) and/or in energy efficiency programs (*tax-and-caulk*).

The carbon tax can be set to reflect what economists call the social cost of carbon (SCC), "the present value of additional economic damages now and in the future caused by an additional ton of carbon emissions." Estimates of SCC vary widely, reflecting uncertainty about future climate change scenarios and disagreement as to how to value the impact of projected climate damages. Peer-reviewed estimates of SCC for 2005 have an average value of $12/metric ton of CO_2.[13]

The tax rate could also be designed to achieve a given stabilization target. An analysis of three energy-economic models estimates that a carbon price trajectory consistent with stabilizing atmospheric CO_2 at 450 parts per million (ppm) would require that the price on emissions reach $25-$70/ton CO_2 by 2020 and continue rising to $127-$230/ton CO_2 by 2050.[14]

The Carbon Tax Center proposes a revenue-neutral "starter" tax of $10/ton CO_2, increasing by $10/ton CO_2 each year for 20 years. Each $10/ton CO_2 charge would raise the price of gasoline by 10¢/gallon and the price of electricity by an average of roughly 0.66¢/kWh. It also would generate $55 billion in revenue and would reduce CO_2 emissions by about 4 percent.[15]

COMPARING THE TWO APPROACHES

A cap-and-trade system and a carbon tax are both market-based policy instruments that create incentives to reduce carbon emissions. A cap-and-trade system is a *quantity-based* instrument; it fixes the total quantity of emissions and allows the price of energy and energy-related products to fluctuate according to market forces. A carbon tax is a *price-based* instrument; it fixes the price of carbon-based energy and allows emissions levels to vary according to economic activity.

Emissions certainty

The strength of the **cap-and-trade** approach is that it can set firm limits on emissions. The cap is set at a level designed to achieve a desired environmental outcome (e.g., reduction of emissions to 80 percent of 1990 levels by 2050), and individual companies have the flexibility to choose how they will achieve their emissions targets. (A "flexible cap" approach, on the other hand—one that includes a safety valve feature, for example—would no longer provide certainty that emissions reduction targets will be met.)

A **carbon tax** does not guarantee achievement of a particular emissions target. It allows the quantity of emissions to fluctuate as the demand for energy rises or falls. Allowing emissions to vary from year to year gives firms the flexibility to abate less and pay more in taxes when abatement costs are unusually high (and vice-versa when abatement costs are low). The tax could be designed to rise steadily over time to achieve a certain stabilization target (e.g., a concentration of atmospheric CO_2 of 450 ppm by 2100).

Price predictability

The advantage of a **carbon tax** is that it can fix the price of carbon emissions. It creates a permanent incentive to reduce emissions, and if set at the appropriate level, it encourages investment in alternative fuels and energy-efficient technologies that have high up-front costs.

Under a **cap-and-trade** system, the price of emissions permits may vary considerably from year to year. An especially cold winter, for example, or sudden growth in a particular industry could increase the demand for energy and cause a spike in the price of permits. This potential volatility could have a disruptive effect on markets for energy and energy products and could make business planning more difficult.

Both major cap-and-trade programs in existence today—the Acid Rain Program and the European Union's Emissions Trading Scheme (ETS)—have experienced significant volatility in the price of emissions permits. In the case of the Acid Rain Program, SO_2 prices fluctuated considerably in the early years of the program and then spiked dramatically in 2004-2005, despite a large bank of allowances. During the three-year ETS trial period (2005-2007), allowance prices that were initially high dropped precipitously in April 2006—after it was discovered that emissions were significantly lower than expected, causing the demand for allowances to plummet.[16]

Environmental effectiveness
The effectiveness of a **cap-and-trade** system depends on a variety of design features. (1) How stringent is the emissions reduction timetable? Will reductions be deep enough to have a meaningful impact on climate change? (2) How will baseline emissions be measured and a corresponding and appropriate number of emissions permits be determined and distributed? (3) Will the cap be applied economy-wide or to only certain sectors or sources? (4) What types of cost-control measures, if any, are included? Are they set high enough to spur investment in clean energy technologies? (5) Will any revenues be generated? Will any portion of these be invested in energy efficiency and low-carbon technologies?

Similar issues must be addressed in designing a **carbon tax** system, such as whether a credible commitment has been made to keep the tax in place, whether exemptions will be granted to certain sectors or industries, and how revenues will be used. Basically, however, the effectiveness of the tax depends in large part on whether the tax rate is set high enough to create real market incentives that lead to developing and adopting climate-friendly technologies. An economy-wide tax that is scheduled to rise steadily over time sends a consistent and long-term price signal that encourages investment in clean energy technologies and energy efficiency.

Equity
Both a carbon tax and a cap-and-trade system raise the cost of products like electricity and gasoline. These price increases would disproportionately affect lower-income households inasmuch as they spend a larger percentage of their income on energy products than do higher-income households. The way in which the two regulatory systems handle any revenues they raise would determine the extent to which each is able to reduce this disparity.

A **carbon tax** directly raises substantial revenues. If the revenues were rebated equally to all citizens or used to reduce regressive taxes (e.g., the federal payroll tax), it would return more money (in rebates or tax savings) to lower-income households (and to people who take steps to reduce their energy consumption) than they would pay in carbon taxes. In contrast, wealthier households, which use more energy on average (flying, driving, living in big houses), would pay more in carbon taxes than they would receive in rebates or tax savings.[17]

Similarly, a **cap-and-trade** system that auctioned permits to the capped entities would generate sizable revenues that could be rebated to citizens or used to reduce other taxes, thereby offsetting the regressive effects of higher energy prices. Free distribution of the permits, on the other hand, could lead to significant windfall profits for the firms receiving the permits. Research indicates that only a modest portion of the allowance value—less than 15 percent—is needed to compensate for the cost of meeting the cap. The remainder would be passed along in higher prices to consumers "downstream."[18]

Simplicity and transparency
A **cap-and-trade** system would require a new administrative structure—a system to allocate emissions permits, markets where firms can buy and sell those permits, and a means of monitoring emissions and trades. Free permit allocation would make it difficult to estimate the economic impact of the cap-and-trade system on consumers and industries. Auctioning permits, on the other hand, would create a clear carbon price signal and provide greater transparency to the system.[19]

A **carbon tax** could build on the well-developed administrative structure of existing taxes, such as the current excise taxes on coal and petroleum.[20] A tax based on BTU heat units—already standardized and quantifiable—would fairly reflect the carbon content of each type of fuel.[21] The underlying premise of a carbon tax—that the price of energy and energy-intensive products should include the environmental costs associated with their production and use—is transparent and readily understood

LOOKING AHEAD

Numerous legislative proposals addressing global climate change were introduced during the 110th Congress (2007-2008), including ten economy-wide cap-and-trade bills. The Lieberman-Warner Climate Security Act (S. 2191) received the most attention—from lawmakers and the public—and was the first GHG cap-and-trade bill ever to be voted out of committee. It sought a 70 percent reduction in GHG emissions from covered sources (representing 80 percent of total U.S. emissions), with "upstream" regulation for transport fuels and natural gas and "downstream" regulation for large coal users and GHG manufacturers. Two carbon tax bills were also introduced, one starting at $10/ton of carbon and the other starting at $15/ton of CO_2. There is every expectation that addressing climate change will be a priority for the 111th Congress.[22]

In the absence of action on climate change at the federal level, a number of states have joined forces to launch regional emissions-trading programs.

> The **Regional Greenhouse Gas Initiative** (RGGI) is a cooperative effort of ten Northeast and Mid-Atlantic states that took effect on January 1, 2009. It establishes a "downstream" cap-and-trade program for CO_2 emissions from power plants of at least 25 megawatts in size. The initial cap for the ten states was set at (approximately) 2009 levels and, starting in 2015, is scheduled to decline 10 percent by 2018. Allowances are to be distributed primarily by auction, with proceeds used to promote energy efficiency and clean energy technologies as well as reduce ratepayer impacts. Power plants can use approved domestic offsets to meet up to 3.3 percent of their compliance obligations.[23]

> The **Western Climate Initiative** (WCI) is a collaborative effort of seven states and four Canadian provinces now in the process of designing a cap-and-trade program to reduce GHG emissions by 15 percent below 2005 levels by 2020. Phase one of the program is to cover emissions from electric power plants and large industrial and commercial sources, beginning January 1, 2012. The second phase, to begin in 2015, will expand the program to emissions from transportation and residential, commercial and industrial fuel use not otherwise covered. Flexibility mechanisms include three-year compliance periods, allowance banking, and limited use of offsets.[24]

The **Midwest Greenhouse Gas Reduction Accord** (MGGRA) was established in 2007 by six states and one Canadian province. Participants have agreed to set GHG emissions reduction targets and to develop a multi-sector cap-and-trade program.[25]

Valuable as these state efforts are, they risk creating an inefficient patchwork of regulations that would pose additional challenges for business. A comprehensive and effective federal program to reduce GHG emissions would provide important certainty and consistency.

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1 U.S. Environmental Protection Agency, Acid Rain Program Basic Information. Available at: http://www.epa.gov/airmarkets/progsregs/arp/basic.html. *Cap and Trade: Acid Rain Program Basics*. Available at http://www.epa.gov/airmarkets/cap-trade/docs/arbasics.pdf.

2 The issues to be addressed in determining the scope of a cap-and-trade program are discussed in detail in *Scope of a Greenhouse Gas Cap-and-Trade Program*, part of the Congressional Policy Brief Series published by the Pew Center on Global Climate Change (November 2008). Available at http://www.pewclimate.org/docUploads/DDCF-Scope.pdf.

3 A credit mechanism would be needed to provide an incentive to coal-fired power plants to invest in technologies like carbon capture and sequestration (CCS), which removes CO_2 *after* combustion. *Ibid.*, p 9.

4 A limited downstream program could lead to "leakage." If the cap applied to electric power plants, for example, but not to natural gas and heating oil, consumers might switch to the energy sources outside the cap. Thus, reductions achieved in the electric power sector could be partially offset by increased emissions from natural gas and heating oil.

5 A sectoral hybrid program presents several special design considerations, including (1) how to translate existing *energy*-efficiency standards into *emissions-limiting* standards, (2) whether to develop new standards for products not covered currently (e.g., commercial and industrial equipment, building envelopes, additional transportation sector sources), and (3) whether to establish "tradable" standards. For a discussion of these issues as well as other hybrid options, see Robert R. Nordhaus and Kyle W. Danish, *Designing a Mandatory Greenhouse Gas Reduction Program for the U.S.*, Pew Center on Global Climate Change (May 2003), pp 36-40. Available at http://www.pewclimate.org/docUploads/USGas.pdf.

6 An offset represents a reduction, avoidance, destruction, or sequestration of GHG emissions from a source not covered by the cap-and-trade program and that can be converted into a credit that a regulated entity can use to meet its compliance obligation.

7 The various options for distributing GHG emissions allowances are discussed in detail in *Greenhouse Gas Emissions Allowance Allocation*, part of the Congressional Policy Brief Series published by the Pew Center on Global Climate Change (November 2008). Available at http://www.pewclimate.org/docUploads/DDCF-AllowanceAllocation.pdf.

8 Terry Dinan, *Trade-Offs in Allocating Allowances for CO_2 Emissions*, Congressional Budget Office (April 25, 2007), p. 5. Available at http://www.cbo.gov/ftpdocs/80xx/doc8027/04-25-Cap_Trade.pdf.

Contrary to what one might expect, free distribution of permits does not prevent consumer prices from rising as a result of the cap. Firms that receive the free permits have the option of forgoing production and selling the permits to other producers. If instead they use the allowances to cover the carbon emissions of their product, they will give up the income they could have earned by selling the allowances. They will pass this "opportunity cost" on to their customers just as they would actual expenses. Thus, free distribution could yield windfall profits for firms' owners and shareholders.

9 For a discussion of the options for containing costs in a cap-and-trade program, see the policy brief *Containing the Costs of Climate Policy*, Pew Center on Global Climate Change (November 2008). Available at http://www.pewclimate.org/docUploads/DDCF-Costs.pdf.

10 Environmental economist Robert Stavins proposes an alternative "sensible" cost-containment mechanism to deal with short-term allowance price volatility: "Such a mechanism could allow capped sources to purchase additional allowances at a predetermined price, set sufficiently high (say, from twice to ten times the expected level of allowance prices, not 10 or 20 percent above) to make it unlikely to have any effect unless allowance prices exhibit truly drastic spikes. The resulting revenue would be dedicated exclusively to financing emissions reductions by uncapped sources, such as of non-CO_2 greenhouse gases, or to buy back allowances in future years. This is very different from standard proposals for a 'safety valve,' both because the environmental integrity of the program (the cap) is maintained by using the revenue for specific uses just mentioned, and because the high predetermined price has no effect unless there are drastic price spikes." Robert N. Stavins, *A U.S. Cap-and-Trade System to Address Global Climate Change*, The Brookings Institution (October 2007), p 22. Available at http://www.brookings.edu/papers/2007/10climate_stavins.aspx.

11 Coal contains 0.03 tons of carbon per million BTU of energy. Oil contains 0.024 tons and natural gas 0.016 tons of carbon/million BTU of energy. (BTU—British Thermal Unit—is a basic measure of the heat, or energy, value of fuels. One BTU is the amount of heat required to raise the temperature of water by 1°F.)

12 Details about how a federal carbon tax might be implemented come from the Carbon Tax Center at http://www.carbontax.org/

13 Working Group II of the Intergovernmental Panel on Climate Change (IPCC) surveyed 100 estimates of the social cost of carbon. Values ranged from $10/tonne carbon ($3/tonne CO_2) to $350/tonne carbon ($95/tonne CO_2). IPCC, Contribution of Working Group II, *Summary for Policymakers* (2007), p 17. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf.

NOTE: In discussions of the social cost of carbon and suggested carbon tax rates, it is important to distinguish between estimates quoted in terms of tons of carbon and those expressed in terms of tons of CO_2. One ton of carbon equals 3.67 tons of CO_2. Explanation: the atomic weight of carbon is 12 whereas the molecular weight of CO_2 is 44 (one carbon atom plus two oxygen atoms, each with an atomic weight of 16). Thus, 1 ton of carbon equals 44/22 = 3.67 tons of CO_2.

To convert a tax on carbon into a tax on CO_2, multiply the $/ton carbon by 12/44. Thus, a $37/ton tax on carbon is equal to about a $10/ton tax on CO_2.

[14] Leon E. Clarke et al., *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations,* U.S. Climate Change Science Program (July 2007), p 124. Available at http://globalchange.mit.edu/files/document/CCSP_SAP2-1a-FullReport.pdf.

[15] See the Carbon Tax Center's National Carbon Tax Model spreadsheet discussed at http://www.carbontax.org/issues/energy-demand-how-sensitive-to-price/

[16] A. Denny Ellerman and Paul L. Joskow, *The European Union's Emissions Trading System in Perspective*, Pew Center on Global Climate Change (May 2008), pp 40-41. Available at http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf.

[17] The Carbon Tax Center provides a detailed discussion of how tax dividends and progressive tax shifting can help lower-income households manage the impacts of a carbon tax at http://www.carbontax.org/issues/softening-the-impact-of-carbon-taxes/

See also Gilbert E. Metcalf, *A Proposal for a U.S. Carbon Tax Swap: An Equitable Tax Reform to Address Global Climate Change*, The Brookings Institution (October 2007), for a detailed proposal for a revenue- and distributionally-neutral carbon tax. Available at http://www.brookings.edu/~/media/Files/rc/papers/2007/10carbontax_metcalf/10_carbontax_metcalf.pdf

[18] Dinan, *Trade-Offs in Allocating Allowances*, pp. 3-5. (See endnote #8 above.)

[19] Dallas Burtraw, *Climate Change: Lessons Learned from Existing Cap and Trade Programs*, (written testimony for the U.S. House of Representatives, March 29, 2007). Available at http://www.rff.org/rff/News/Releases/2007Releases/BurtrawKoppTestimony3-29-07.cfm.

Burtraw notes that "the best market design is simple and transparent. This is the best guarantee that a cap-and-trade market is fair and efficient. If, as they say, the devil is in the details, then the more details there are, the more places there are for the devil to hide. In many cases, details that seem compelling to appease one group or to fix one problem only beget other problems, opening the door for unintended consequences."

[20] "[C]oal producers already pay an excise tax (which is used to fund the Black Lung Trust Fund) as do producers and importers of petroleum (to fund the Oil Spill Trust Fund). A CO_2 tax based on the sales of coal or petroleum would be an additional excise tax and could, presumably, be implemented at a relatively modest incremental cost. While natural gas is not subject to a federal excise tax, many natural gas processors are subject to a corporate income tax." *Policy Options for Reducing CO_2 Emissions*, Congressional Budget Office (February 2008), p. 16. Available at http://www.cbo.gov/ftpdocs/89xx/doc8934/02-12-Carbon.pdf.

[21] A discussion of the various fuel types and their carbon content is available at http://www.carbontax.org/issues/implementing-carbon-taxes/.

[22] The Pew Center on Global Climate Change tracks and summarizes legislative activity related to global climate change. A chart outlining the provisions of the ten economy-wide cap-and-trade bills introduced in the 110th Congress is available at http://www.pewclimate.org/docUploads/Chart-and-Graph-120108.pdf.

A description of the two carbon tax bills is available at http://www.pewclimate.org/federal/congressional-proposals/110/Carbon%20Tax

[23] For information about the Regional Greenhouse Gas Initiative: http://www.rggi.org/about

[24] Western Climate Initiative website: http://www.westernclimateinitiative.org/

[25] For information about the Midwestern Greenhouse Gas Reduction Accord: http://midwesternaccord.org/index.html