THE DESIGN OF A CARBON TAX

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We consider the design of a tax on greenhouse gas emissions for the United States. We consider three major issues: the tax rate (including the use of the revenues and rate changes over time), the optimal tax base, and international trade concerns. We show that a well-designed carbon tax can capture about 80% of U.S. emissions by taxing only a few thousand taxpayers, and almost 90% with a modest additional cost. We recommend full or partial delegation of rate setting authority to an agency to ensure that rates reflect current information about the costs of carbon emissions and abatement. Adjustments should be made to the income tax to ensure that a carbon tax is revenue neutral and distributionally neutral. Finally, we propose an origin-basis system for trade with countries that have an adequate carbon tax, and a system of border taxes for imports from countries without a carbon tax. We suggest a system that imposes presumptive border tax adjustments, but allows an individual firm to prove that a different rate should apply. The presumptive tax could be based on average emissions for production of the item by either the exporting country or the importing country.

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Introduction

This Paper considers the design of a tax on greenhouse gases ("GHGs"). The purpose of such a tax, which we will generally refer to as a carbon tax, is to internalize externalities associated with anthropogenic climate change.[1] Without a carbon tax, individuals face a distorted set of prices. Activities that result in carbon emissions are relatively too cheap because individuals will not consider the costs the emissions impose on others, including on future generations. A tax forces individuals to consider the full set of consequences from emissions.

The theory behind using taxes to internalize externalities dates back seventy years to writings by Pigou, but there is little experience with the design of these taxes and almost none with a "Pigouvian tax" that covers a substantial portion of the economy, as would a carbon tax.[2] There are several existing carbon taxes, but all are comparatively narrow or are otherwise badly designed.[3] There have also been several proposed carbon taxes intro-

[1] As we will discuss below, there are a wide variety of GHGs other than carbon dioxide. For a list of GHGs, see Susan Solomon et al., *Technical Summary*, *in* Intergovernmental Panel on Climate Change, Climate Change 2007 — The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the IPCC 19, 33 tbl.TS.2 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-ts.pdf. We refer to the tax generically as a carbon tax with the understanding that it will likely cover a wide variety of GHGs. We will not discuss the science behind anthropogenic climate change.

[2] *See* Arthur Cecil Pigou, The Economics of Welfare 192-93 (Transaction Publishers 2002) (4th ed., rev. prtg. 1952). For a review of the theory behind environmental taxes, see A. Lans Bovenberg & Lawrence H. Goulder, *Environmental Taxation and Regulation*, *in* 3 Handbook of Public Economics 1471 (Alan J. Auerbach & Martin Feldstein eds., 2002). A number of papers consider design issues from a general perspective, such as how to set the tax when there are administrative costs of collection. *See, e.g.*, A. Mitchell Polinsky & Steven Shavell, *Pigouvian Taxation with Administrative Costs*, 19 J. Pub. Econ. 385 (1982).

[3] *See* discussion *infra* Part I.B.

duced into legislation in the United States, but only in skeletal form.[4] Although one can learn from these examples, they do not serve as adequate models for the best possible design of a carbon tax.

We consider three central design issues: the tax rate (including distributional issues, the use of the revenues, and tax rate changes); the tax base (including possible offsets or credits); and international trade concerns. Although the theory behind setting the rate is well known — it should equal the marginal harm from emissions — there are a number of difficult design considerations.[5] The most significant challenge is the design of a system for ensuring that the rate changes over time as new information becomes available about the costs and benefits of reducing emissions. The central problems in addressing climate change include uncertainty about its effects and uncertainty about the costs of abatement. The best available option is to utilize a crude estimate of the optimal rate and adjust the rate as new information arises. We suggest a delegation or partial delegation of rate-setting authority to an expert agency, which will ensure that the tax rate is reexamined at appropriate intervals and will provide expertise in the relevant parameters for setting the rate. Given the size of the tax and the potential winners and losers from rate changes, full delegation may not be possible, in which case we recommend a number of intermediate regimes. We also discuss the use of the revenues, recommending a revenue neutral and distributionally neutral adjustment to the income or payroll taxes.

With respect to the tax base, we show that collecting the tax upstream would make it possible to accurately and cheaply cover 80% of U.S. emissions by collecting the tax at fewer than 3000 points, and that it would be possible to cover close to 90% of U.S. emissions at a modest additional cost.[6] As the base gets broader, the collection costs increase; the tradeoff between the increased collection costs and the benefits of a broader base determines the optimal tax base. The main problem presented by upstream collection is that a tax credit or offset must be given for fossil fuels that are not combusted. For example, if the tax is imposed at the refinery and some distillates are sequestered into products such as asphalt, the tax will be too broad. We discuss how such a credit system would be designed.

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[4] For example, in the 110th Congress, the House introduced two bills. *See* Save Our Climate Act of 2007, H.R. 2069, 110th Cong. (2007); America's Energy Security Trust Fund Act of 2007, H.R. 3416, 110th Cong. (2007). Rep. John Dingell also put forth a proposal but did not actually introduce it. In the current session of the 111th Congress, H.R. 3416 has been reintroduced. *See* America's Energy Security Trust Fund Act of 2009, H.R. 1337, 111th Cong. (2009).

[5] The optimal tax rate in a second-best world is a bit more complicated. *See* discussion *infra* Part II.A.

[6] The 80% figure represents the share of U.S. CO_2e emissions consisting of CO_2 from fossil fuel combustion, virtually all of which could be included in the tax base by imposing the tax at a relatively small number of upstream points, as discussed in Part III.B., *infra*. The 90% figure reflects our judgment that, in addition to this initial 80%, it would be feasible to include in the tax base non-fossil-combustion sources accounting for roughly half of the remaining U.S. CO_2e emissions, as discussed in Part III.C., *infra*.

The third design issue relates to trade in carbon-intensive goods. We argue that border tax adjustments for a carbon tax are necessary and appropriate. There is, however, no simple and clearly legal method of implementing a system of border tax adjustments to prevent so-called carbon "leakage," the shifting of production to countries without a carbon pricing mechanism. The key problem is that to set the border tax adjustment, information is needed about the particular production technology and sources of energy used to produce an item. In contrast, border tax adjustments under a value-added tax ("VAT") require only readily available data: for imports, knowledge of the item's price, and for exports, verification of export.[7] The necessary information may be difficult to obtain for a carbon tax.

We consider a number of possible options and their legality, recommending a system of presumptive border tax adjustments that allow individual firms to provide evidence of lower emissions. The presumptive border tax can be based on average emissions from the production of like products in either the exporting or importing country. Using information from the exporting country is preferable, but obtaining that information may be more difficult, and using it raises additional trade-related legal issues.[8]

While this Article deals with a carbon tax in the United States, many of the same issues arise under any market-based scheme for regulating carbon emissions in developed and perhaps also in certain developing nations. Cap-and-trade systems are currently the favored carbon pricing mechanism. The European Union uses a cap-and-trade system for compliance with the Kyoto Protocol,[9] and cap-and-trade systems have been considered by the U.S. Congress.[10] Although there are many reasons for preferring a tax,[11] if a cap-and-

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[7] For a description of how VATs and consumption taxes work, see David A. Weisbach, *Ironing Out the Flat Tax*, 52 STAN. L. REV. 599, 603-13 (2000); CHARLES E. MCLURE, JR., THE VALUE-ADDED TAX: KEY TO DEFICIT REDUCTION? 15-20, 23-25 (1987).

[8] *See* discussion *infra* Part V.

[9] Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 37 I.L.M. 22 [hereinafter Kyoto Protocol].

[10] *See, e.g.*, Resources for the Future, Summary of Market-Based Climate Change Bills Introduced in the 110th Congress (Dec. 3, 2008), http://www.rff.org/News/Features/Documents/110th_Legislation_Table_Graph.pdf (on file with the Harvard Environmental Law Review).

[11] Many articles discuss the advantages of a tax over a cap-and-trade system. *See, e.g.*, Michael Hoel & Larry Karp, *Taxes Versus Quotas for a Stock Pollutant*, 24 RESOURCE & ENERGY ECON. 367 (2002); Larry Karp & Jiangfeng Zhang, *Regulation of Stock Externalities with Correlated Abatement Costs*, 32 ENVTL. & RESOURCE ECON. 273 (2005); William D. Nordhaus, *To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming*, 1 REV. ENVTL. ECON. & POL'Y 26 (2007); Marc J. Roberts & Michael Spence, *Effluent Charges and Licenses under Uncertainty*, 5 J. PUB. ECON. 193 (1976); Martin L. Weitzman, *Prices vs. Quantities*, 41 REV. ECON. STUD. 477 (1974). Most of these discussions focus on theoretical issues such as the deadweight loss from error.

We note that from an administrative perspective a carbon tax can be more quickly implemented than a cap-and-trade system. Coal producers already pay an excise tax to fund the Black Lung Disability Fund and oil producers pay a tax to fund the Oil Spill Liability Trust Fund. *See* Gilbert E. Metcalf, *Federal Tax Policy Towards Energy*, 21 TAX POL'Y & ECON. 145, 151-53 (2007) (describing these funds). We also have precedents in federal fuels tax credits for refundable credits for sequestration activities. *See id.* at 162. In contrast, we have no administrative structure in place for running a carbon cap-and-trade program. The Acid trade system is ultimately adopted, most of the design issues for the tax will be relevant for a cap-and-trade system. For example, it is likely that the United States will want to use the same point in production for remittance of a tax and for the imposition of a permit requirement. Carbon leakage also raises similar issues under both a cap-and-trade regime and under a tax. Thus, a detailed consideration of how to implement a carbon tax can inform the discussion of how best to implement a cap-and-trade system should a cap-and-trade system end up being chosen as the carbon pricing mechanism.

Our focus here is on a tax implemented in a developed country. We have the United States in mind, and use U.S. data, but the considerations may be similar in other developed countries, even if some particulars change. Other issues may arise in developing countries: for example, tax enforcement may not be as robust, and the sources of emissions are likely to be very different (with agriculture and deforestation playing a larger role and energy a smaller role).

Our goal is to consider the design of an ideal tax, a tax that best trades off the internalization of emissions externalities with administrative and collection costs. We do not generally consider the political concessions that will be necessary to enact the tax, leaving that to the give-and-take of the political process. Although we understand that a tax as actually enacted will likely be different from an ideal tax, a model tax can serve as the baseline from which the political process can do its work.

Part I provides background on GHG emissions and the various regulatory regimes used currently to control them. Part II discusses principles related to rate setting, including the use of the tax revenues and adjustment for distributive effects of the tax. Part III addresses the tax base. It begins with a discussion of the theory of setting the optimal base. It then turns to the details of the various production systems and discusses how best to collect a tax on various types of emissions. Part IV considers sequestration and other carbon-reducing activities that should receive tax credits. Part V analyzes the interaction of a carbon tax with trade rules. Part VI discusses interactions with other domestic regulations and taxes that affect carbon emissions. Part VII concludes.

I. Emissions and Current Control Mechanisms

As background to understanding how best to design a carbon tax regime in the United States, we begin with a review of U.S. GHG emissions. We also briefly review carbon pricing policies in other countries.

Rain Program is a helpful precedent, but the value of permits is an order of magnitude smaller than the potential value of carbon emission permits. It also is highly concentrated among a small set of electric utilities. For an overview of the Acid Rain Program, see U.S. Envtl. Prot. Agency, Acid Rain Program (Apr. 14, 2009), http://www.epa.gov/airmarkets/progsregs/arp/basic.html (on file with the Harvard Environmental Law Review).

A. Emissions

According to the 2008 Inventory of U.S. Greenhouse Gas Emissions and Sinks ("EPA Inventory") prepared by the U.S. Environmental Protection Agency ("EPA"),[12] the United States emitted about seven billion metric tons of carbon dioxide ("CO_2") equivalents in 2006,[13] roughly 20% of worldwide emissions (not counting emissions from land use change).[14] This amount consists of emissions of CO_2 and emissions of other gases such as methane and nitrous oxide that also contribute to the greenhouse effect. It is conventional to convert the emissions of other gases to CO_2 equivalent amounts ("CO_2e") by determining how much CO_2 would have to be emitted to have the same effect on the climate. The conversion factors are known as global warming potentials ("GWPs").[15] Methane, for example, has a 100-year GWP of twenty-one, which means that a ton of methane has the same climate forcing impact as twenty-one tons of CO_2. Researchers and policy

[12] Parties to the United Nations Framework Convention for Climate Change ("UNFCCC") must provide inventories of their GHG emissions. The U.S. inventory is done by EPA following guidelines set by the Intergovernmental Panel on Climate Change ("IPCC") pursuant to the UNFCCC. *See* U.S. Envtl. Prot. Agency, EPA 430-R-08-005, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006 (2008) [hereinafter EPA Inventory], *available at* http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf. The most recent EPA Inventory available in the period when this article was being prepared includes data through 2006. Much of our data is based on this source.

[13] *See id.* at 2-1. Net emissions in the United States — gross emissions less carbon sinks — were approximately 6.2 billion metric tons. *See id.* at 1-12 tbl.1-4. Carbon sinks are measured in the EPA report as those arising from land use, land use changes, and forestry activities ("LULUCF"). *See id.* at 1-11.

[14] In 2005, U.S. GHG emissions equaled 18.44% of the worldwide total. Authors' queries to World Resources Institute, Climate Analysis Indicators Tool (CAIT), Online Database Version 6.0 (2009), http://cait.wri.org (last visited Apr. 23, 2009) [hereinafter CAIT] (on file with the Harvard Environmental Law Review).

[15] Calculation of GWPs is not straightforward. The problem is that different gases have different lifetimes in the atmosphere, so determining GWPs involves aggregating over time. Current inventories of GHG emissions use the 100-year GWPs calculated by the IPCC. *See* Solomon et al., *supra* note 1, at 33 tbl.TS.2. To avoid some of the problems with discounting, the IPCC also reports the GWPs over various time periods. The following is a selection of 100-year GWPs for important gases along with their associated U.S. emissions (in CO_2e) in million metric ton ("MMT") units:

GWPs and 2006 GHG Emissions

	CO_2e (MMT)	GWP
Carbon Dioxide	5,983.1	1
Methane	555.3	21
Nitrous Oxide	367.9	310
Hydrofluorocarbons	124.5	140 to 11,700
Perfluorocarbons	6.0	6500 to 9200
Sulfur Hexafluoride	17.3	23,900
Total	7,054.2	

Source: EPA Inventory, *supra* note 12, at ES-3 tbl.ES-1, ES-5 tbl.ES-2.

makers have settled on a 100-year window for measuring the GWP by convention although this is somewhat arbitrary.[16] All of the numbers used in this Article are in CO_2e units unless otherwise indicated.

In 2006, 80% of U.S. GHG emissions were CO_2 emissions from the combustion of fossil fuel.[17] Petroleum use makes up 34% of total emissions, coal makes up 29%, and natural gas makes up 16%.[18] Non-energy uses of fossil fuel as well as other miscellaneous uses add a modest amount of additional emissions.[19] Of the three fossil fuels, coal has the highest carbon content per unit of energy (ranging from 93 to 104 kg of CO_2 per million BTUs ("MMBtu") depending on the type of coal), followed by petroleum (74 kg of CO_2 per MMBtu for crude oil) and natural gas (54 kg of CO_2 per MMBtu).[20]

The four major uses of fossil fuels are industrial, transportation, residential, and commercial. Industrial emissions account for nearly 29% of total U.S. emissions.[21] Roughly two-thirds come from direct combustion of fossil fuels to produce steam or heat for industrial processes, and the remaining one-third comes from electricity use by industry.[22]

Transportation makes up the second largest category of emissions, with nearly 28% of all U.S. emissions.[23] Transportation emissions come almost exclusively from petroleum. Over 60% of transportation emissions are from personal vehicle use. Most of the remainder comes from heavy-duty vehicles and aircraft.[24]

Residential and commercial end-uses each make up about 17% of emissions.[25] These sources rely heavily on electricity, with the remaining emissions coming from natural gas or petroleum used for heating and cooking.[26]

Electricity acts as an intermediate source of emissions — emissions result from the generation of electricity, which is then used by consumers in the four categories listed above. Emissions from the generation of electricity were included in the end-use numbers reported above, but as a separate category, electricity accounts for 34% of total emissions.[27] The type of fuel used for electricity generation has a significant effect on emissions. Electricity can be generated through non-emitting methods — hydroelectric, nuclear, or

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[16] *See* EPA Inventory, *supra* note 12, at 1-6.
[17] *Id.* at ES-7.
[18] *See id.* at 3-4 tbl.3-3 (providing U.S. CO_2 emissions from fossil fuel combustion by fuel type); *id.* at 2-1 (providing total U.S. GHG emissions).
[19] *See id.* at 2-4 tbl.2-1.
[20] *See* Energy Info. Admin., U.S. Dep't of Energy, Voluntary Reporting of Greenhouse Gases Program: Emission Factors and Global Warming Potentials, http://www.eia.doe.gov/oiaf/1605/emission_factors.html (follow "Fuel Emission Factors" hyperlink) (last visited Apr. 9, 2009) (on file with the Harvard Environmental Law Review).
[21] *See* EPA Inventory, *supra* note 12, at 2-21 tbl.2-14.
[22] *See id.*
[23] *See id.*
[24] *See id.* at 2-24 tbl.2-15.
[25] *See id.* at 2-21 tbl.2-14.
[26] *See id.* at 2-26.
[27] *See id.* at 2-18 tbl.2-12.

geothermal energy — as well as through emitting methods — combustion of coal, natural gas and various petroleum distillates. Almost all coal used in the United States (93% in 2007) is used for electricity generation.[28] Conventional use of coal to generate electricity is by far the highest-emitting method of generating electricity. Figure 1 summarizes U.S. fossil fuel emissions, expressed in millions of metric tons ("MMT"), keeping electricity as a separate category.

FIGURE 1. CO_2 EMISSIONS (MMT) FROM FOSSIL FUEL COMBUSTION BY SECTOR AND FUEL TYPE[29]

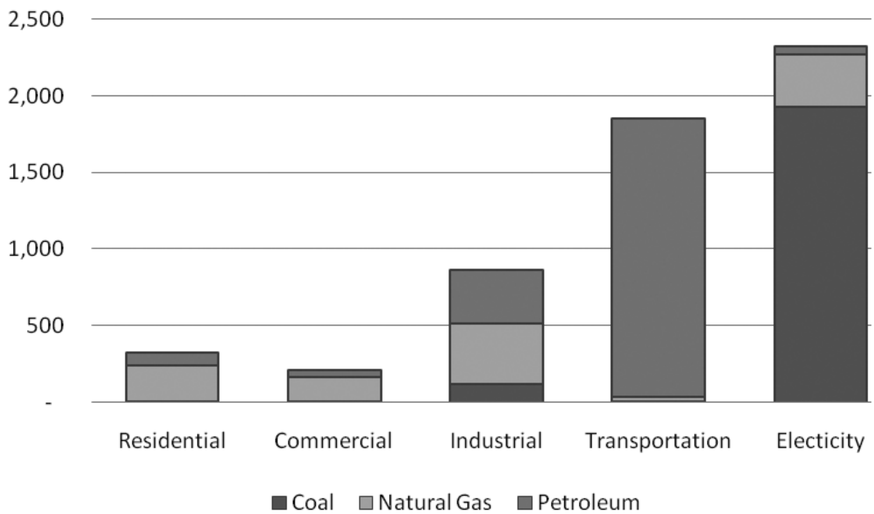

Table A gives a list of the major sources of GHG emissions in the United States. The top source outside of fossil fuel combustion, agricultural soils management, produced 265 MMT CO_2e in 2006, while fossil fuel combustion produced 5637 MMT, more than twenty-one times that amount. Cement production (i.e., emissions associated with the production process itself, not from the fossil fuel energy used in the process) caused direct emissions of 45 MMT CO_2e, which is less than one one-hundredth of overall fossil fuel emissions. Nevertheless, these non-fossil-fuel energy sources together make up about 20% of U.S. emissions.

[28] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0384, ANNUAL ENERGY REVIEW 2007, at xxix fig.39 (2008), *available at* http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf.

[29] Data taken from EPA INVENTORY, *supra* note 12, at 3-4 tbl.3-3.

TABLE A. GHG SOURCES ABOVE 20 MMT CO_2E IN 2006[30]

Rank	Source	Gas	MMT CO_2e	% of Total	Cumulative % of Total
1	Fossil Fuels	CO_2	5,637.0	79.9	79.9
2	Agricultural Soil Management	N_2O	265.0	3.8	83.7
3	Non-Energy Use of Fuels	CO_2	138.0	2.0	85.6
4	Enteric Fermentation	Methane	126.2	1.8	87.4
5	Landfills	Methane	125.7	1.8	89.2
6	ODS Substitutes	HFC	110.4	1.6	90.8
7	Natural Gas Systems (methane)	Methane	102.4	1.5	92.2
8	Coal Mining	Methane	58.5	0.8	93.0
9	Iron and Steel Production	CO_2	49.1	0.7	93.7
10	Cement Manufacturing	CO_2	45.7	0.6	94.4
11	Manure Management	Methane	41.4	0.6	95.0
12	Mobile Combustion	N_2O	33.1	0.5	95.4
13	Natural Gas Systems (CO_2)	CO_2	28.5	0.4	95.8
14	Petroleum Systems	Methane	28.4	0.4	96.2
15	Forest land remaining forest	Methane	24.6	0.3	96.6
16	Wastewater Treatment	Methane	23.9	0.3	96.9
17	Municipal Solid Waste Combustion	CO_2	20.9	0.3	97.2
	Total		6,858.8		
	U.S. Total		7,054.2		

While emissions from each of these non-fossil-fuel energy sources are relatively small, some of these sources are good candidates for inclusion in the tax base. As we will discuss below, in determining what should be taxed, marginal abatement costs — how much it costs to achieve an incremental unit of abatement — matter more than the total size of emissions from a given source. To minimize the total cost of abatement, the tax base

[30] Adapted from EPA INVENTORY, *supra* note 12, at ES-5 tbl.ES-2.

must include low marginal abatement cost items even if their total contribution to emissions is small. For example, if it is easy to reduce methane emissions from landfills, it may be important to include them in the tax base notwithstanding the modest amount of these emissions. Many items with low marginal abatement costs will be unrelated to fossil fuels.[31]

Worldwide emissions of GHGs were 42 billion metric tons (42,000 MMT) CO_2e in 2005.[32] Energy use is a relatively smaller component of the worldwide total than it is for the United States, comprising just over 75% of worldwide emissions, compared to 87% of U.S. emissions.[33] Land use change, particularly deforestation, is a significant contributor worldwide.[34] Preventing deforestation in highly forested nations such as Indonesia and Brazil is likely to be a low-cost method of abatement;[35] it would therefore be important to include in a global climate policy. Similarly, emissions from agriculture make up about 16% of worldwide emissions but only 6% of U.S. emissions.[36]

B. Existing Carbon Control Regimes

Neither the United States nor the rest of the world makes any significant use of taxes explicitly on carbon. There are currently only six countries explicitly taxing carbon (five Scandinavian countries and the United Kingdom). There are, however, a wide variety of taxes on, and subsidies for, energy (as well as a wide variety of regulatory regimes for other GHGs). Although not designed to set a uniform price for carbon across different types of energy, these taxes and subsidies will undoubtedly affect carbon emissions. A survey of energy taxes in twelve countries revealed that, as of 2000, the vast majority of energy taxes are on gasoline and diesel fuel, with very few taxes on coal and natural gas.[37]

All of the Scandinavian countries adopted carbon taxes in the 1990s. These taxes have narrow bases and do not impose a uniform tax on emissions from the sources that they do cover. Instead, they provide a wide variety of different rates.[38] The Norwegian carbon tax covers about 64% of

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[31] *See* John M. Reilly, Henry D. Jacoby & Ronald G. Prinn, Multi-Gas Contributors to Global Climate Change: Climate Impacts and Mitigation Costs of Non-CO_2 Gases 23-24 (2003), *available at* http://www.pewclimate.org/docUploads/Multi-Gas.pdf.

[32] Authors' calculations based on queries to CAIT, *supra* note 14 (on file with the Harvard Environmental Law Review).

[33] Authors' queries to CAIT, *supra* note 14 (on file with the Harvard Environmental Law Review).

[34] *Id.* (on file with the Harvard Environmental Law Review).

[35] *See* Georg Kindermann et al., *Global Cost Estimates of Reducing Carbon Emissions Through Avoided Deforestation*, 105 Proc. Nat'l Acad. Sci. U.S. 10,302, 10,305 (2008).

[36] Authors' queries to CAIT, *supra* note 14 (on file with the Harvard Environmental Law Review).

[37] *See* Andrea Baranzini, Jose Goldemberg & Stefan Speck, *A Future for Carbon Taxes*, 32 Ecological Econ. 395, 398 (2000).

[38] *See* Paul Ekins & Terry Barker, *Carbon Taxes and Carbon Emissions Trading*, 15 J. Econ. Surv. 325, 341 (2001).

CO_2 emissions and 49% of total GHG emissions.[39] According to Nicholas Stern, the impact of the tax is weakened by numerous exemptions related to competitiveness concerns.[40] Moreover, the tax does not accurately reflect variations in emissions across fuels. Finally, even though the Scandinavian countries are relatively similar and each adopted a carbon tax, they differed considerably in what they included in the tax base and what tax rate they applied to different sectors.[41] This makes it difficult for these neighboring countries to harmonize their taxes.

The United Kingdom instituted a climate tax (known as the climate change levy or "CCL") in 2001.[42] The levy is imposed on industrial and commercial use of energy, and excludes transportation and domestic (residential) use. The rate is currently modest. For example, electricity is charged as £4.56 per megawatt hour ("MWh"). Gas is taxed at £1.59 per MWh.[43] At the prevailing end-use prices for residential electricity and natural gas in 2007, this tax amounts to 4.6% on electricity and 5.2% on natural gas.[44] Moreover, taxpayers can enter into agreements with the government to reduce emissions in exchange for a significantly reduced rate of tax, effectively converting the climate change levy into a command-and-control regulation. Total collections from the levy are around £700 million ($1 billion) annually.[45]

If the United States were to adopt a carbon tax, an important design issue would be how it interacted with other carbon pricing and energy policies both domestically and abroad. Internationally, the major program with which a domestic tax would have to interact is the European Union Emis-

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[39] *See* Annegrete Bruvoll & Bodil Merethe Larsen, *Greenhouse Gas Emissions in Norway: Do Carbon Taxes Work?*, 32 Energy Pol'y 493, 498 (2004) (noting carbon tax covers 64% of CO_2 emissions). Norway's total GHG emissions in 2000 were 53.8 MMT CO_2e, including 41.1 MMT CO_2. *See* Nor. Pollution Control Auth., National Inventory Report 2005 Norway: Greenhouse Gas Emissions 1990-2003 Reported According to the UNFCCC Guidelines 10 (2005), *available at* http://www.sft.no/publikasjoner/luft/2097/ta2097.pdf.

[40] Nicholas Stern, The Economics of Climate Change: The Stern Review 386 (2007).

[41] *See* Ekins & Barker, *supra* note 38, at 341.

[42] For information on the CCL, see U.K. Dep't for Env't, Food & Rural Aff., Climate Change Agreements: The Climate Change Levy (Dec. 8, 2008), http://www.defra.gov.uk/environment/climatechange/uk/business/cca/levy.htm (on file with the Harvard Environmental Law Review).

[43] These rates were effective as of April 1, 2008. *See* Her Majesty's Revenue & Customs Office (U.K.), Climate Change Levy (CCL): Changes to Rates, http://customs.hmrc.gov.uk (search for "CCL changes to rates"; then follow "Climate Change Levy (CCL): Changes to Rates" hyperlink) (last visited Apr. 8, 2009) (on file with the Harvard Environmental Law Review). As of Apr. 8, 2009, these taxes corresponded to $6.71 per MWh for electricity and $2.34 per MWh for gas. Yahoo! Finance Currency Converter, http://finance.yahoo.com/currency-converter (last visited Apr. 8, 2009) (on file with the Harvard Environmental Law Review).

[44] Authors' calculations based on query to SourceOECD, IEA Energy Prices and Taxes, http://www.sourceoecd.org/database/1683626X/energypricestaxes (last visited Apr. 22, 2009) (on file with the Harvard Environmental Law Review).

[45] *See* Her Majesty's Treasury, Budget 2008, at 187 tbl.C6 (2008), *available at* http://www.hm-treasury.gov.uk/d/bud08_completereport.pdf.

sions Trading System ("EU ETS").[46] The EU ETS is a cap-and-trade program applicable to EU emissions from the energy industry and energy-intensive industries. Phase I of the program ran from 2005 through 2007 and was viewed as a trial run to develop the market mechanisms to support permit trading. Phase II, running from 2008 through 2012, is designed to help the EU meet its Kyoto Protocol obligation of an 8% reduction below the base year levels (generally 1990 levels). The burden-sharing allocation within the EU is complex.[47]

We do not discuss the merits of the EU ETS in this Article but do wish to comment on two aspects of its design. First, the EU system is implemented at the level of the industry or electric utility. This point of regulation significantly multiplies the number of covered installations and makes a comprehensive system difficult to implement. Second, the EU ETS only covers a relatively small portion of GHG emissions in the EU. The European Commission estimates that less than one-half of CO_2 emissions and less than one-third of all GHG emissions will be subject to the EU ETS caps in 2010.[48] In particular, the transportation sector is excluded. It has been argued that the transportation sector was excluded from the EU ETS because it was already subject to high taxes on motor fuels.[49] These energy taxes, however, were presumably motivated by other externalities and costs associated with driving, though it might be argued that the rate is higher than necessary.[50] Therefore, these taxes need to be imposed in addition to, rather than as a replacement for, a carbon tax. Moreover, to the extent that an element of these taxes did relate to carbon emissions, nothing precluded the EU from including transport in the EU ETS and encouraging member countries to impose motor fuels taxes only to an extent that would correct for non-carbon externalities from driving.[51] To the extent EU motor fuels taxes

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[46] *See generally* EUROPEAN COMM'N, EU ACTION AGAINST CLIMATE CHANGE: THE EU EMISSIONS TRADING SYSTEM (2008), *available at* http://ec.europa.eu/environment/climat/pdf/brochures/ets_en.pdf.

[47] For a detailed description, see A. DENNY ELLERMAN, BARBARA K. BUCHNER & CARLO CARRARO, ALLOCATION IN THE EUROPEAN EMISSIONS TRADING SCHEME: RIGHTS, RENTS AND FAIRNESS (2007).

[48] Frank J. Convery & Luke Redmond, *Market and Price Developments in the European Union Emissions Trading Scheme*, 1 REV. ENVTL. ECON. & POL'Y 88, 93 (2007).

[49] For a comparison of U.S. and EU gasoline tax rates, see Gilbert E. Metcalf, *Tax Policy for Financing Alternative Energy Equipment*, J. EQUIPMENT LEASE FINANCING, Spring 2008, at 1.

[50] *See* Sijbren Cnossen, *Tax Policy in the European Union: A Review of Issues and Policies*, 58 FINANZARCHIV 466, 504-05 (2001).

[51] One obstacle to this swap was that the permits were given away and, as a result, national governments lost revenue. But the amounts in question were small. Average gasoline tax rates in Organization for Economic Cooperation and Development ("OECD") countries other than the United States averaged $2.30 per gallon as of January 2007, according to the OECD database on environmental taxes. Authors' calculation (unweighted average) based on OECD/EEA, Economics Instruments Database, http://www2.oecd.org/ecoinst/queries/UnleadedPetrolEuro.pdf (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law Review). At the current price for EU ETS permits (in the neighborhood of 13 Euros), this would raise the price of gasoline by about 15¢ per gallon. *See* European Climate Exchange, http://www.ecx.eu (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law

are thought of as part of its carbon pricing regime, the EU has a hybrid cap-and-trade tax regime rather than a pure cap-and-trade regime.

None of these carbon pricing regimes serves as a good model for the design of a carbon tax. All have comparatively narrow bases, and none is designed to minimize compliance and administrative costs.

II. Rates

A. *Setting the Rates*

At the most basic level, the principles for setting the correct tax rate were established long ago by Pigou: at any given level of emissions, the tax rate should equal the social marginal damages from producing an additional unit of emissions or, more or less equivalently, the social marginal benefit from abating a unit of emissions.[52] If the tax has to be set at a fixed rate, as is likely in any broad-based tax, the optimal tax rate would be where the marginal benefit of abatement equals the marginal cost of abatement. To set such a tax, the government obviously would need to estimate both the marginal abatement cost curve and the marginal abatement benefit curve.

Estimates of the optimal tax rate vary widely. The calculation is difficult, perhaps even heroic, because it involves combining uncertain science, including predictions of the local effects of climate change, with predictions about economic and technological developments in the distant future. In addition, all of these values must be discounted to the present.[53] The Intergovernmental Panel on Climate Change ("IPCC") surveys 100 different studies of the optimal tax rate and estimates a mean for 2005 of $12 per metric ton of CO_2, but notes that estimates range from $3 to $95 per metric ton.[54] The report adds that these figures are likely to underestimate the costs of carbon emissions because of the difficulty in quantifying many impacts.[55]

Review) (providing current EU ETS permit prices); Energy Info. Admin., U.S. Dep't of Energy, Fuel and Energy Source Codes and Emission Coefficients, http://www.eia.doe.gov/oiaf/1605/coefficients.html (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law Review) (providing amount of carbon per gallon of gasoline); Yahoo! Finance Currency Converter, http://finance.yahoo.com/currency-converter (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law Review). If countries chose to include transport fuels in the cap-and-trade system, thereby increasing fuel prices, and if they then chose to reduce transport fuel taxes to offset those price increases, they could recoup the lost tax revenue by auctioning (rather than giving away) a modest portion of the permits.

[52] *See* Pigou, *supra* note 2, at 192-93.

[53] For a discussion of the discounting debate, see Robert C. Lind, *A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options*, *in* Discounting for Time and Risk in Energy Policy 21 (Robert C. Lind ed., 1982); Geoffrey Heal, *Intertemporal Welfare Economics and the Environment*, *in* 3 Handbook of Environmental Economics 1105 (Karl-Göran Mäler & Jeffery R. Vincent eds., 2005).

[54] *See* Intergovernmental Panel on Climate Change, *Summary for Policymakers*, *in* Climate Change 2007 — Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the IPCC 7, 17 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf.

[55] *See id.*

The revenue raised from such a tax would depend on the coverage and the elasticity of emissions to taxation, but rough and ready figures suggest that a modest tax on emissions from fossil fuels alone would likely raise between $75 billion and $100 billion per year.[56]

Because of the difficulties in computing the optimal tax rate from estimates of social cost, an alternative used by some analysts is to determine a set of taxes over time that would result in meeting a target for emissions reductions or total carbon concentrations in the atmosphere. This approach separates the analysis into two components: an overall social decision about what level of GHG concentrations to tolerate and a technical analysis of how best achieve that goal. When analysts take this approach and use likely targets, the ranges of tax rates they produce are similar to those generated from trying to find the social cost of carbon.[57]

There is a longstanding debate about whether the tax rate should be adjusted because of interactions with the labor tax.[58] The original view was that environmental taxes create a "double dividend" because they internalize environmental externalities and allow the distorting income tax to be reduced by the revenue that they raise.[59] The most recent view is that the extent (and even the direction) of an adjustment to environmental taxes depends on subtle factors, such as the use of revenues and whether there are pre-existing distortions.[60] For example, environmental taxes themselves may reduce labor supply in much the same way as a labor tax. Therefore, substituting an environmental tax for a labor tax may not reduce such distortions. Regardless of the details of this debate, given the heroic assumptions needed to compute the optimal carbon tax rate, the double-dividend hypothesis is a second-order consideration — determining the carbon tax rate at this point

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[56] *See* Gilbert E. Metcalf et al., Analysis of U.S. Greenhouse Gas Tax Proposals 31-32 (2008), *available at* http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt160.pdf (providing revenue estimates for several carbon tax bills). The authors' estimates range from $69 billion to $126 billion for revenue raised in 2015 from relatively narrow taxes. *Id.* at 31 tbl.9. To put this in context, a carbon tax of $25 per metric ton CO_2e would raise the price of gasoline by about 22¢ per gallon and the price of coal-fired electricity by roughly 2.5¢ per kilowatt-hour. A carbon tax would also increase the price of other commodities that use energy as an intermediate good. *See* Kevin A. Hassett, Aparna Mathur & Gilbert E. Metcalf, *The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis*, 30(2) Energy J. 157, 175 app. tbl.1 (2009) (estimating that a $15 per ton tax would raise the purchase price of a new automobile by about 0.9%).

[57] For a comparison of economic models of climate change using similar emissions scenarios, see Leon E. Clarke et al., U.S. Climate Change Science Program, Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations: Synthesis and Assessment Product 2.1a (2007), *available at* http://www.climatescience.gov/Library/sap/sap2-1/finalreport/sap2-1a-final-all.pdf.

[58] *See* A. Lans Bovenberg & Ruud A. de Mooij, *Environmental Levies and Distortionary Taxation*, 84 Am. Econ. Rev. 1085, 1085 (1994); Lawrence H. Goulder, Ian W.H. Parry & Dallas Burtraw, *Revenue-Raising Versus Other Approaches to Environmental Protection: The Critical Significance of Preexisting Tax Distortions*, 28 RAND J. Econ. 708 (1997); Don Fullerton & Gilbert E. Metcalf, *Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing?*, 73 Chi.-Kent L. Rev. 221 (1998).

[59] *See, e.g.*, Bovenberg & de Mooij, *supra* note 58, at 1085.

[60] *See* Louis Kaplow, The Theory of Taxation and Public Economics 212-16 (2008).

involves guessing about orders of magnitude and not about potentially subtle adjustments.

B. Revenue and Redistribution

Depending on one's frame of reference, a carbon tax is likely to be modestly to highly regressive. Using data from 2003, Table B shows the distributional burden of a $15 per ton carbon tax across households.[61]

TABLE B. CARBON TAX BURDEN ACROSS INCOME GROUPS[62]

Income Decile	Direct	Indirect	Total
Bottom	2.12	1.60	3.74
Second	1.74	1.31	3.06
Third	1.36	0.99	2.36
Fourth	1.19	0.88	2.06
Fifth	0.97	0.78	1.76
Sixth	0.85	0.68	1.53
Seventh	0.69	0.61	1.30
Eighth	0.61	0.63	1.23
Ninth	0.53	0.49	1.01
Top	0.36	0.45	0.81

Based on the practice in European VAT systems of zero rating and exemptions,[63] one might ask whether similar exemptions should be built into the carbon tax to reduce its regressivity. The answer is no. Redistributing income or wealth through adjustments to a commodity tax is in general less efficient than redistributing through adjustments to direct taxes on labor or income.[64] Thus, the distributive effects of a carbon tax should be offset through adjustments to the overall tax system (in particular, the income tax)

[61] Hassett et al. assess the distribution of the tax across households using both annual income and two proxy measures for lifetime income and find that the tax appears considerably less regressive when a lifetime income measure is used. *See* Hassett et al., *supra* note 56, at 168-69; *see also* METCALF ET AL., *supra* note 56, at 3, 39-41 (showing that over time, more of the carbon tax is passed back to resource owners and owners of capital, also somewhat mitigating the regressivity).

[62] Hassett et al., *supra* note 56, at 164. The table reports the within-decile average carbon tax burdens as percentages of annual income. Direct burden refers to fuel consumption. Indirect burden refers to higher prices of goods due to use of energy as an input. The sum of direct and indirect differs from the total due to rounding error.

[63] European VATs take the credit-invoice approach. They tax revenue from sales of products and provide a tax credit for VAT paid at previous stages of production. Zero rating means that no tax is applied on sales, but a credit is still received for taxes paid at previous stages of production. Exemption means that the product is simply not subject to the tax (and receives no credit for previously paid VAT). *See* Gilbert E. Metcalf, *Value-Added Taxation: A Tax Whose Time Has Come?*, J. ECON. PERSP., Winter 1995, at 121, 125-26.

[64] *See* A.B. Atkinson & J.E. Stiglitz, *The Design of Tax Structure: Direct Versus Indirect Taxation*, 6 J. PUB. ECON. 55, 74 (1976); Louis Kaplow, *On the Undesirability of Commodity*

rather than through adjustments to the design of the carbon tax itself. In particular, adjustments to the carbon tax for distributive effects produce the same types of distortions that adjustments to labor income taxes do. For example, progressive taxes reduce work incentives. In addition, adjusting the carbon tax for distributive effects would reduce the environmental benefits of the tax: carbon emissions would not be priced equal to their marginal damages. Therefore, the better approach is to design the carbon tax to best internalize the effects of emissions and to adjust the income or payroll tax for any distributive effects. This reflects the fact that distortions arise from redistribution in the tax code.[65]

To a large extent, the design of a carbon tax is separable from the issue of how to spend the money. Moreover, as noted, the potentially regressive distributive effects of a carbon tax should be offset through adjustments to the income tax rather than through adjustments in the design of the carbon tax, so that distributive issues are also separable. Nevertheless, because the revenue and distributive effects are significant, it is worth spending a few words on these issues. We consider two alternatives.

Our first and preferred option is to maintain revenue and distributional neutrality. Whatever the decision is on proper size of government and proper deficit, the enactment of a carbon tax does not, and should not, change it. So if the current judgment, right or wrong, is that the federal government should be 19% of the economy, the enactment of a carbon tax should not alter this percentage. Similarly, whatever the decision is on the proper degree of progressivity of the tax system, the enactment of a carbon tax should not, and need not, change these views. Under this argument, carbon tax revenues should be used to reduce other taxes in a way that retains the same degree of progressivity.[66]

Even if other taxes are adjusted to maintain overall progressivity, a carbon tax will have a disproportionate impact on certain industries, with the coal industry being a prime example. But because of coal's very high carbon content and the quantity of emissions from coal combustion, coal could not reasonably be exempted from an effective carbon tax. This suggests the need for transition assistance for coal industry workers who would be displaced as a result of a carbon policy. Such assistance need not be very expensive.

The value added by the coal industry (labor compensation, owners' profits, and indirect business taxes) amounted to $11 billion in 2005.[67] If the share of labor compensation in coal mining value added is unchanged from

Taxation Even When Income Taxation Is Not Optimal, 90 J. PUB. ECON. 1235, 1238, 1246 (2006).

[65] *See* KAPLOW, *supra* note 60, at 27.

[66] For an example of such a proposal, see GILBERT E. METCALF, A PROPOSAL FOR A U.S. CARBON TAX SWAP: AN EQUITABLE TAX REFORM TO ADDRESS GLOBAL CLIMATE CHANGE (2007), *available at* http://www.brookings.edu/papers/2007/10carbontax_metcalf.aspx.

[67] E-mail from Shawn Snyder, Economist, Bureau of Economic Analysis, U.S. Dep't of Commerce, to author (Aug. 20, 2007) (on file with author).

1997, when labor accounted for one-half of the value added in coal mining,[68] the maximum potential loss to labor is $5.5 billion annually. Demand will fall sharply, but not to zero, so the loss in value added will be less than $11 billion annually. Moreover, as time goes on, participants in this industry can begin to make adjustments to move into other sectors. Thus, any transitional assistance should be temporary in nature, with particular attention paid to those workers that are least able to transition to new jobs.

A second option is to spend some of the tax revenue to help shift toward a low-carbon economy. An increase in federal research funding for basic energy-related research and development certainly would be beneficial. A number of studies suggest that a doubling of such funding could be spent productively.[69] This would require funds in the range of $4 billion per year in addition to what is currently spent.[70] This amount could be funded through tax revenues or by removing subsidies to energy production that are either unproductive or unnecessary in the presence of a carbon tax. By no means would it be sensible to spend all of the carbon tax revenue on basic research and development related to reducing GHG emissions.

Some funding will also be needed to move advanced technologies, such as carbon capture and storage ("CCS"), to a large scale. The recent setback in funding for FutureGen[71] is unfortunate and speaks to the large financial risks facing firms that try to undertake such investments on their own. CCS illustrates another set of issues requiring government action. A national CCS system will require a network of pipelines to move carbon from generators to storage sites. This may require some funding by the government.[72] Similarly, low-carbon sources of energy, such as wind, may not be located near population centers, which means that an enhanced transmission grid

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[68] *See* Bureau of Economic Analysis, U.S. Dep't of Commerce, Gross-Domestic-Product-by-Industry Accounts, 1947-2007, http://www.bea.gov/industry/gpotables/gpo_action.cfm (follow "Composition of Gross Output by Industry" hyperlink) (last visited Apr. 14, 2009) (on file with the Harvard Environmental Law Review).

[69] *See* Richard G. Newell, A U.S. Innovation Strategy for Climate Change Mitigation 32 (2008), *available at* http://www.brookings.edu/papers/2008/12_climate_change_newell.aspx (citing studies and making proposal); *see also* Jason Furman et al., The Hamilton Project, An Economic Strategy to Address Climate Change and Promote Energy Security 25 (2007), *available at* http://www.brookings.edu/papers/2007/10climatechange_furman.aspx (discussing proposals).

[70] *See* Newell, *supra* note 69, at 32.

[71] *See, e.g.*, Editorial, *The Demise of FutureGen*, Wash. Post, Feb. 16, 2008, at A20.

[72] While funding will be required to build this network, equally important will be a review and potential overhaul of state and federal regulatory systems to remove obstacles to the development of this network. Important questions in this review will include: At what level in the federal system will regulatory oversight of this network take place? What is the right balance between national interests in a CCS system and local property rights? Who will bear the liability if stored carbon leaks in the near or long term? What insurance mechanisms will be necessary to cover that liability? For a discussion of barriers and choices involved with CCS deployment, see John Deutch et al., The Future of Coal: Options for a Carbon-Constrained World 43-62 (2007), *available at* http://web.mit.edu/coal/The_Future_of_Coal.pdf.

may be required.[73] Given the complex regulatory and land use issues in building such a grid, federal involvement and funding may be necessary.

In addition, enhanced support for energy efficiency investments contributes to a reduction in energy consumption and carbon emissions. Increasing energy prices through a carbon tax will contribute to increased efficiency investments, but two factors would support a policy of further stimulating efficiency investments with more generous tax credits. First, certain sectors of the economy may not respond to energy price increases arising from a carbon policy. Commercial real estate and rental housing are sectors where the economic agent who makes efficiency investments (the developer or property owner) is not the person who benefits from the energy savings (the tenant). Second, the hidden nature of many efficiency improvements makes it difficult to recapture the energy savings through their capitalization into building prices or rents.[74] In addition, empirical work suggests that efficiency investment tax credits have a substantial impact on adoption of such efficiency investments.[75]

In summary, we believe that, in large measure, funds from a carbon tax should be used as part of a "carbon tax swap" that is revenue and distributionally neutral.[76] A small portion of the funds might be directed to providing transition relief for displaced workers (such as miners), supporting basic energy research and development, solving vexing issues associated with bringing CCS to scale, constructing any necessary transmission lines, and perhaps encouraging conservation activities that market imperfections might otherwise block. But we reiterate that the decision about how to spend carbon tax revenues is separate from the decision to enact a carbon tax.

C. Initial Enactment and Grandfathering

There are a number of options for initial enactment of a carbon tax, including a slow ramp-up of the tax, grandfathering existing emissions, and immediate uniform adoption (a "cold-turkey" approach). A slow ramp-up would gradually introduce the tax over time, perhaps by starting with a low initial rate or a narrow initial base and then increasing the rate or base at a pre-announced schedule to reach the desired system. Grandfathering would exempt from taxation a baseline level of emissions, such as an amount equal to emissions in a reference year. A cold-turkey approach would simply introduce the tax without any special provision for transition.

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[73] *See* N. Am. Elec. Reliability Corp., Electric Industry Concerns on the Reliability Impacts of Climate Change Initiatives 11-12 (2008), *available at* http://www.nerc.com/files/2008-Climate-Initiatives-Report.pdf.

[74] *See* Am. Council for an Energy-Efficient Econ., Quantifying the Effects of Market Failures in the End-Use of Energy 2 (2007), *available at* http://www.aceee.org/energy/IEAmarketbarriers.pdf.

[75] *See, e.g.*, Kevin A. Hassett & Gilbert E. Metcalf, *Energy Tax Credits and Residential Conservation Investment: Evidence from Panel Data*, 57 J. Pub. Econ. 201, 216 (1995).

[76] *See, e.g.*, Metcalf, *supra* note 66, at 2.

While cold-turkey introduction is likely the least politically feasible approach, it is our preferred option for two reasons. First, an immediate, uniform tax imposition maximizes what one might call the "anticipation effect." If businesses understand today that the eventual carbon tax will be imposed without special relief for existing investments, they will start adjusting their behavior now, anticipating the future effects of the tax. For example, a utility constructing a power plant now is more likely to use gas instead of coal if it is clear that the plant's future emissions will be fully exposed to a future tax on carbon (gas being much less carbon-intensive than coal). One can, in effect, think of cold-turkey as pushing some of the effects of the policy earlier in time, which in this case is a good thing.[77]

An argument against this sort of anticipation effect is that individuals act, or should be allowed to act, without trying to guess future government policy — they should be allowed to rely on current law. The government, by passing current law, has effectively told people what their compliance obligations are, and it is unfair to change those obligations midstream. This argument, however, is circular. Individuals or industries only know they can rely on unchanging rules (or grandfathering, if the rules do change) if there is some external reason why that should be the case. For example, the Fifth Amendment to the Constitution allows property owners to rely on their rights to prevent government takings.[78] Taxes, however, change all the time and there is no fairness reason why people should be able to rely on them not changing. This is particularly true with respect to a carbon tax, as carbon pricing policies have been widely discussed for a long time.

Our second reason for preferring a cold-turkey approach is that the revenues raised by a carbon tax are likely to be significant — in the range of \$100 billion per year[79] — and those revenues can likely be spent in better ways than grandfathering carbon emissions. For example, the taxes could be used to reduce the income or payroll taxes. Alternatively, shifting to a low-carbon economy may require significant changes in infrastructure, and some of the tax revenues could be used to pay for those changes. As implied in our discussion of the use of revenues, it is hard to imagine that there are not better ways to spend the money than giving it to industries that currently emit carbon. Grandfathering the energy sector also has been shown to have perverse distributional consequences.[80] The value of grandfathered permits accrues to owners of capital, thereby exacerbating the undesirable distributional consequences of carbon pricing.

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[77] *See* Michael J. Graetz, *Legal Transitions: The Case of Retroactivity in Income Tax Revision*, 126 U. Pa. L. Rev. 47, 54-57 (1977); Louis Kaplow, *An Economic Analysis of Legal Transitions*, 99 Harv. L. Rev. 509, 551 (1986); Daniel Shaviro, When Rules Change: An Economic and Political Analysis of Transition Relief and Retroactivity 27-32 (2000).

[78] U.S. Const. amend. V, cl. 5.

[79] *See* Robert N. Stavins, *A Meaningful U.S. Cap-and-Trade System to Address Climate Change*, 32 Harv. Envtl. L. Rev. 293, 317 n.94 (2008).

[80] *See* Gilbert E. Metcalf, *Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions*, 3 Rev. Envtl. Econ. & Pol'y 63, 74 (2009).

A slow ramp-up can be seen simply as an intermediate solution between grandfathering and cold-turkey. It is like grandfathering that is gradually phased out over time. Therefore, the same arguments apply to the extent the phase-in is like grandfathering.

The possibility of grandfathering a carbon tax based on business-as-usual emissions allows a carbon tax to have the same effect as a cap-and-trade system with free allocation of permits, if such a system were to be desired. A cap-and-trade system can buy the support of blocking industries to allow legislation to pass relatively efficiently through the free allocation of allowances. This is relatively efficient because the blocking industry would still face the right price at the margin; the industry would benefit from any increase or decrease in emissions by an amount equal to the price of the permits. One could claim that a tax must exempt the industry to buy it off, which is less efficient. However, this is not true. An identical economic outcome can be obtained in a carbon tax by taxing emissions above some floor. This preserves the impact at the margin while exempting initial emissions in a lump-sum fashion.[81]

D. Anticipated Rate Schedule

The optimal schedule of tax rates over time will depend on how the target is being set. In a welfare-maximizing framework where the benefits and costs of carbon abatement are both taken into account, the tax rate should match social marginal damages across time.[82] Where the goal is to cap emissions at some fixed amount over a set time period, the tax rate should grow at the rate of return on capital.[83] Metcalf et al.[84] develop the argument as follows. They start by imagining that rather than imposing a carbon tax, the government issues a set of permits that can be used over time. The permits would be an asset. Holders would save that asset for later use if its value went up more quickly than the rate of return on other assets, but they would use it sooner if its value went up more slowly. In equilibrium, the price of permits would increase at the same rate as the return on other forms of capital.[85] Taxes and permits, however, are merely substitute methods of imposing the Pigouvian price on emissions in the absence of uncertainty. Therefore, if permits optimally have this price pattern, taxes must as well.

William Nordhaus undertakes an explicit welfare-maximizing analysis and finds that tax rates grow over time in a pattern that resembles exponen-

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[81] An interesting issue we have yet to fully resolve is why the EU ETS required participating countries to freely allocate permits instead of giving each local country the choice about how to distribute them. This requirement is particularly puzzling in light of the inefficiency of free allocation.

[82] This analysis abstracts from other distortions that may affect the optimal tax rate.

[83] This analysis abstracts away from risk or multiple forms of capital with different return characteristics.

[84] METCALF ET AL., *supra* note 56, at 28-29.

[85] *Id.*

tial growth.[86] His model includes population growth, technology changes, and non-constant discount rates. If there are technological surprises, the optimal tax rate will also adjust to take these into account. In general, in broad-based general equilibrium models one would expect the optimal tax rate to grow at an underlying exponential growth rate that is modified by other forces at work in the model.

The real world is significantly more complicated than even the most complex computable general equilibrium model. Multiple forms of capital exist with different rates of return based on their risk characteristics. What is the right capital rate of return to serve as a benchmark for the growth of the carbon tax rate? The logic of the Metcalf et al. study suggests that the appropriate form of capital would be that with similar risk characteristics to the hypothetical permit program that is equivalent to the carbon tax. But immediately this logic breaks down, since taxes and permit systems are no longer equivalent in a world with uncertainty.[87]

In practice, the best that may be possible is to set out a given real growth rate for the tax rate (say, 4% or 5%) in carbon tax legislation and anticipate the need to adjust the rate as more information becomes available. We turn next to this issue.

E. Rate Changes

Tax rates must be adjusted to reflect new information about the marginal cost and marginal benefit of abatement. New information is likely to arise all the time as the science of climate change progresses and as abatement technologies are discovered and developed. The question is how often to change the tax rate.

Many commentators have expressed concerns over the price volatility associated with cap-and-trade systems because of worries that price volatility will reduce or delay long-term investment.[88] It is not clear, however, why carbon prices are different from any other sort of price. The price of a barrel of oil changes all the time, and yet markets function and investment takes place. Those who need price stability use futures markets or other hedging techniques. On the other hand, there is a belief in the value of stability in law, expressed in the judicial doctrine of stare decisis. Because the general importance of stability in the law is unknown, the costs and benefits of rapid changes to carbon prices are uncertain as well.

We need not resolve the issue of the optimal pace of change for laws — there is surprisingly little literature addressing this point — because most significant abatement opportunities involve long-term investments, such as changing the structure of the power industry. This means that there will be

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[86] Nordhaus, *supra* note 11, at 42.

[87] Weitzman, *supra* note 11, at 482.

[88] *See, e.g.*, DALLAS BURTRAW, KAREN PALMER & DANNY KAHN, A SYMMETRIC SAFETY VALVE 2 (2009), *available at* http://www.rff.org/RFF/Documents/RFF-DP-09-06.pdf.

little benefit from adjusting rates in the short run. If a utility is considering the design of a power plant that has a fifty-year life, it probably would matter little whether the carbon tax were to adjust every year or every five years. So if there were any cost to frequent changes, less frequent changes would be preferred.

The question for the design of a carbon tax is whether there is some mechanism for causing intelligent rate changes to happen at regular intervals. One possibility is to delegate the responsibility to set the rate to an expert agency. An agency might be relatively free from political pressure and would have the advantages of being able to revisit the rate at regular intervals and of employing experts who are able to distill the complex information needed to determine the correct rate. Agencies commonly set prices for significant items when they set electricity, airfare, and railroad rates. Agencies have also been used to set tariffs. Although many of these pricing decisions are now made in the private market, the government must set the tax rate, and these examples illustrate the feasibility of delegation of similar decisions.[89]

If Congress is unwilling to delegate tax rate decisions of this scope to an agency — the revenue numbers are large and many important industries or regions can be hurt — intermediate solutions are available. An agency could recommend a rate, and then various procedural rules could force Congress to consider the recommendation, or perhaps even give procedural protection to the recommendation. The military base closing commission might serve as an example.[90] An even milder form of delegation is to require a commission to meet on a regular basis to recommend rates. Although most commissions have little effect, there have been some that have worked, notably the National Commission on Social Security Reform, chaired by Alan Greenspan.

If an intermediate delegation system of this sort is not feasible, Congress might consider a system that forces reconsideration of the rate at regular intervals. Two obvious possibilities are a pre-scheduled rate that either goes up quickly, forcing Congress to act to reduce it as necessary, or goes down quickly (i.e., the tax expires), forcing Congress to increase it. Although this approach would mean that the nominal rate does not increase exponentially, as would be desired in the absence of new information about the marginal costs and benefits of abatement, it would force Congress to consider new information about these marginal costs and benefits and potentially produce a better overall rate schedule.

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[89] Various ways of framing the tax may change perceptions of whether delegation is appropriate. For example, if the tax is seen as a user fee, delegation may seem more appropriate. Similarly, if carbon tax revenues are dedicated to a particular use, the entire system looks more like traditional agency action as compared to the setting of a tax rate that raises general revenues.

[90] The Defense Base Closure and Realignment Commission is authorized by Congress through the Defense Base Closure and Realignment Act of 1990, Pub. L. No. 101-510, § 2902 (current version at 10 U.S.C. § 2687 (2006)).

III. The Tax Base

We begin the discussion of the carbon tax base with a review of the theory of how to set the base when there are measurement and collection costs. We then turn to a discussion of particular sources of emissions, focusing first on fossil fuels and then on other sources of emissions.

A. *Theory*

Absent administrative, enforcement, and political costs, an ideal tax system would include all activities that produce climate externalities. This includes emissions of all GHGs from any activity, including not only energy usage but also agriculture, forestry, and industrial emissions. Moreover, absent administrative costs, the tax would include not only emissions of gases but also any climate forcing (i.e., any activity that causes a change in the climate), such as changes to albedo caused by forestry activities.

There are, however, hundreds of sources of GHGs, most of them very small contributors. Moreover, many sources of emissions may be hard to measure and tax. To determine the optimal tax base, the administrative savings of a narrow base must be compared to the efficiency benefits of a broad base. In particular, the tax base should be set so that the benefit of a small expansion in the base is equal to the increase in administrative or compliance costs.

One can think of broadening the tax base as adding more potential sources of abatement, some of which may have marginal abatement costs lower than those of emitters already included in the tax base. These new sources create the possibility of a lower aggregate cost to achieve any given aggregate amount of abatement. In Figure 2 below, the steeper marginal abatement cost curve reflects a narrow tax base. Broadening the base rotates the curve to the right, and optimal abatement increases from A_N to A_B given the marginal benefit of abatement curve MB. The marginal benefit from broadening the tax base is equal to triangle Oab in the figure.[91]

To determine whether it is desirable to add any particular item to the tax base, it is necessary to know the marginal abatement costs for the activity generating the emissions and the costs of administering a tax on the item. In our discussion below, we use the estimates of the marginal abatement costs produced by EPA in 2006.[92] We do not have data on the administrative costs of including various items in the tax base; we make judgments based on information about the relevant activity, but better data might lead to a revision of these judgments. In general, items that offer large opportunities for

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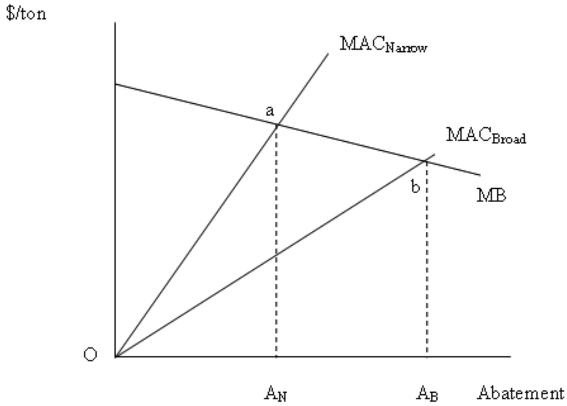
[91] This analysis abstracts from interactions with other tax distortions. In a second-best world with pre-existing distortions, lowering the environmental tax rate will have first-order efficiency gains not reflected in the diagram.

[92] *See* U.S. Envtl. Prot. Agency, EPA 430-R-06-005, Global Mitigation of Non-CO_2 Greenhouse Gases (2006) [hereinafter Global Mitigation], *available at* http://epa.gov/climatechange/economics/downloads/GlobalMitigationFullReport.pdf.

FIGURE 2. ILLUSTRATIVE ECONOMIC BENEFIT FROM BROADENING TAX BASE



low-cost abatement and low monitoring costs are candidates for inclusion in the tax base.

There is also a set of complicated political considerations. Adding items to the tax base increases the number of special interests that will oppose the tax. At the same time, broadening the base allows the tax rate to be lower overall, thereby possibly reducing opposition from those already in the base.

A final tax base issue is whether to tax GHGs on the basis of where the products giving rise to emissions are produced (an origin basis) or where the products are consumed (a destination basis). This distinction matters where trade is involved. We defer discussion of this point until Part V, but note here that we propose a modified origin basis. Under this approach, the United States would levy a tax at the border on fossil fuel imports from countries that do not have a substantive carbon pricing system in place. Fossil fuel imports from countries that have a substantial origin-based carbon pricing system in place would not be subject to a border tax. This principle would extend to a number of carbon-intensive products, as discussed below. In neither case would the U.S. carbon tax be rebated on exports.[93]

B. Fossil Fuels

Fossil fuels made up approximately 80% of all U.S. emissions in 2006.[94] Most developed countries have a similar profile. Developing countries will tend to have higher emissions from agriculture and deforestation,

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[93] Maintaining the origin basis principle, it is presumed that other countries with carbon pricing systems in place would also follow an origin basis principle with respect to the United States and would therefore not tax imports from the United States that already have a carbon tax embedded in their price.

[94] *See* EPA INVENTORY, *supra* note 12, at ES-7.

so considerations of how to include those activities in the tax base will be more important for developing countries.

There are two principles, one physical and one economic, which allow the collection and enforcement costs for a tax on emissions from fossil fuels to be relatively low. The first is that a unit of fossil fuel will emit the same amount of carbon regardless of when or where it is burned. For carbon emissions from fossil fuel combustion, there is an almost perfect correspondence between input and output. Therefore, it is possible to tax the input — the fossil fuel — rather than the output — the emission. The primary exception to this rule is for fossil fuel permanently sequestered, such as fuel used for tar or carbon that is captured and stored. This issue is discussed in Part IV.

The second principle is that the incidence of a tax and its efficiency effects are unrelated to the statutory obligation to remit the tax. This means that, in deciding where to impose the tax (choosing the remitting entity), one can focus on minimizing collection and monitoring costs while ensuring maximum coverage. In general, imposing the tax upstream (i.e., at the earliest point in the production process) will achieve these goals because (1) there are far fewer upstream producers than there are downstream consumers and (2) the cost will be lower per unit of tax due to economies of scale in tax administration.

To illustrate, there are approximately 146 petroleum refineries in the United States, but there are 247 million registered motor vehicles as well as millions of users of other petroleum distillates.[95] As a result, imposing the tax at the refinery level on petroleum products will be far less expensive than, say, trying to monitor emissions at the tailpipe. Similar principles apply to other fossil fuels. The key is to find a place between extraction and consumption where it is easiest to tax all or almost all of a fuel.

Arguments for downstream imposition of the tax tend to be based on a claim that a downstream tax is more visible than an upstream tax and, therefore, a downstream tax will have a greater effect. The claim would be that consumer response depends on visibility.[96] It is doubtful that this effect could be very large in the case of a carbon tax for two reasons. First, firms are likely to advertise the embedded tax in, say, gasoline, so drivers would be aware that part of the cost of the gasoline is the tax. Second, key energy

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[95] The number of operating refineries is from ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, REFINERY CAPACITY 2008, at 1 tbl.1 (2008), *available at* http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/refinery_capacity_data/current/refcap08.pdf. The number of registered motor vehicles is from FED. HIGHWAY ADMIN., U.S. DEP'T OF TRANSP., HIGHWAY STATISTICS 2007: STATE MOTOR-VEHICLE REGISTRATIONS tbl.MV-1 (2008), *available at* http://www.fhwa.dot.gov/policyinformation/statistics/2007/pdf/mv1.pdf.

[96] *See generally* Raj Chetty, Adam Looney & Kory Kroft, *Salience and Taxation: Theory and Evidence*, AM. ECON. REV. (forthcoming) (presenting evidence that the salience of a tax increases the elasticity of demand among consumers); Amy Finkelstein, *E-ZTax: Tax Salience and Tax Rates*, 124 Q.J. ECON. (forthcoming Aug. 2009) (presenting evidence that the salience of a tax increases the elasticity of demand among commuters on a toll road).

consumers — electric utilities and industrial energy users — are unlikely to be affected by this behavioral phenomenon.[97]

1. *Natural Gas*

Combustion of natural gas was responsible for 1163 MMT CO_2 emissions in the United States in 2006.[98] Natural gas is used largely for heating in the industrial and residential sectors and for producing electric power.[99] It is the most carbon-efficient fossil fuel in the sense that it produces the largest amount of energy for a given quantity of CO_2 emitted.

Natural gas is produced in a variety of circumstances. Most natural gas comes from stand-alone gas wells, but some is associated with oil production.[100] An additional source (about 9% of the U.S. total as of 2004) is releases from coal beds.[101] There were almost 450,000 natural gas wells in the United States in 2007,[102] but these are operated by a relatively small number of operators. According to the Energy Information Administration, the top 500 operators had about 95% of the proved reserves and more than 93% of production in 2006.[103]

Most natural gas is "wet" when extracted and must be processed to remove water vapor, thereby creating "dry" gas that can be put into the pipeline system. There are 530 large natural gas processors in the lower forty-eight states, and these process a substantial majority of the natural gas

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[97] None of the existing carbon pricing schemes is imposed upstream. Instead, they tend to be imposed midstream on large industrial point sources of emissions, such as power plants and industrial users of fuel. For example, the EU emissions trading regime is imposed midstream. One possible reason for this approach may have been to exclude the transportation sector, since it was already subject to high taxes on motor fuels. An upstream tax would have a harder time excluding transportation, so the compromise was a more expensive downstream tax. A related issue is the allocation of free permits. If there are short-term price rigidities — such as through electricity price regulation — it may matter which entities receive the free allocation. *See* ANTHONY PAUL, DALLAS BURTRAW & KAREN PALMER, COMPENSATION FOR ELECTRICITY CONSUMERS UNDER A U.S. CO_2 EMISSIONS CAP (2008), *available at* http://www.rff.org/RFF/Documents/RFF-DP-08-25.pdf. Midstream allocation of the permits may allow politicians to buy off potentially blocking interests.

[98] ENERGY INFO. ADMIN., *supra* note 28, at 344 fig.12.3. This figure represents CO_2 emissions from combustion of natural gas and excludes emissions of unburned natural gas (methane) into the atmosphere.

[99] *See id.* at 181 diagram 3.

[100] For a summary of natural gas production data, see Energy Info. Admin., U.S. Dep't of Energy, U.S. Natural Gas Gross Withdrawals and Production (Apr. 2, 2009), http://tonto.eia.doe.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm (on file with the Harvard Environmental Law Review).

[101] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, DOE/EIA-0216, U.S. CRUDE OIL, NATURAL GAS, AND NATURAL GAS LIQUIDS RESERVES: 2006 ANNUAL REPORT 38 (2007), *available at* http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/historical/2006/pdf/arr.pdf.

[102] Energy Info. Admin., U.S. Dep't of Energy, Number of Producing Gas Wells (Apr. 2, 2009), http://tonto.eia.doe.gov/dnav/ng/ng_prod_wells_s1_a.htm (on file with the Harvard Environmental Law Review)

[103] Authors' calculations based on ENERGY INFO. ADMIN., *supra* note 101, at A-4 tbl.A2, A-5 tbl.A3.

used. Some natural gas, however, is processed close to the point of extraction in smaller "skid" processors. Other natural gas, mostly coal-bed methane as well as gas from some wells that produce relatively dry gas, enters the pipeline system without substantial processing.[104] Once processed, natural gas enters into the pipeline system and is delivered to the local distribution companies. Virtually all gas goes through the pipeline system. Not all gas goes to a local distribution company, however, as some large-volume consumers buy directly from the transmission pipelines.

Most natural gas used in the United States is produced domestically, but some is imported from Canada through pipelines and from other places through liquefied natural gas facilities. Currently there are only fifty-five locations where natural gas (or liquefied natural gas) can be imported or exported, consisting of six liquefied natural gas facilities and forty-nine pipeline border points.[105] All these facilities and entry points are regulated by the Federal Energy Regulatory Commission.[106]

The collection point for the tax on natural gas needs to minimize administrative costs while maximizing coverage. The two most likely places to do this are at the operator level or at the processing plant (plus imports and coal-bed methane). Operators already pay state severance taxes, which means that they have the administrative capacity to pay the tax and that states are already collecting the necessary data. Although there are many small operators, taxing the top 500 would capture almost all the natural gas produced in the United States.[107] If the tax is levied on the processor, small operators would no longer be able to avoid the tax, and the tax system would not need to address the problem of different wells producing natural gas of differing carbon content (i.e., differing amounts of contaminants). The problem with taxing the processor is that some natural gas is put into the pipeline system without processing. Either choice may be sensible.

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[104] *See* Energy Info. Admin., U.S. Dep't of Energy, Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market 3 (2006), *available at* http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2006/ngprocess/ngprocess.pdf.

[105] *See* Energy Info. Admin., U.S. Dep't of Energy, About U.S. Natural Gas Pipelines — Transporting Natural Gas 64 (2007), *available at* http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/fullversion.pdf.

[106] *See* 15 U.S.C. § 717b (2006).

[107] *See* Joel Bluestein, Coverage of Natural Gas Emissions and Flows Under a Greenhouse Gas Cap-and-Trade Program 16-17 (2008), *available at* http://www.pewclimate.org/docUploads/NaturalGasPointofRegulation09.pdf (estimating that 70% of emissions from the natural gas sector are brought into a carbon pricing system if processors and importers are the point of regulation). We add major producers who add gas directly to the pipeline network without going through a processing plant. Broader emissions coverage can be obtained at the producer level (gas wells) or at the level of large users and local distribution companies, but at the cost of dramatically increasing the number of covered entities. *See id.* at 21 tbl.5.

2. *Coal*

Coal can be taxed at the production level (mines and import points) or at the consumption level (electric utilities and industry). We recommend the former. There were 1438 operating mines in the United States in 2006.[108] Almost all coal used in the United States is produced here, and there are very few exports.[109] Taxing at the mine would capture virtually 100% of U.S. coal production. Moreover, as noted, coal mines are potential sources of methane or natural gas, either captured and put into the pipeline system or released into the air. If it is captured, this source of natural gas may not need to be processed. Therefore, having mines as taxpayers may create synergy — they can pay the tax on this source of natural gas as well. If it is not captured, coal mines should pay a tax on any release. Coal-bed methane emissions in 2006 were around 58.5 MMT CO_2e,[110] so imposing this tax will be important.

An alternative is to tax coal downstream. Almost 93% of coal is used in electricity generation, and nearly all the rest is used by industry. There are 1470 coal-fueled electric generating units in the United States,[111] so taxing the power plants would not be more difficult than taxing at the mine and would have only a slightly smaller base. Taxing at the utility, however, would mean losing the synergy created by taxing at the mine discussed above.[112] As there does not appear to be any advantage to taxing at the utility and some disadvantage, taxing at the mine seems to be preferable.[113]

In the United States, coal is sorted into four types: anthracite, bituminous, subbituminous, and lignite. Each of these grades has a different car-

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[108] Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0584, Annual Coal Report 2006, at 12 tbl.1 (2007), *available at* http://tonto.eia.doe.gov/FTPROOT/coal/05842006.pdf.

[109] Energy Info. Admin., *supra* note 28, at 215 tbl.7.7.

[110] EPA Inventory, *supra* note 12, at 3-36.

[111] Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0348, Electric Power Annual 2007, at 25 tbl.2.2 (2009), *available at* http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf. The number of power plants with coal-fueled units is smaller because many power plants have multiple generating units.

[112] It also increases the administrative burden for power plants that are dual-fired (burning coal and natural gas). Plants burning coal would be required to file taxes while plants burning only gas would not.

[113] If a large percentage of utilities are eventually in the tax system because of credits for CCS activities, there may be little difference in the number of taxpayers. Mines will be taxpayers because of coal-bed methane, and coal-burning utilities will be taxpayers because of CCS. Moreover, unless CCS credits were refundable or tradable, having utilities as taxpayers would reduce problems with unusable credits. On the other hand, CCS does not right now exist in the United States and it is not clear how long it will be before it is in widespread use. *See* Keith Johnson, *FutureGen Fiasco: Killing Illinois Plant Set Clean Coal Back 10 Years, Congress Says*, Wall Street Journal Environmental Capital Blog, Mar. 11, 2009, http://blogs.wsj.com/environmentalcapital/2009/03/11/futuregen-fiasco-killing-illinois-plant-set-clean-coal-back-10-years-congress-says (on file with the Harvard Environmental Law Review). Taxing utilities may also be more complex because some plants can use more than one type of fuel, so the tax would have to vary depending on the fuel being used. In addition, taxing utilities would require industrial users of coal to be subject to tax separately, a step that is not necessary if the mines are taxed.

bon content and, therefore, would need to face a different tax rate.[114] If the carbon content within any one of the U.S. grades is relatively uniform, there would be little reason to consider a more fine-grained approach. If, however, there is significant variation within a grade, finer gradations may be worth considering. Existing cap-and-trade bills in Congress generally delegate this decision to the relevant agency, and a similar delegation would probably be sensible for a carbon tax.

3. *Petroleum*

The two potential places to tax petroleum products are at the source (the well or import point) or at the refinery. Taxing petroleum downstream is impractical — there are over two hundred million cars plus many users of distillates other than gasoline. There were only 146 operating refineries in the United States in 2008,[115] making the refineries a logical place to impose the tax. The advantage of taxing refineries is that they could pay a separate tax on each distillate depending on the carbon content. Distillates, such as tar, that would not be burned would not be subject to tax. Imports of crude oil from countries with no carbon pricing system would be subject to the tax at the refinery without any special provision. Imports of refined products (about 3.5 million barrels per day), however, would need to be taxed if they are from a country without a carbon pricing system.[116]

Refineries often engage in inventory exchanges with other refineries. Although the sale of inventory would normally be the event that triggers the carbon tax, inventory exchanges should not be taxed because doing so would cascade the tax: the inventory would be taxed when refinery 1 exchanges it with refinery 2 and once again when refinery 2 sells it into the market.

4. *Other Issues with the Taxation of Fossil Fuels*

We approached carbon emissions from fossil fuels by looking at each fuel. It is worth pausing to look at whether the structure of particular industries will affect how the tax works. We examine here regulated power and transportation (road, air, and sea). In Part IV, we examine permanently sequestered carbon.

The most important issue with respect to the regulated power industry is to ensure that the tax is included in the operating cost component of rates so that it is passed on to customers. If it is not, users will not see the appro-

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[114] Estimated carbon dioxide emission factors for the various grades are 103.6, 93.5, 97.1, and 96.4 kg CO_2 per MMBtu for anthracite, bituminous, subbituminous, and lignite, respectively. Energy Info. Admin., *supra* note 20.

[115] *See* ENERGY INFO. ADMIN., *supra* note 95, at 1 tbl.1.

[116] An advantage of taxing at the refinery is that we would be setting rates for refined products that could then be used for taxing imports of refined products. Note that we need to ensure that any fuel used by refineries would be taxed under this system. That is, we have to ensure the tax on refined products is not only on the sale of refined products but also on the refinery's own use of any petroleum.

priate price, defeating part of the reason for the tax.[117] This should not be an issue with a tax on the fuel purchased by the utility: if the tax is imposed upstream, it would simply be embedded in the price and naturally flow into electricity rates through fuel costs. This presumes that state regulators allow utilities to pass fuel cost increases through to consumers. It is not obvious that this will always occur. Regulatory reluctance to flow permit costs through will likely be higher for a cap-and-trade system where permits are given away; there is an opportunity cost to using a permit even if received for free, but it is very unlikely that a regulator will allow a utility to charge customers a non-zero opportunity cost related to use of a permit that the utility received for free.[118] Similar issues may arise with respect to tax credits intended to act similarly to freely allocated permits.[119]

The major issue with respect to road transportation is the interaction with existing tax and regulatory regimes. There are gas taxes under current law as well as regulatory regimes designed to alter gasoline usage.[120] The question is whether the carbon tax is additional to these regimes or replaces some or all of them.

There are numerous non-carbon externalities from driving, including accidents, congestion, and non-carbon pollution. The optimal gas tax has been estimated to be roughly twice as high as the current U.S. tax.[121] The most important source of externalities from driving is congestion; carbon emissions are a relatively small element. Therefore, the imposition of a tax on petroleum, and hence gasoline, to internalize externalities from carbon emissions should not result in a reduction in the existing gasoline tax.

The appropriate treatment of emissions from international aviation and maritime fuels (known as bunker fuels) is part of the larger issue of carbon leakage and optimal border tax treatment. We discuss this in greater detail below, but we make some preliminary comments here. Taxing emissions from aviation on purely domestic flights would be straightforward — jet fuel would be taxed at the refinery. There are, however, two problems with taxing emissions from international aviation. The first is that there is an existing treaty under the International Civil Aviation Organization ("ICAO")

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[117] Investors would see the effect, however, potentially leading to beneficial diversion of investment into low carbon technology.

[118] Kevin A. Hassett, Aparna Mathur & Gilbert E. Metcalf, *The Consumer Burden of a Cap-and-Trade System with Freely Allocated Permits* 2 (Am. Enter. Inst. for Pub. Policy Research, Working Paper No. 144, 2008), *available at* http://www.aei.org/docLib/20081223_ConsumerBurden.pdf (discussing the distributional implications of different regulatory treatment of freely allocated versus auctioned permits).

[119] For a history of and rationale for electricity industry deregulation and discussion of differences between the regulated and deregulated systems, see Paul L. Joskow, *Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector*, J. ECON. PERSP., Summer 1997, at 119.

[120] *See, e.g.*, *infra* text accompanying notes 228-233.

[121] Ian W.H. Parry & Kenneth A. Small, *Does Britain or the United States Have the Right Gasoline Tax?*, 95 AM. ECON. REV. 1276, 1277 (2005).

that prohibits imposing taxes on fuel carried on international services.[122] Second, because of the possibility of fueling or refueling in countries without a tax, carbon leakage could be a significant problem.[123] Moreover, taxing fuel at the refinery may not be feasible if, at the time of taxation, it is unknown whether the fuel will be used for international or domestic flights.

There are two primary options. First, the United States could impose a tax on international aviation by making several adjustments. The ICAO treaty could be renegotiated (or the United States could simply breach it). In addition, to prevent carbon leakage, the United States could impose a surcharge for any fuel taken on in a non-taxing country for flights with a U.S. destination. The second alternative is to forgo taxing fuel used in international aviation. Airlines would get a credit for fuel used in international flights much like the crediting system for CCS. The problem with this alternative is that it would leave out a significant source of emissions — international aviation emissions worldwide are nearly double domestic aviation emissions.[124]

The economic issues are similar for bunker fuels in shipping. While there is no treaty preventing the taxation of bunker fuels in ships, the problem of carbon leakage is serious — ships would have incentives to refuel in locations where there is no tax. Moreover, it might be more complicated to track fuel use on ships than on aircraft, making it more difficult to impose a surcharge for such refueling.

C. *Other Sources of Emissions*

In addition to emissions from fossil fuel combustion, GHG emissions include (1) non-combustion CO_2 emissions; (2) non-CO_2 GHG emissions, including emissions of methane and N_2O from agriculture; and (3) emissions from forestry and land use activities. We discuss below the extent to which these sources should be included in the tax base. The EPA data on marginal abatement costs allows us to estimate the benefits of including various sources in the tax base, but there is no data on the administrative costs of doing so. Therefore, the judgments below are necessarily preliminary, and greater study of most of these sources of emissions is warranted.

1. *Non-Combustion CO_2 Emissions*

Non-combustion carbon dioxide emissions accounted for less than 4% of CO_2 emissions in 2006.[125] Cement manufacturing and steel and iron pro-

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[122] Int'l Civil Aviation Org. [ICAO], Convention on International Civil Aviation, art. 24, Dec. 7, 1944, T.I.A.S. No. 1591, 15 U.N.T.S. 295 (9th ed., ICAO Doc. 7300/9, 2006).

[123] Carbon leakage is discussed more extensively in the context of border tax adjustments in Part V.B.2, *infra*.

[124] Stern, *supra* note 40, at 549.

[125] Authors' calculations based on EPA Inventory, *supra* note 12, at 2-4 tbl.2-1.

duction accounted for approximately half the emissions in this category.[126] It may be reasonable to include their emissions (as well as emissions from a few other industries in this category) in the tax base.

Cement manufacturing produced about 45.7 MMT CO_2 in 2006 separate from the emissions associated with energy used during production.[127] The emissions stem from the production of clinker, an intermediate product, which is a combination of lime and silica-containing materials.[128] According to EPA, CO_2 emissions from production are directly proportional to the lime content of the clinker.[129] The tax would be imposed at the source of clinker production. There are 116 cement plants in the United States; as of 2005, they were owned by thirty-nine companies.[130] These are large, stationary sources of emissions and, therefore, should be relatively easy to tax.

Steel and iron production produced 49.1 MMT CO_2 in 2006.[131] The emissions, separate from the emissions associated with the energy used to produce iron and steel, come from the production of metallurgical coke, pig iron, and steel itself.[132] The emissions can be measured indirectly by the amount of coke, pig iron, and steel production. The tax can be applied at the point of production. There are only twenty-three steel mills in the United States.[133] Therefore, like cement manufacturing, steel and iron production should be relatively easy to include in the tax base.

2. *Other Greenhouse Gas Emissions*

In addition to carbon dioxide, a number of other gases contribute to global warming. Gases other than carbon dioxide account for 15% of total U.S. emissions.[134] Methane is the most important, followed by nitrous oxide, fluorinated gases and sulfur hexafluoride.[135] While non-CO_2 emissions are not a large share of total emissions, studies suggest that they will provide a relatively low-cost source of emission reductions under a carbon tax or other form of carbon pricing. One study, for example, estimates that about one-

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[126] *See id.*

[127] *Id.* at 4-3 tbl.4-1.

[128] *Id.* at 4-5.

[129] *Id.*

[130] Portland Cement Ass'n, Cement Industry Overview (May 2008), http://www.cement.org/econ/industry.asp (on file with the Harvard Environmental Law Review); Portland Cement Ass'n, Overview of the Cement Industry (May 2003), http://www.cement.org/basics/cementindustry.asp (on file with the Harvard Environmental Law Review). For more detail on the industry, see Lisa J. Hanle, Kamala R. Jayaraman & Joshua S. Smith, CO_2 Emissions Profile of the U.S. Cement Industry (2004), *available at* http://www.epa.gov/ttn/chief/conference/ei13/ghg/hanle.pdf.

[131] EPA Inventory, *supra* note 12, at 2-4 tbl.2-1.

[132] *Id.* at 4-34.

[133] Energy International, Metals Advisor — Iron and Steel Overview: Integrated Mill Business Structure, http://www.energysolutionscenter.org/HeatTreat/MetalsAdvisor/iron_and_steel/overview/integrated_mill_business_structure.htm (last visited March 15, 2009) (on file with the Harvard Environmental Law Review).

[134] *See* EPA Inventory, *supra* note 12, at 2-4 tbl.2-1.

[135] *Id.*

third of the initial emission reductions from carbon pricing would come from reductions in non-CO_2 emissions.[136]

a. Methane

Five sources account for about 85% of all methane emissions in the United States. These are enteric fermentation (126.2 MMT CO_2e), landfills (125.7 MMT), natural gas systems (102.4 MMT), coal mining (58.5 MMT), and manure management (41.4 MMT).[137]

Enteric fermentation is a part of the digestive process in ruminants (in the United States, largely cattle), which produces methane. The feed quality and feed intake affect emissions.[138] The U.S. inventory system measures emissions from enteric fermentation through detailed calculations that separate cattle by region, age, reproductive status, and industry segment.[139] The system uses estimates of the digestible energy and methane conversion rates from various diets to determine emissions from the various categories.[140]

EPA estimates the marginal abatement costs for methane from enteric fermentation. For the United States, it estimates that emissions in 2010 could be reduced by 6.4% at zero cost and 21.4% at $45 per ton of CO_2e.[141] These are reasonably large reductions for the cost. As a result, the United States might consider levying a head tax on cattle based on average emissions for a small number of cattle types. Since modifications to diet can reduce emissions, taxpayers should be allowed a reduced rate when they provide proof that they are using approved diets that reduce emissions.

According to the EPA Inventory, roughly 1800 operating landfills exist in the United States.[142] Municipal landfills account for nearly 90% of methane landfill emissions, with industrial landfills making up the rest.[143] Methane recovery has grown over time since 1996 federal regulations required large landfills to capture and combust landfill methane[144] (thereby converting it to less potent CO_2). Whereas only 20% of landfill methane was burned for energy, flared, or oxidized in 1990, over half of methane emissions were in 2006.[145] EPA estimates that with a tax of forty-five dollars per ton, more than 80% of U.S. landfill emissions could be eliminated.[146] Requiring monitoring of all landfills and including their emissions in the tax base should be relatively straightforward.

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[136] SERGEY PALTSEV ET AL., ASSESSMENT OF U.S. CAP-AND-TRADE PROPOSALS 18 (2007), *available at* http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt146.pdf.
[137] EPA INVENTORY, *supra* note 12, at ES-5 tbl.ES-2.
[138] *Id.* at 6-2.
[139] *Id.* at 6-3 to 6-4.
[140] *See id.*
[141] GLOBAL MITIGATION, *supra* note 92, at V-49 tbl.1-18.
[142] EPA INVENTORY, *supra* note 12, at 8-2.
[143] *Id.*
[144] *See id.* at 8-3.
[145] *See id.* at 8-3 tbl.8-3.
[146] GLOBAL MITIGATION, *supra* note 92, at III-10 tbl.1-6.

Methane emissions from natural gas systems arise in field production (27%), processing (12%), transmission and storage (37%), and distribution (24%).[147] So-called "direct inspection and maintenance" can significantly reduce these emissions.[148] Despite the growth in natural gas consumption between 1990 and 2006, emissions in the processing, transmission and storage, and distribution stages fell by approximately 20%.[149] Implementing the carbon tax on processors based on inputs will ensure that some of these emissions are brought into the carbon tax base and thereby provide the appropriate incentives to implement improvements to reduce accidental releases. In addition, it might be possible to add transmission, storage, and distribution systems to the tax base by monitoring inputs and outputs and imposing taxes on any natural gas that is unaccounted for. If such a system is feasible, about three-quarters of methane emissions from natural gas would be included in the tax base.

Bringing field production emissions into the tax system is probably not realistic. Instead, mandates for certain processes or technologies may be useful here. The rising price of natural gas over time will also provide an incentive to reduce emissions (as they reflect natural gas that cannot be sold).

Methane emissions from other sources can be considered for inclusion in the tax base on a case-by-case basis. Emissions from coal mines are easily monitored and collected in some (but not all) cases. Nearly two-thirds of these emissions come from underground mines[150] where methane is removed through ventilation systems for safety reasons and so can be collected, measured, and made subject to the tax.[151] Emissions from surface mines, on the other hand, are more difficult to capture since they are released as the overburden is removed. Surface mine emissions are much lower in amount, however.[152] EPA estimates that almost 86% of methane emissions from coal mining can be eliminated at fifteen dollars per ton, making coal-bed methane a good target for inclusion in the tax base.[153]

b. Nitrous Oxide

Nitrous oxide ("N_2O") has a 100-year GWP of 310. About three-quarters of the 368 MMT CO_2e of annual U.S. N_2O emissions come from agricultural management activities.[154] These emissions are a prime example

[147] Shares of emissions from EPA Inventory, *supra* note 12, at 3-43 tbl.3-34.
[148] Global Mitigation, *supra* note 92, at II-16.
[149] EPA Inventory, *supra* note 12, at 3-43 tbl.3-34.
[150] *Id.* at 3-36 tbl.3-27.
[151] Prior to 2002, coal-bed methane was eligible for the section 29 non-conventional fuels tax credit of three dollars per barrel of oil equivalent. *See* Curtis Carlson & Gilbert E. Metcalf, *Energy Tax Incentives and the Alternative Minimum Tax*, 61 Nat'l Tax J. 477, 480 (2008). The credit could be reinstated or methane flaring could be allowed as an offset activity to provide a financial incentive to capture these emissions.
[152] Global Mitigation, *supra* note 92, at II-2, II-3.
[153] *Id.* at II-10 tbl.1-8.
[154] EPA Inventory, *supra* note 12, at 2-5 tbl.2-1, 6-1 tbl.6-1.

of a case where there are large emissions (almost 4% of the U.S. total) but where it will be difficult to include them in the tax base. The reason is that the emissions stem from a wide variety of sources that are difficult to observe.[155] The particular extent of emissions depends on the precise nature and location of the activity, making it difficult to set tax rates. A full exploration of emissions from agricultural soil management would need a separate study. We make only a few initial observations here.

N_2O is produced naturally in soils through nitrification and denitrification. Various agricultural activities increase mineral nitrogen availability in soils, increasing the amount of N_2O emitted. These include application of synthetic nitrogen fertilizers, organic amendments to soil (such as manure, compost, and sludge), urine and dung from grazing animals, and crop residues.[156] Various soil management activities, such as irrigation, drainage, tillage, and fallowing of land influence nitrogen mineralization.[157]

The precise emissions from any given activity depend on many factors. For example, the granularity of the soil affects the process of denitrification.[158] This means that the tax rate can only be correct on average. Actual emissions from any particular activity cannot be measured. Instead, a tax would have to rely on rough proxies, such as the total amount of fertilizer applied or the total number of livestock grazing during the year. It is worth noting, however, that EPA estimates that roughly 20% of N_2O emissions arise from the use of artificial fertilizers.[159] A fertilizer tax would likely lead to less fertilizer use but could lead to other practices that release nitrogen. For example, if fertilizer is taxed but manure is not, there would be incentives to substitute manure for fertilizer (thereby increasing the value of a livestock byproduct and consequently making livestock relatively less costly to raise), and it is possible that emissions from livestock could increase as a result.

The second largest source of N_2O is mobile combustion emissions (33.1 MMT).[160] Mandating annual vehicle emissions tests would provide a way to include these in the tax base.[161] The remaining N_2O emissions can be added to the tax base on a case-by-case basis.

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[155] *See id.* at 6-17 to 6-31.

[156] *Id.* at 6-18 fig.6-2 (providing a picture of agricultural sources of nitrogen that result in N_2O emissions).

[157] *See id.* at 6-17.

[158] *Id.* at 6-19.

[159] *Id.* at 6-19 tbl.6-15.

[160] *Id.* at 3-30 tbl.3-22.

[161] Annual emissions are the product of emissions per gallon gasoline, miles per gallon, and annual miles driven. The first and third components of this can be measured at the inspection (assuming mileage records are kept as part of the inspection). Assumptions about fuel efficiency can be built into the tax based on year and model of the vehicle.

c. Fluorinated Gases and Sulfur Hexafluoride

There are a large number of man-made gases with high GWPs (generically, fluorinated gases) used throughout the economy.[162] Chlorofluorocarbons ("CFCs") and related chemicals were in wide use prior to the Montreal Protocol but were banned because of their effect on ozone. Hydrofluorocarbons ("HFCs") were developed as alternatives to these ozone-depleting substances for industrial, commercial, and consumer products. The GWPs of these gases range from around 140 (HFC-152a) to 11,700 (HFC-23).[163] They have varying atmospheric lives, with some very short and some ranging up to tens of thousands of years. If treated as a single category, they make up about 125 MMT CO_2e emissions in the United States each year.[164] This would make them one of the top five sources of emissions.

Because they have very high GWPs, the tax on these chemicals will be many times the market price. The price signal from taxation, therefore, may be very important for these chemicals. Nevertheless, they may not be easy to tax through a direct mechanism. The reason is that emissions from fluorinated gases are largely fugitive emissions, gases that inadvertently escape through leakage or inappropriate disposal. This means that there is no observable transaction on which to base the tax. For example, a significant source of HFCs is leakage from air conditioning for cars and trucks. Similarly, certain types of foam contain significant HFCs and improper disposal can lead to the eventual release of the gases.[165]

A promising method of taxing emissions of these gases is a deposit-refund system. In a deposit-refund system, an initial presumptive tax is levied on the manufacture or purchase of an item and a refund is provided upon proof of proper disposal. To illustrate, consider an automobile with an air conditioner that uses HFCs. Imagine that it uses an amount that if emitted to the atmosphere would trigger a tax of $1000. Any HFCs that have not leaked out of the car can be recovered upon scrapping of the car and reused, thereby avoiding any release to the atmosphere. Rather than try to tax the leakage, the United States can impose a tax of $1000 per unit purchased and refund the tax for all HFCs that are recycled upon retirement of the automobile. Even though disposition of the automobile may not be easily moni-

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[162] Information for this section of the paper comes from INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SAFEGUARDING THE OZONE LAYER AND THE GLOBAL CLIMATE SYSTEM: ISSUES RELATED TO HYDROFLUOROCARBONS AND PERFLUOROCARBONS (2005) [hereinafter SAFEGUARDING THE OZONE LAYER], *available at* http://www.ipcc.ch/pdf/special-reports/sroc/sroc_full.pdf.

[163] The GWPs of these gases are very sensitive to the period of measurement as they have a wide range of atmospheric lifetimes. For a complete list of these chemicals and their GWPs over various periods, see Solomon et al., *supra* note 1, at 33 tbl.TS.2.

[164] EPA INVENTORY, *supra* note 12, at 4-3 tbl.4-1.

[165] *Id.* at 4-54.

tored, an incentive exists to capture and recycle the HFCs. The tax is then paid only on the HFCs that have leaked out of the car over its lifetime.[166]

A deposit-refund system potentially works in the fluorinated gas context because there are relatively few manufacturers, making collection of the upfront tax easy. For example, there are only five producers of HFCs in the United States right now.[167] In addition, in many places, there are well-developed recycling, reuse, or disposal requirements for these chemicals at the state and local level, which means that tracking disposal would not be expensive. In addition, given the refund upon proper disposal, there would be an incentive to reveal information about disposal to be eligible for refunds. For example, when a vehicle is junked, there would be an incentive to remove the air conditioning system with the HFCs intact to obtain the refund.

A deposit-refund system faces many of the same design issues as does a tax. For example, imports would have to be carefully monitored and taxed. If the gases can be imported without tax, businesses could earn profits by manufacturing the chemicals abroad for the sole reason of obtaining the refund in the United States. Since most HFCs are used in refrigeration and air conditioners, imposing a tax on imports should not be overly difficult.

In a related vein, some of these gases are used in the production of other goods, such as the use of perfluorocarbons in semiconductor manufacturing.[168] Unless imports of goods manufactured with these chemicals are subject to tax, taxing domestic production would create an incentive to shift production abroad, particularly because the tax would be many times the cost of the chemical (due to the high GWP). However, an accurate tax on imports might be difficult to assess because emissions from manufacturing abroad would not be observable. Therefore, depending on how easy it is to shift manufacturing using these gases abroad, a lower tax rate may be appropriate. This is simply another example of the border tax problem that we discuss in Part V.

A major source of emissions of fluorinated gases comes from existing banks of these gases rather than new production. According to the IPCC, there are almost twenty-one billion metric tons (21,000 MMT) CO_2e in banked fluorinated gases.[169] Because of the Montreal Protocol,[170] production of CFCs has ceased in the developed world.[171] Nevertheless, emissions from CFCs continue because they remain in existing refrigeration and other systems.[172] Banked gases will not have been subject to the tax on production, so

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[166] Deposit-refund systems are discussed extensively in Don Fullerton & Ann Wolverton, *The Two-Part Instrument in a Second-Best World*, 89 J. PUB. ECON. 1961 (2005). It might be necessary to create tightness quality standards for automobile air conditioners since it is difficult for the consumer to monitor the quality of the air conditioner.

[167] SAFEGUARDING THE OZONE LAYER, *supra* note 162, at 407 fig.11.1.

[168] EPA INVENTORY, *supra* note 12, at ES-6 tbl.ES-2.

[169] SAFEGUARDING THE OZONE LAYER, *supra* note 162, at 9.

[170] Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, S. TREATY DOC. NO. 100-10, 1522 U.N.T.S. 29.

[171] EPA INVENTORY, *supra* note 12, at ES-2.

[172] *Id.* at 4-52.

the question is whether they should be subject to the refund on proper disposal. Our view is that they should: the refund on proper disposal creates an incentive not to emit these gases. Given the size of existing banks, proper disposal is important. This is analogous to an offset provision for GHG emissions that are not included in the tax base.

Finally, sulfur hexafluoride (SF_6) is a potent GHG. It is used in electrical transmission and distribution equipment with most emissions arising from leakage.[173] SF_6 has a 100-year GWP of 23,900, so a $25 per ton CO_2e carbon tax would be equal to $597,500 per ton of SF_6.[174] Therefore, even a modest carbon tax may have a large effect on the use of this chemical. Emissions of SF_6 fell by nearly 50% between 1990 and 2006, reflecting the higher price of the product.[175] A deposit-refund mechanism here would be a relatively simple way to bring this gas into the carbon tax base.

3. *Forestry and Land Use Activities*

Forestry and land use serves as a net sink, removing some 900 MMT CO_2e from the atmosphere in 2006.[176] Changes in land and forest use can add or remove carbon on balance. Adding these activities to the tax base would require establishing a baseline. To see the complexity of this, consider a forest that currently sequesters 100 tons of CO_2 per year. Should an owner of that property receive a tax credit for the 100 tons of sequestered CO_2? Or perhaps the owner should be subjected to a tax on fifty tons of CO_2 because an "undisturbed" forest would sequester 150 tons of CO_2? One way to proceed would be to set as a baseline the emissions/sequestration as of the first year of the carbon tax. But if the tax is anticipated, it creates an incentive to cut down the forest prior to the first year of the tax so as to obtain large amounts of credits in early years, since young forests absorb more carbon than do mature forests.[177]

Once a baseline is set, a forestry carbon assessment could be undertaken periodically (e.g., every ten years) and the tax applied retrospectively. Continuing with the example above, assume the forest in question is an immature forest and over a ten-year period sequestration falls to eighty tons per year. With 100 tons per year established as the baseline, the annual emissions would be estimated to rise from zero tons in $year_0$ to twenty tons in $year_{10}$. The retrospective tax would be equal to two tons in $year_1$ times the $year_1$ tax rate plus four tons in $year_2$ times the $year_2$ tax rate and so on to $year_{10}$ when the tax is twenty tons times the $year_{10}$ tax rate. Landowners

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[173] *Id.* at 4-61.
[174] *Id.* at 1-7 tbl.1-2.
[175] *Id.* at 4-61.
[176] *Id.* at 7-2 tbl.7-1.
[177] The anticipation problem might be avoided by setting a past year as the baseline year for allocation of permits.

could be required to make estimated payments over the decade in anticipation of the retrospective liability.[178]

One can imagine any number of complications with such a system. It may be preferable to leave forestry and land use out of the tax system but provide the opportunity for owners of such resources to opt in through offsets.[179] This might be limited to major landowners to limit administrative costs. Considering forest ownership, the United States might limit offsets to the major paper and forest product companies and require that they consider offsets on their entire stock of land rather than individual parcels. This reduces problems of non-additional projects (projects that would be undertaken regardless of whether there is a carbon tax).

4. *Summary*

We offer here a brief survey of non-fossil fuel combustion emissions. Determining the full extent of the tax base for these emissions would require a more detailed examination of each item. Based on the analysis above, however, it seems likely that the United States could include in the tax base somewhere around half of the emissions from sources other than fossil fuel combustion at a reasonable cost. In particular, if emissions from landfills, enteric fermentation, substitutes for ozone depleting chemicals, natural gas systems, coal mining, and steel and cement production were included in the base, plus possibly some fraction of nitrous oxide emissions from mobile sources, it would be possible to reach about half of the non-fossil fuel combustion emissions. There might, moreover, be additional room for expanding tax base beyond these categories.

IV. Carbon Sequestration Credits

We have noted above in several places the need to provide credits for activities that permanently sequester carbon. Carbon capture and storage ("CCS"), for example, is a much discussed technology to capture CO_2 emissions from coal combustion in electricity generators. The CO_2 is compressed, liquefied, and transported to a geologically desirable location where it is permanently stored underground. The technology for CCS is well understood and CO_2 is injected underground now as part of enhanced oil recovery methods.[180]

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[178] *See* John M. Reilly & Malcolm O. Asadoorian, *Mitigation of Greenhouse Gas Emissions from Land Use: Creating Incentives within Greenhouse Gas Emissions Trading Systems*, 80 Climatic Change 173, 187-188 (2007); Gilbert E. Metcalf & John M. Reilly, *Policy Options for Controlling Greenhouse Gas Emissions: Implications for Agriculture*, Choices, 1st Quarter 2008, at 34.

[179] Such an offset system would work similarly to the CDM, i.e., by establishing a baseline rate of deforestation and providing credits for improvements from that baseline.

[180] The Weyburn-Midale fields in Saskatchewan, Canada, are oil fields where CO_2 is used for enhanced oil recovery on a large scale. Petroleum Tech. Research Ctr., Weyburn-Midale

While it is clear that CCS works in single applications, little is known about the potential to scale the technology up to levels that will be required given our current and projected coal consumption. No existing projects are associated with coal production,[181] as the United States faces many obstacles in developing a major CCS program for coal, such as finding adequate and safe storage sites for large volumes of carbon dioxide and developing a pipeline system for transporting it.[182] One study has estimated that a price in the neighborhood of thirty dollars per ton of CO_2 begins to make CCS economically viable, assuming that the various technical, regulatory, financial, and political obstacles can be overcome.[183]

Regardless of the feasibility of CCS, the carbon tax will only provide an incentive for sequestration if the tax base excludes fossil fuel use for which emissions are captured and stored. This can be done either by explicitly excluding such fuels (and other gases for which sequestration occurs) from the tax base or by levying the tax and providing a credit for approved sequestration activities. We advocate the latter as being easier to administer. Credits could be applied against carbon tax liability. Because firms engaging in CCS and other approved sequestration activities may not be the same firms that pay the carbon tax, we recommend that the credits be made tradable as is effectively done with other tax credits such as the low-income housing tax credit. Making the credits tradable ensures that their full value is realized by firms engaging in sequestration activities.[184]

CO_2 Project: Overview, http://www.ptrc.ca/weyburn_overview.php (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review). The CO_2 is purchased from the Dakota Gasification Company synfuels plant in North Dakota and shipped by pipeline to the Canadian fields. *Id.* As of 2006, it was sequestering nearly 9000 metric tons of CO_2 per day in the field making it a leading sequestration project in operation today. Petroleum Tech. Research Ctr., Weyburn-Midale CO_2 Project: History, http://www.ptrc.ca/weyburn_history.php (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review). StatoilHydro has CCS programs in place at several natural gas fields, too. At its Sleipner field, it captures one MMT CO_2 annually and stores it 800 meters below the seabed. StatoilHydro, Sleipner Vest, http://www.statoilhydro.com/en/EnvironmentSociety/Sustainability/2007/Environment/Climate/CarbonCapture/Capture/Pages/SleipnerVest.aspx (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review). Gas from the Snøhvit field is converted to liquefied natural gas and the CO_2 is frozen and removed. StatoilHydro, Snøhvit, http://www.statoilhydro.com/en/EnvironmentSociety/Sustainability/2007/Environment/Climate/CarbonCapture/Capture/Pages/Snøhvit.aspx (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review). The CO_2 is transported back to the field and stored in a porous sandstone structure below the gas field. *Id.* A third CCS project in the In Salah gas field in Algeria captured and reinjected roughly 700,000 metric tons of CO_2 into the gas field as of 2007. StatoilHydro, In Salah, http://www.statoilhydro.com/en/EnvironmentSociety/Sustainability/2007/Environment/Climate/CarbonCapture/Capture/Pages/InSalah.aspx (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review).

[181] *See* Deutch et al., *supra* note 72, at 59.

[182] *Id.* at 56-59.

[183] *Id.* at xi.

[184] The final incidence of the credits will depend on the relative supply and demand elasticities for these credits. We anticipate that the demand elasticity would be significantly greater than the supply elasticity so that most of the value of credits will go to firms engaging in approved sequestration activities.

Tax credits are also an issue for fossil fuels that are used as feedstocks or converted into non-fuel end-products such as asphalt, lubricants and waxes. Table C shows ultimate CO_2 emissions and storage for fossil fuels applied to these non-fuel uses.

TABLE C. 2006 CO_2E EMISSIONS AND STORAGE FROM NON-ENERGY FUEL USE[185]

Source	Emissions (MMT)	Stored (MMT)	Percentage Stored
Feedstocks	82.8	132.4	62
Asphalt	0.0	92.8	100
Lubricants	19.1	1.8	9
Waxes	0.8	1.1	58
Other	35.3	11.7	25
Total	138.0	239.8	63

Emissions from non-energy use accounted for 2% of total emissions in 2006.[186] Feedstocks are the main source of these emissions. An upstream carbon tax will incorporate these emission sources in the tax base. The more salient issue for non-energy fuel use is to ensure that the United States taxes only emissions and not the carbon that is captured and permanently sequestered. As Table C indicates, the percentage of carbon stored varies widely across non-energy uses. A simple tax credit works well where all carbon is captured (as is the case with CCS or the use of fuels in asphalt). For intermediate fuels used as feedstocks, the EPA Inventory assumes that 62% of all carbon is stored regardless of the feedstock source.[187] Thus, one approach would allow a credit for fuels sold as feedstocks to receive a partial credit (62% of one CO_2e ton per credit) with periodic updating of the storage factor as needed. It may be that providing a credit for asphalt and feedstock use is sufficient given the small amounts of stored carbon in the other categories.

Tax credits can be combined with a system of offsets for non-covered activities. As noted above, we see a role for qualified offsets that pass the additionality test (activities that lead to a net reduction in emissions and would not have taken place in the absence of the offset funds). The difficulty, of course, is in assessing additionality. Offsets would be provided to entities that demonstrate to the government's satisfaction that their activities that fall outside the tax base are reducing GHG emissions. The offsets could be traded like the tax credits and used to reduce the carbon tax liability. An open question is whether offsets should be limited to activities within the

[185] Authors' calculations using data from EPA INVENTORY, *supra* note 12, at 3-22 to 3-23, tbls.3-13 to 3-15.

[186] Id. at 3-19.

[187] *Id.* at 3-21 to 3-22, 3-23 tbl.3-15.

United States or available for activities undertaken elsewhere. For example, offsets might be allowed for projects that satisfy the Kyoto Protocol's Clean Development Mechanism ("CDM") criteria.[188] The experience with CDMs is instructive here. Progress has been very slow in certifying and accepting CDM projects.[189] The certifying of projects occurs on a case-by-case basis.[190] Some have argued for sector-based CDM eligibility.[191] All the issues that arise with assessing CDM projects would also arise with domestic offset programs.

V. Trade

Because carbon emissions are a global externality — emissions anywhere affect everyone — and because of the large volume of trade in fossil fuels and in goods produced with fossil fuels, carbon taxes must always be designed with international considerations in mind. In an ideal world, all countries would impose a harmonized carbon tax so that emissions anywhere in the world faced the same price. Realistically, some major emitting countries either will refuse to impose any price on carbon at all or will do so in a narrow or perfunctory way. Even countries that impose carbon pricing regimes may not harmonize their regimes,[192] creating problems when goods subject to different tax rates are traded.

There are good arguments that border tax adjustments — taxes on imports to compensate for taxes on domestic production and rebates of such domestic taxes on exports — are not inconsistent with, and in fact are required by, the principles of free trade. Free trade relies on the principle of comparative advantage. In a free market, everyone is better off if those who can produce a good at lowest cost do so. A country without a carbon price does not have a true comparative advantage in producing carbon-intensive goods relative to a country with a carbon price; it produces at what looks like a lower cost only because the nominal price of the good does not include the full costs of production.

The key problem with border tax adjustments for carbon taxes is determining the carbon content of goods that are exported or imported. Border

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[188] *See* Kyoto Protocol, *supra* note 9, art. 12. Of course, projects that are used as offsets under a U.S. carbon tax should not be allowed as offsets under the EU ETS.

[189] *See, e.g.*, Brian Fallow, *Carbon Price Anyone's Guess*, N.Z. Herald, Nov. 22, 2007, at C2.

[190] *See* Michael Wara, *Measuring the Clean Development Mechanism's Performance and Potential*, 55 UCLA L. Rev. 1759, 1770 (2008).

[191] *See, e.g.*, Joséluis Samaniego & Christiana Figueres, *Evolving to a Sector-Based Clean Development Mechanism*, *in* Building on the Kyoto Protocol: Options for Protecting the Climate 89 (Kevin A. Baumert et al. eds., 2002), *available at* http://pdf.wri.org/opc_full.pdf.

[192] *See* discussion *supra* Part I.B (discussing the failure of the Scandinavian countries to harmonize their carbon tax schemes).

tax adjustments under a VAT are based on the price of the good. Unlike the price of a good, the carbon content of a good is not readily observable.

So long as the two trading countries both have the same carbon price, however, border tax adjustments are not necessary. If both trading partners have the same carbon price, neither would gain an advantage in trade with the other. Therefore, it is possible to substantially reduce administrative costs by using an origin-basis system (i.e., no border tax adjustments) for trade between countries with an adequate carbon price. Imports from countries without an adequate carbon price would, however, most likely need to be subject to a tax at the border as a substitute for their lack of a carbon price, and below we discuss ways to administer such a system. Exports to these countries could be allowed a rebate for carbon taxes paid here. There may be modest efficiency advantages to allowing a rebate, but the administrative costs could be substantial.

Although a complete analysis of border tax adjustments for carbon taxes requires a separate paper, we provide a short discussion of the issues here.

A. Trade in Carbon-Intensive Goods

Before discussing the economic and legal issues related to border tax adjustments, it is worth having a sense of the extent of trade in carbon-intensive goods and the sources of imports. In the United States, the most energy-intensive manufacturing industries are petroleum refining, paper, mineral products (such as lime and cement), chemicals, ferrous metals (iron and steel), and nonferrous metals (largely aluminum).[193] Border tax adjustments for imports of crude oil for petroleum refining should be relatively uncontroversial, so the major issues relate to the remaining five industries.[194]

These products vary in their exposure to trade. The United States imports more than 40% of its aluminum and copper, but only 13-15% of its paper.[195] Surprisingly, the United States imports 25% of the cement it consumes, notwithstanding its weight.[196] The most energy-intensive goods tend to be less exposed to trade than non-energy-intensive goods.[197]

Although trade discussions often explicitly or implicitly focus on China because of its increasing share of U.S. imports, China is a relatively small source of these five carbon-intensive products. Canada is instead the dominant exporter of such goods to the United States. As shown in Table D,

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[193] TREVOR HOUSER ET AL., LEVELING THE CARBON PLAYING FIELD: INTERNATIONAL COMPETITION AND U.S. CLIMATE POLICY DESIGN 8 (2008), *available at* http://pdf.wri.org/leveling_the_carbon_playing_field.pdf.

[194] We focus here on energy-intensive goods. Note, however, that there may be goods that have high associated CO_2e emissions because they are produced using high GWP gases.

[195] HOUSER ET AL., *supra* note 193, at 8.

[196] *Id.*

[197] *See id.* at 9 fig.1.3.

China is significant only with respect to cement, and Canada dominates all categories except for chemical imports, where it is second.

TABLE D. U.S. IMPORTS BY ORIGIN, 2005[198]

	Steel		Aluminum		Chemicals		Paper		Cement	
	Source	*%*	*Source*	*%*	*Source*	*%*	*Source*	*%*	*Source*	*%*
1	Canada	18.6	Canada	51.0	Trinidad	41.6	Canada	66.9	Canada	16.1
2	EU	17.3	Russia	17.1	Canada	19.3	EU	16.8	China	14.0
3	Mexico	13.1	EU	6.2	Ukraine	7.3	China	3.5	EU	13.9
4	Brazil	8.2	OPEC	5.1	OPEC	6.6	S. Korea	2.2	OPEC	10.0
5	China	7.1	Brazil	3.8	EU	4.5	Mexico	2.2	Thailand	8.6

It is worth making several comments on this table. First, it does not include finished products such as automobiles. These products may be very carbon-intensive and their sources may be different than the sources listed above. Second, the manufacture of many of these items has been shifting toward developing nations, and the 2005 data presented may not reflect long-term trends. Finally, as discussed below, even though a large majority of U.S. imports of carbon-intensive goods originate in developed countries that are likely to enact or have already enacted carbon pricing regimes, border tax adjustments can still be important because they will have net revenue effects (unlike the typical case of border tax adjustments under a VAT).

B. The Effect of Border Tax Adjustments

1. *The Effect of Border Tax Adjustments for a Specific Excise Tax*

Border tax adjustments provide a rebate for any taxes paid when a good is exported and impose a tax when a good is imported. They are standard in VAT regimes around the world. A VAT with border tax adjustments is known as a destination-basis VAT, and a VAT without border tax adjustments is known as an origin-basis VAT. Virtually all VATs are destination-basis.

Border tax adjustments under a broad-based VAT have no net present value effect on trade or the present value of tax revenues because the present value of exports has to be equal to the present value of imports.[199] Therefore, the present value of the rebate on exports must equal the present value of the tax on imports.[200] There are timing differences in the flow of revenues to the government — imports and exports with the same present value can happen at different times — but the long-term effect has a net present value of zero.

[198] *See id.* at 44 tbl.3.1.
[199] *See* Weisbach, *supra* note 7, at 618-22.
[200] A key assumption is that the VAT covers all exports and imports.

Because origin- and destination-based systems have the same net effect, it usually does not matter which VAT system is used, apart from administrative cost and compliance issues. Moreover, it does not matter whether countries imposing a VAT harmonize with one another with respect to border tax adjustments (again, apart from administrative or compliance issues).

These results do not hold for a specific excise tax like a carbon tax. We consider four effects. First, border tax adjustments will have present value revenue effects, because the present values of imports and exports of embedded carbon may not be the same. For example, carbon-intensive products can be imported or exported in exchange for services or non-carbon-intensive goods. The taxes or rebates on carbon-intensive products will not be offset by the taxes or rebates on the services or non-carbon-intensive goods. For trade between two countries with harmonized carbon taxes, the main effect of border tax adjustments is the recipient of the revenue: a destination-basis system gives the revenue to the country where consumption takes place, while an origin-basis system gives the revenue to the country where production takes place.

Second, border tax adjustments and the location of tax remittance interact. In a world with cross-border trade in taxed products, it is no longer true that the location of tax remittance matters only with respect to administrative and compliance costs. Instead, countries that import carbon-intensive goods receive revenues from a destination-based system while countries that export carbon-intensive goods receive revenues from an origin-based system.

To illustrate, suppose that a carbon-intensive good like petroleum is produced in three stages: extraction, refining, and consumption. Suppose also, as is often the case, that extraction takes place in a different country from refining and consumption. In particular, suppose that C_1 extracts oil and sells it to C_2 in exchange for untaxed items. C_2 then refines and consumes the oil.

If C_1 collects the tax at the wellhead and there are no border adjustments, C_1 keeps the revenue and, depending on the incidence of the tax, some combination of individuals in C_1 and C_2 bear the tax. If there are border tax adjustments in both countries, C_1 rebates the taxes when the oil is exported and C_2 imposes a tax when the oil is imported. In effect, the border tax adjustment acts as an indirect transfer of the tax revenues from the extracting country to the consuming country. If, on the other hand, the tax is collected at the refinery in the importing country or upon consumption, border tax adjustments have no effect because the tax is imposed in the same country as the consumption. As with a sales tax levied at the retail stage, there is no occasion for border tax adjustments to operate.

In general, if the good is produced in one country and consumed in another, it matters if the producer or the consumer of the good remits the tax, and it matters whether there are border tax adjustments. To foreshadow the discussion below, if one concludes that border tax adjustments for a carbon tax imposed upstream are illegal under current trade law, but a carbon tax imposed directly on consumers would not be illegal (because there would be no border tax adjustments), that amounts to saying that the legal rules care about the technical issue of which entity is responsible for tax remittance rather than the economic effects of border tax adjustments. This seems inappropriate.

Third, when there is trade between two countries with carbon taxes, the system of border tax adjustments must be harmonized. Either both countries need to impose border tax adjustments or neither should impose them. Without harmonization, products can be subject to either double taxation or no taxation, depending on the direction of trade. To illustrate, suppose that both C_1 and C_2 have carbon taxes, and that C_1 has no border tax adjustments and C_2 has them. If a product is produced in C_1, is subject to a carbon tax in C_1, and then is exported to C_2, there will be no rebate by C_1 since there are no border tax adjustments. However, C_2 will impose a tax at the border, resulting in a double tax on the product. If a product is produced in C_2 and exported to C_1, however, there would be no tax because C_2 would rebate the tax at the border and C_1 would not impose a border tax adjustment. Thus, harmonization is needed.

Note that the same effect can occur in a world entirely without border tax adjustments but where countries do not harmonize with regard to the location of tax collection. For example, if C_1 imposes a tax upstream on producers and C_2 imposes a tax downstream on consumers, the result is exactly the same as in the preceding example: two taxes on the same emission, even if neither C_1 nor C_2 has border tax adjustments. Border tax adjustments eliminate this problem because they ensure that the consuming country ends up with the tax. In this sense, one can view border tax adjustments as simply a mechanism for allowing the location of tax remittance to be determined purely on administrative cost grounds. As we will see, however, there is a trade-off, because border tax adjustments themselves are complex.

Finally, and most centrally, border tax adjustments ensure that the terms of trade are consistent with the principle of comparative advantage where one trading partner has a carbon price and the other does not. As noted above, if two countries produce a good at the same cost, but one imposes a carbon tax on production and the other does not, it is not correct to say that the country without the tax has a comparative advantage and is therefore the efficient producer of the good. The sole advantage of the non-taxing country is simply its willingness to impose an externality on the rest of the world. This is not an advantage that free trade laws should protect.

Another way to put this point is that the logic behind free trade relies on well-functioning markets to allocate production of goods. When there is a massive externality such as the emission of carbon, a Pigouvian tax on that externality is entirely consistent with free trade, since the tax ensures that prices are correct. Border tax adjustments are necessary to impose a Pigouvian tax where there is an export from a non-taxing country.

One argument against border tax adjustments for carbon taxes is a slippery slope argument: if border tax adjustments are allowed in this case, they would be allowed for a wide variety of measures with protectionist intent or effect. Any "trade plus" problem (trade plus labor, trade plus environment, etc.) can be recast as an externality. For example, low-wage or child labor in a trading partner can be thought of as creating externalities in the form of empathy for the workers. A border tax would be necessary to internalize this harm. Because almost anything can be cast as an externality, there appear to be no limits to this logic.

Slippery slope arguments rely on an institutional inability to distinguish cases. The argument is that if one takes action *x*, one inevitably will take action *y*, and action *y* is undesirable. This logic is spurious in the context of climate change. Legal and tax systems around the world regularly must decide which types of harms to recognize. For example, tort systems must decide when an action by one party creates a compensable obligation. Harms such as those expected from climate change — measurable and large harms — are easily distinguished from other types of harms.

2. *Border Tax Adjustments and Renegade Countries*

Carbon tax design and implementation will likely take place in a world where at least some major producing countries do not agree to impose a tax (or other carbon pricing regime) or do so only at minimal levels. Thus, China, the United States, or some other major carbon producing country may not find it in its interest to impose a carbon pricing regime when other countries do. Border tax adjustments can play a central role in such a world. They have two effects: preventing "leakage" and encouraging renegade countries to put a price on carbon.

Leakage in the carbon pricing context refers to the shifting of production of carbon-intensive goods to countries that do not impose a price or otherwise regulate carbon. A producer in a country with a carbon tax might move the location of production to a country without the tax and thereby avoid the tax.[201]

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[201] A second reason why carbon leakage will occur in these circumstances is that if the demand for energy goes down in the taxing countries because of the carbon tax, it will be cheaper for producers in non-taxing countries to use energy-intensive production processes. If the United States reduces its demand for oil, China may simply increase its demand, offsetting the conservation efforts made in the United States.

The extent of carbon leakage is uncertain and is the subject of a number of studies. Modeling the problem is complex because it requires modeling production location decisions. Technological change also plays a role. *See* Mustafa Babiker, *Climate Change Policy, Market Structure, and Carbon Leakage*, 65 J. INT'L ECON. 421, 441 (2005) (arguing that carbon leakage from the Kyoto Protocol may actually be substantially more than 100%, meaning that Kyoto would actually increase total carbon emissions). *But see* Corrado Di Maria & Edwin van der Werf, *Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technical Change*, 39 ENVTL. & RESOURCE ECON. 55 (2008) (arguing that induced technological change may counterbalance the effect of carbon prices on the terms of trade). The idea is that high carbon prices in countries that impose a tax or quota change the relative profitability of investing in clean technology. There are numerous other studies of the issue. *See, e.g.*, Stefan Felder & Thomas F. Rutherford, *Unilateral CO_2 Reductions and Carbon Leakage: The Consequences of International Trade in Oil and Basic Materials*, 25 J. ENVTL. ECON. & MGMT. 162 (1993); Sergey V. Paltsev, *The Kyoto Protocol: Regional and Sectoral Contributions to the Carbon*

With a border tax adjustment, the tax cannot be avoided by altering the location of production. Suppose that production originally takes place in C_1 and some consumption takes place in each of C_1 and C_2. If C_1 imposes a carbon tax without border adjustments and C_2 does not impose a carbon tax, shifting production to C_2 avoids the tax entirely. If C_1 imposes border tax adjustments, there is no advantage to shifting the location of production. Consumption in C_1 will be taxed and consumption in C_2 will not be taxed regardless of where production takes place. Thus, border tax adjustments reduce this form of leakage.

The second, closely related, reason for having border tax adjustments is to reduce the incentive for countries to behave as renegades. The focus in this second argument is on the incentives for countries themselves as opposed to the incentives for industries. Border tax adjustments reduce the benefit to renegade countries of remaining renegades because they would no longer be able to attract production through their lack of a carbon tax.[202]

A mixed regime of border tax adjustments for renegades and no adjustments (an origin-based system) for countries with harmonized taxes could be used to actually create an incentive for renegades to price carbon. In particular, suppose that border tax adjustments were only applied to imports from and exports to countries without a carbon pricing mechanism. Goods from a country without a carbon pricing scheme exported to a country with a carbon tax would face a border tax adjustment, and the revenues would go to the consuming country. There would be no tax revenues and no advantage for the non-pricing country. If the country priced carbon, however, it would be able to keep the revenues — there would be no border adjustment — but not face any additional disadvantage with respect to trade. Its own citizens, of course, would now be subject to a tax on carbon consumption, but the tax could be made revenue neutral through reductions in other taxes.

C. *Legal Issues with Border Tax Adjustments*

The legal status of border tax adjustments under a carbon tax is uncertain. The problem with their legality relates to the detailed rules under the General Agreement on Tariffs and Trade ("GATT") and the World Trade Organization ("WTO") governing border tax adjustments in general and the scope of the so-called environmental exception. A detailed discussion of the legal issues related to border tax adjustments for carbon taxes is well beyond the scope of this paper.[203] Briefly, a tax on imports can only be imposed if

Leakage, 22(4) ENERGY J. 53 (2001); Thomas Eichner & Rüdiger Pethig, *Carbon Leakage, the Green Paradox and Perfect Future Markets* (CESifo, Working Paper No. 2542, 2009), *available at* http://www.cesifo-group.de/~DocCIDL/cesifo1_wp2542.pdf. Regardless of the extent of leakage, however, it is clear that any leakage is inefficient and that border tax adjustments prevent leakage through the location of production decisions.

[202] This border tax adjustment is slightly different from that discussed in VAT systems, as we propose that the United States would not rebate the tax on exports to renegade countries.

[203] *See* Gavin Goh, *The World Trade Organization, Kyoto and Energy Tax Adjustment at the Border*, 38 J. WORLD TRADE 395 (2004); Javier de Cendra, *Can Emissions Trading*

there is an equivalent tax on like products in the home country.[204] There are two key concepts: "likeness" and "on the product."

"Likeness," as currently construed by the GATT, does not include how a product is produced.[205] Thus, a widget produced using coal as the source of energy and an identical widget produced using hydroelectric power are considered like products if the widgets themselves are alike. If a product is produced in an exporting country using a different method from that used in the importing country, the importing country may not be able to impose a border tax based on the emissions created by the production of the good.

Conceivably, the likeness restriction would not be fatal because the United States could impose a tax on imports equal to the tax imposed on domestic production of the good. This would be imperfect — foreign producers with high emissions would face too low a tax and foreign producers with low emissions too high a tax. Nevertheless, if the variance in emissions from production of the good is not too great, it might be a reasonable approach.

The second phrase in the GATT rule, however, may make this approach illegal. The United States cannot impose a border tax adjustment equivalent to the domestic tax unless the domestic tax is "on the product,"[206] and it is unclear whether a carbon tax is a tax "on the product." The object of taxation, carbon, is not the product being imported. Because the same product can face different taxes based on the production mechanism (and under the reasoning behind the "likeness" rule, production methods are not part of the product), the tax is arguably not on the product at all. Therefore, even a tax on imports based on domestic emissions when the product is produced may not be legal. Tax rebates on exports are covered under a different set of provisions governing illegal export subsidies. Rebates are allowed for prior stage cumulative taxes borne by a like product when destined for local consumption.[207] The definition of this phrase is obscure, but under existing interpretations, there are serious concerns that a carbon tax would not fall under the definition.[208]

Finally, mixing origin- and destination-based systems to create an incentive for renegade countries to impose a pricing regime would arguably

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Schemes Be Coupled with Border Tax Adjustments? An Analysis vis-à-vis WTO Law, 15 RECIEL 131, 135-36 (2006); Roland Ismer & Karsten Neuhoff, *Border Tax Adjustment: A Feasible Way to Support Stringent Emission Trading*, 24 EUR. J. L. & ECON. 137, 143-52 (2007).

[204] General Agreement on Tariffs and Trade, art. III, para. 2, Oct. 30, 1947, 61 Stat. A11, 55 U.N.T.S. 187 [hereinafter GATT].

[205] *See* RAJ BHALA, MODERN GATT LAW: A TREATISE ON THE GENERAL AGREEMENT ON TARIFFS AND TRADE 3-4, 639-40, 677-79 (2005); *see also* sources cited *supra* note 203.

[206] By "on the product," we mean the tax is not imposed on the process used to produce the product. *See, e.g.*, Douglas A. Kysar, *Preferences for Processes: The Process/Product Distinction and the Regulation of Consumer Choice*, 118 HARV. L. REV. 525, 540-48 (2004).

[207] *See* sources cited *supra* note 203.

[208] *See* sources cited *supra* note 203. The original intent of this phrase was to allow border tax adjustments for the turnover taxes that many nations levied at that time. It has been interpreted to mean that border tax adjustments are allowed for VATs.

fail the most favored nation ("MFN") requirement, which is a fundamental tenet of trade law.[209] In particular, renegade nations subject to a border tax would argue that they are treated worse than other nations, contrary to MFN principles.

An entirely separate and possibly more promising legal approach is to claim that border tax adjustments are allowed under the so-called "environmental exception" to the normal GATT rules. Under the exception, trade restrictions are allowed if needed to protect "human, animal, or plant life or health" or if they relate "to the conservation of exhaustible natural resources" and "such measures are made effective in conjunction with restrictions on domestic production or consumption."[210] Any such trade restriction under these rules must not be applied "in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade."[211]

Interpretation of the environmental exception has been controversial. There have been many attempts to prevent trading partners from engaging in various practices viewed by the importing nation as environmentally inappropriate. For example, the United States attempted to impose rules to protect dolphins from tuna harvesting[212] and to protect turtles affected by shrimp farming.[213] Most of these restrictions have been struck down, although the U.S. turtle/shrimp rules were allowed. The reasoning behind these cases is obscure — it is difficult to differentiate dolphin-safe tuna and turtle-safe shrimp.[214]

It is difficult to see why the legal rules should be interpreted to prevent border tax adjustments. As noted above, direct taxation of the consumer would have the same effect as taxation of production plus border tax adjustment, and there is no argument that direct taxation of consumers would be an illegal trade barrier. Border tax adjustments are also consistent with, indeed mandated by, the principles behind free trade.[215]

As noted above, a concern with border tax adjustments for carbon is the problem of slippery slopes. Although carbon emissions are a very serious international problem, allowing taxes on imports under an environmental or human health argument could allow all kinds of poorly justified border taxes. Without a clear set of principles delineating when border taxes for

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[209] *See* GATT, *supra* note 204, art. I.

[210] GATT, *supra* note 204, art. XX.

[211] *Id.*

[212] *See* Panel Report, *United States — Restrictions on Imports of Tuna*, DS21/R (Sept. 3, 1991), GATT B.I.S.D. (39th Supp.) at 155 (1993).

[213] *See* Appellate Body Report, *United States — Import Prohibition of Certain Shrimp and Shrimp Products*, WT/DS58/AB/R (Oct. 12, 1998).

[214] *See* sources cited *supra* note 203; Bhala, *supra* note 205, at 633-79 (discussing these and other cases).

[215] On the other hand, the GATT rules are often formalistic, drawing distinctions that do not seem to make sense. Border tax adjustments are allowed for indirect taxes like the VAT but not for economic equivalents, like wage taxes. *See, e.g.*, Goh, *supra* note 203, at 399 & n.13.

externalities will be allowed, trade courts might be reluctant to allow any such taxes. We do not think that this concern should prevent necessary border tax adjustments for a problem as serious as climate change.

D. The Problem of Determining Carbon Content

Beyond legal issues, a central problem with border tax adjustments is that it is difficult to determine the carbon content of a good when it is imported. This problem is especially salient for so-called non-Annex I (developing) countries under the United Nations Framework Convention on Climate Change. These countries do not submit regular, detailed carbon inventories, making it difficult to determine the carbon content of their exports. Moreover, these countries may not agree to impose a price on carbon.[216]

One possibility is that the border tax be imposed based on the carbon that would have been emitted had the product been produced in the United States.[217] This proposal gets around the "likeness" problem with a tax on imports (although there remains the problem of whether a carbon tax is a tax on the product). It also reduces the information problem both by using domestic information and by limiting the class of goods it applies to.

The major problem with this tax is that it will often be very inaccurate because foreign production of a good often results in very different emissions from U.S. production. Figure 3 estimates the carbon intensity of steel production in major producing countries. As can be seen, there are dramatic differences. The U.S. tax on steel would be significantly too low for imports of steel from Russia, for example.

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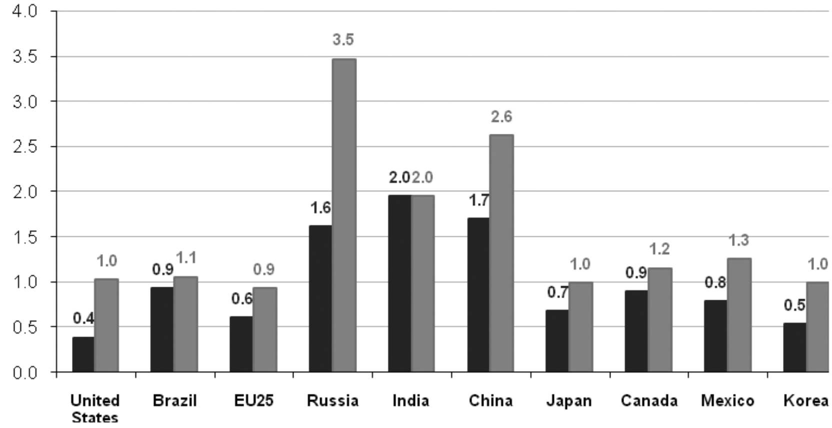
[216] For example, a number of studies have measured the carbon content of U.S. produced goods relying on input-output accounts. *See* Hassett et al., *supra* note 56, at 163. Comparable quality data that covers multiple years in an up-to-date fashion simply do not exist for China and other major exporting developing countries.

[217] For example, a similar proposal has been suggested jointly by American Electric Power and the International Brotherhood of Electrical Workers. For description and discussion, see STAFF OF H. COMM. ON ENERGY & COMMERCE, 110TH CONG., CLIMATE CHANGE LEGISLATION DESIGN WHITE PAPER: COMPETITIVENESS CONCERNS/ENGAGING DEVELOPING COUNTRIES 8-10 (2008), *available at* http://energycommerce.house.gov/images/stories/Documents/PDF/selected_legislation/White_Paper.Competitiveness.013108.pdf.

FIGURE 3. STEEL CARBON INTENSITY: TONS OF CO_2 EMISSIONS PER TON OF PRODUCT, 2005[218]



Similarly, U.S. carbon intensity for chemicals is often higher than the intensity in other countries, producing too high a border tax.[219]

On a related matter, a tax based on U.S. emissions would not create any incentive for foreign producers to substitute low-emission production techniques for high-emission production techniques. The tax would remain the same, so if a low-emission production technique is otherwise less desirable, the tax will not induce the needed switching.[220]

An alternative system would be to base border tax adjustments on estimates of average emissions in the exporting nation from production of a given good. This would require information about production techniques and energy systems abroad at the national level but not at the firm level. While possibly more information-intensive than basing the tax on the importing country's emissions, it is potentially more accurate. Thus, the border taxes for steel would reflect the national differences illustrated in Figure 3. The main question will be the availability and reliability of national-level data for developing countries. In addition, this approach runs directly into the legal problem with basing taxes on production techniques.[221]

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[218] HOUSER ET AL., *supra* note 193, at 47 (copyright Peterson Institute, used by permission). The darker (left-hand) bars represent direct emissions, and the lighter (right-hand) bars represent the sum of direct and indirect emissions.

[219] *See id.* at 48-49.

[220] An additional problem might arise if emissions from production of a good vary widely in the United States. It would then be difficult to determine which production system to base the border tax on.

[221] The system must ensure that the calculation method is the same for both domestic and foreign producers (i.e., how the domestic level is set must be the same as how the foreign level is set). Otherwise, the system will encounter the same trade law conflicts seen in the *Reformulated Gasoline* case. *See* Appellate Body Report, *United States — Standards for Reformulated and Conventional Gasoline*, WT/DS2/AB/R (Apr. 29, 1996); *see also* BHALA, *supra* note 205, at 648-58.

Yet another refinement would be to allow individual exporting firms to provide information proving that they are below their national averages. A particularly efficient firm, therefore, could get a lower border tax, creating an incentive to shift to more efficient technologies.

Any border tax adjustment, whether based on importing country information, exporting country information, or firm-level information, will require significant information gathering, documentation, categorization, and recordkeeping. Without border tax adjustments, a carbon tax could cover 80% of U.S. emissions by taxing roughly 3000 companies and could cover an even larger fraction without imposing a significant additional burden. If border tax adjustments are added, the United States would need records of carbon emissions from a wide variety of activities. Dispute resolution mechanisms would also be needed. Because technology changes all the time, disputes would persist.

By way of analogy, consider how hard carbon footprint labeling has been.[222] The problem for determining proper border tax adjustments is essentially the same. The carbon tax, which looked so simple, suddenly becomes a very difficult administrative exercise.

E. Summary

The above discussion leads us to the following conclusions. Border tax adjustments may be necessary, but only for trade with countries without a carbon price. Moreover, they are likely to be very complicated to administer and legally suspect. Therefore, for trade within the set of countries with an adequate carbon price, an origin-basis system (one without border tax adjustments) is preferable. The major effect of this choice is to allocate carbon tax revenues to countries producing carbon-intensive goods instead of to countries consuming carbon-intensive goods.

For imports from countries without an adequate carbon price, the United States most likely would need to impose a border tax based on either the U.S. or foreign production method to prevent leakage. Moreover, when combined with the origin-basis system, a border tax adjustment creates an incentive for these countries to impose a carbon price. By imposing a carbon price, they would effectively get the revenue that the United States would otherwise receive because of the border tax. Limiting border tax adjustments to the most carbon-intensive goods and goods where the production is particularly mobile might help reduce the administrative cost. However, it would increase "rent-seeking" costs as individual industries lobby for border tax adjustments.

A more difficult issue is whether to allow rebates for exports to countries without an adequate carbon price. Not allowing rebates may significantly reduce the administrative complexity of the system. The idea would

[222] *See, e.g.*, *Not on the Label: The Environment*, ECONOMIST, May 19, 2007, at 90.

be that the United States generally has an origin-basis system and does not allow rebates. The border tax on the import is imposed only as a substitute for the carbon price that was not imposed in the producing country, and this border tax upon import does not warrant a corresponding rebate on export.

Without rebates on export, however, there would be an incentive to shift production to countries without a carbon price to the extent that the goods are consumed there. For example, suppose that a producer in the United States is exporting a carbon-intensive good to a country without a carbon price. If the United States does not give a rebate of the carbon tax on export, the producer could shift the production to the foreign country to avoid the tax. A second problem is that there could be double taxation under certain circumstances: if raw materials subject to a carbon tax are exported to a country without carbon pricing, made into final goods and imported into a country with a carbon price, there would be a risk of imposing the carbon tax twice. Administering a system to prevent such double taxation would be complex. Finally, a one-way system of taxes on import without rebates on export might be harder to justify under the GATT/WTO system. If these problems are severe, the United States could offer rebates for exports to countries without a carbon price. As with imports, the United States could reduce administrative costs by limiting rebates to the most carbon-intensive goods.

VI. Interaction with Existing Domestic Taxes and Regulations

There are a large number of regimes in the United States that affect carbon emissions, from various command-and-control regulations to incentives and taxes. An important question in implementing a carbon tax is how it interacts with existing rules. In this Part, we offer a brief review of the relevant existing regimes and a discussion of whether and how they would need to be modified if the United States instituted a broad-based carbon tax.

We have already noted that the United States imposes a tax on motor fuels. We argued that this should remain in place if a carbon tax is enacted on the basis that the motor fuels taxes correct for externalities from driving not related to climate change.[223]

The major form of support for renewable energy production in the United States is the system of production tax credits ("PTCs") for renewable power enacted in the Energy Policy Act of 1992.[224] PTCs are provided for qualifying facilities (wind power, biomass, and geothermal, among other sources) for ten years at a rate of 1.5¢ per kilowatt-hour ("kWh").[225] PTCs have generally been viewed as successful except for the uncertainty sur-

[223] *See* discussion *supra* Part III.B.4.

[224] Pub. L. No. 102-486, 106 Stat. 2776 (codified as amended in scattered sections of 42 U.S.C.).

[225] *See* Metcalf, *supra* note 11, at 161 (describing federal energy tax policies in detail and providing a levelized cost analysis of the benefit of these subsidies); Carlson & Metcalf, *supra*

rounding their congressional renewal every two years. Congressional delays have twice led to their temporary expiration with a consequent fall in investment in the following year.[226]

The role of PTCs is to reduce the price of electricity generated from renewable sources relative to the price of fossil- or nuclear-fueled electricity. A carbon tax would also lower the relative price of non-fossil-fueled electricity compared to that of fossil-fueled electricity, but by raising the cost of the latter rather than by subsidizing the former. A tax-based approach has two advantages over the PTC approach. First, the carbon tax raises the cost of electricity on average while the PTC lowers it on average. The tax then provides an additional mechanism to reduce carbon emissions by reducing overall demand for electricity rather than stimulating it as the PTC subsidy does. Second, the carbon tax creates a price differential among fossil fuels based on their carbon content. Studies have shown that an early response to carbon pricing is fuel substitution of natural gas for coal in the electric utility industry.[227] These considerations all suggest that the appropriate policy would be to eliminate PTCs if a carbon tax were enacted.

A second regulatory approach at the federal level is the mandating of minimum fuel efficiency standards through the Corporate Average Fuel Economy ("CAFE") program. CAFE mandates fleet standards for automobiles and light trucks. CAFE standards were significantly tightened in the Energy Independence and Security Act of 2007,[228] which will raise the fleet average from the current level of 26.7 miles per gallon ("mpg") in 2007 to 35 mpg by 2020.[229]

Ellerman, Jacoby, and Zimmerman consider how CAFE standards could be integrated into a cap-and-trade system.[230] They estimate that the cost of carbon emission reductions through CAFE is in the neighborhood of \$25 per ton of CO_2e,[231] significantly higher than estimates of initial tradable

note 151, at 481 (discussing the interaction between energy credits and the corporate alternative minimum tax).

[226] *Clean Energy: From the Margins to the Mainstream: Hearing Before the S. Comm. on Finance*, 110th Cong. 18 (2007) (Statement of Ryan Wiser, Scientist, Lawrence Berkeley Nat'l Lab.), *available at* http://eetd.lbl.gov/EA/EMS/reports/wiser-senate-test-4-07.pdf.

[227] METCALF ET AL., *supra* note 56, at 36.

[228] Pub. L. No. 110-140, 121 Stat. 1492 (codified as amended in scattered sections of 42 U.S.C.).

[229] Prior to the 2007 Act, separate standards existed for automobiles and light trucks. In 2007 the standards were 27.5 mpg and 22.2 mpg respectively with a realized fleet average of 26.7 mpg. For fleet efficiency data and CAFE standards, see NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., U.S. DEP'T OF TRANSP., NVS-220, SUMMARY OF FUEL ECONOMY PERFORMANCE (2008), *available at* http://www.nhtsa.gov (follow "Fuel Economy" hyperlink; then follow "Summary of Fuel Economy Performance, Nov. 2008" hyperlink).

[230] A. DENNY ELLERMAN, HENRY D. JACOBY & MARTIN B. ZIMMERMAN, BRINGING TRANSPORTATION INTO A CAP-AND-TRADE REGIME (2006), *available at* http://mit.edu/globalchange/www/MITJPSPGC_Rpt136.pdf.

[231] *Id.* at 7. Ellerman et al. estimate that the penalty automakers face for violating the CAFE standards equates to a price of \$90 per ton of carbon, which is equivalent to a price of \$24.50 per ton CO_2e.

permit prices under prominent legislative cap-and-trade proposals.[232] This estimate helps make two points. First, sector-based regulatory policies that are not integrated more broadly into a carbon reduction scheme can be very expensive. Second, the early reductions in carbon emissions are likely to occur in industry and electric utilities rather than in the transport sector. Since the source of emissions has no bearing on damages associated with climate change, sector-based approaches are likely to be quite inefficient.[233]

At the sub-federal level, the number of state-level programs to control GHG emissions or to encourage renewable energy programs is growing. Thirty-four states have some form of renewable portfolio standard ("RPS") mandating that a given percentage of electricity be provided by renewable sources.[234] RPS programs generally mandate that electricity distributors or retailers must obtain Renewable Energy Credits ("RECs") for a given percentage or amount of the electricity that they sell.[235] A qualifying renewable facility is provided a number of RECs based on its electricity production that the facility may then sell in the REC market to distributors or retailers needing RECs to match their power sales.[236] The sale of RECs provides a subsidy to renewable electricity generators.

A slightly different approach to supporting renewable electricity generation is a Feed-in Tariff ("FIT"). FITs require utilities to purchase power from qualifying facilities at a fixed rate (or premium) for a given number of years. FITs differ from RPSs in setting a price for renewable electricity rather than in requiring a fixed amount of new supply.[237] They differ from PTCs in two important ways. First, they can be designed to provide a price guarantee rather than a fixed premium.[238] This has two benefits. If the generation price of competing fossil fuel generators falls, the FIT subsidy rises to maintain a fixed purchase price. This provides price stability to investors.

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[232] For projections of permit prices under selected cap-and-trade proposals, see PALTSEV ET AL., *supra* note 136, at 29. For an example of one such legislative proposal (post-dating the Paltsev et al. analysis), see the Lieberman-Warner Climate Security Act, S. 2191, 110th Cong. (2008).

[233] Other pollutants or market failures may provide a rationale for reducing oil consumption or tailpipe emissions. This simply reflects the fact that multiple instruments are generally needed to address multiple market failures.

[234] *See* Database of State Incentives for Renewables & Efficiency, Rules, Regulations & Policies for Renewable Energy, http://www.dsireusa.org/summarytables (follow "Rules, Regulations & Policies for Renewable Energy" hyperlink) (last visited Apr. 8, 2009) (on file with the Harvard Environmental Law Review).

[235] For a description of the market for these credits, see David Berry, *The Market for Tradable Renewable Energy Credits*, 42 ECOLOGICAL ECON. 369 (2002).

[236] *Id.* at 370.

[237] In this sense the two instruments correspond to subsidy versions of price and quantity controls.

[238] FITs have been constructed to provide a price premium or a fixed price. European FITs have generally been of the fixed price rather than premium type. *See* Metcalf, *supra* note 49, at 2 (discussing European FITs); *see also* WILSON RICKERSON, FLORIAN BENNHOLD & JAMES BRADBURY, FEED-IN TARIFFS AND RENEWABLE ENERGY IN THE USA — A POLICY UPDATE 2-3 (2008), *available at* http://www.boell.org/Pubs_read.cfm?read=169 (discussing possible use of FITs in the United States).

On the other hand, if competing generation prices rise, the FIT subsidy phases out and so reduces the cost to ratepayers. Second, while PTCs are subsidized by the federal government and subject to reauthorization every two years, FITs are subsidized by ratepayers. This may reduce politically motivated price volatility, which has occurred with PTCs in recent years.[239]

RPS and FIT programs serve to support renewable electricity generation. Unlike PTCs, they raise the average price of electricity, thereby providing a demand-side reduction in emissions. Unlike a carbon tax, however, they are sector-based policies and thus will not necessarily lead to the equalization of marginal abatement costs across different sources of carbon, a necessary condition for efficiency in carbon emission policy. An important federalism question also arises with the adoption of a federal carbon tax. Should the tax supplant these state-level policies or coexist with them? For the RPS program, a national carbon tax would reduce the value of RECs by the magnitude of the carbon tax.[240] As discussed in Part II.C. with respect to the transition to a carbon tax, governments should not give compensation for takings of this sort.[241] For the FIT program, the carbon tax would simply replace a portion (or all) of the FIT subsidy. To see this, imagine that a natural gas power plant is the marginal fuel source and produces electricity at a total cost (including return to capital) of 6¢ per kWh. A wind generator in contrast produces electricity at a total cost of 9¢ per kWh. The FIT subsidy would be 3¢ per kWh for the wind facility, funded by ratepayers of the utility purchasing the wind power. Now consider a carbon tax that raises the total cost of the gas-generated electricity from 6¢ per kWh to 8.5¢ per kWh. The FIT subsidy automatically drops to 0.5¢ per kWh on the wind-generated electricity.

A third regulatory regime of importance is the emerging carbon cap-and-trade programs at the state or regional level. The two most significant to date are the Global Warming Solutions Act in California and the Regional Greenhouse Gas Initiative ("RGGI") in the Northeast.[242] The California Act establishes a statewide emissions cap in 2020 equal to 1990 levels.[243] The California Air Resources Board, the agency tasked with implementing this law, has recommended a mix of instruments to meet this goal, including a cap-and-trade system.[244] The RGGI initiative builds on state-level initiatives

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[239] *See* Ryan Wiser, Mark Bolinger & Galen Barbose, *Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States*, ELECTRICITY J., NOV. 2007, at 77, 81.

[240] If the RPS program were abolished upon enactment of a carbon tax, the value of RECs would go to zero.

[241] *See* discussion *supra* Part II.C.

[242] *See* California Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE §§ 38500-38599 (West 2006); Reg'l Greenhouse Gas Initiative, About RGGI, http://rggi.org/about (last visited Mar. 17, 2009) (on file with the Harvard Environmental Law Review).

[243] CAL. HEALTH & SAFETY CODE § 38550 (West 2006).

[244] CAL. AIR RES. BD., CLIMATE CHANGE PROPOSED SCOPING PLAN: A FRAMEWORK FOR CHANGE 30-38 (2008), *available at* http://www.arb.ca.gov/cc/scopingplan/document/psp.pdf. The proposed plan was approved in December 2008. *See* Press Release, Cal. Air Res. Bd.,

to cap emissions from the electric power sector in their states. RGGI establishes a regional trading system to reduce costs among participating states.[245] In the first phase, it caps emissions at current levels by 2009.[246] Current emissions are defined as 188 million short tons of CO_2, roughly 4% above average regional emissions from 2000 to 2004.[247] It would then reduce emissions gradually to achieve a 10% reduction from current levels by 2018.[248]

In addition to RGGI, the Midwestern Greenhouse Gas Reduction Accord was established in November 2007 with six states and one Canadian province participating.[249] A separate Western Climate Initiative has recently set a goal of a 15% reduction below 2005 levels by 2020.[250]

A similar issue arises with regional or state cap-and-trade programs as with RPS programs upon enactment of a carbon tax. If a federal tax must be paid on emissions for which a state or regional permit is required, the value of the permit will fall by the amount of the tax (or to zero, whichever is less). States might argue that the carbon tax should not apply to emissions subject to state or regional permits. This would be equivalent to carbon tax revenues being levied on all emissions and rebated to holders of state or regional cap-and-trade permits. This would be a mistake as it confers a windfall gain on holders of state or regional permits. This creates efficiency losses and has regressive distributional implications.

VII. Conclusion

Most carbon pricing regimes are imposed on relatively narrow bases and are imposed midstream, on industrial users of energy. Moreover, the trend seems to be in the direction of a cap-and-trade system. We propose a different approach here. For reasons long established in the literature, a carbon tax is preferable to a cap-and-trade system. We show that a well-implemented carbon tax imposed upstream can easily cover 80% of U.S. emissions and can likely cover almost 90% with a modest additional cost. The benefits of the broad base and lower compliance costs are likely to be significant.

ARB Says Yes to Climate Action Plan (Dec. 11, 2008), *available at* http://www.arb.ca.gov/newsrel/nr121108.htm.

[245] Reg'l Greenhouse Gas Initiative, *supra* note 243.

[246] Reg'l Greenhouse Gas Initiative, Overview of RGGI CO_2 Budget Trading Program 2 (2007), *available at* http://www.rggi.org/docs/program_summary_10_07.pdf.

[247] *Id.* at 2 n.4.

[248] *Id.* at 2.

[249] *See* Midwestern Governors Ass'n, Midwestern Greenhouse Gas Accord (2007), *available at* http://www.midwesternaccord.org/midwesterngreenhousegasreductionaccord.pdf.

[250] Western Climate Initiative, Overview: The Western Climate Initiative's Cap-and-Trade Program Design Recommendations (2009), *available at* http://www.westernclimateinitiative.org/ewebeditpro/items/O104F19872.pdf.