Implementing Cap-and-Trade in Washington to Reduce Greenhouse Gas Emissions: Regional Regulation of a Global Problem and the Risk of Carbon Leakage

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This is to certify that I have examined this copy of the Capstone manuscript by

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Chapter 1. Purpose of the Study

This capstone research provides exploratory analysis of a regional cap-and-trade (CAT) program to limit greenhouse gas (GHG) emissions. The effectiveness of using a regional program to address a global issue has limitations; one of these limitations includes the possibility that firms will avoid operating in regions with strict GHG regulations. This analysis includes an assessment of the potential mobility of firms to move outside the region to avoid GHG emission regulations; such movement of firms is called carbon leakage. If firms move outside the region, they will still emit GHGs; so there is no net reduction in global GHG emissions, just a reduction in regional emissions. Another consequence of carbon leakage is the adverse economic impact to the state from the loss of employment earnings and tax revenue because of firm mobility.

Determining the exact number of firms that may move outside the regulated region and therefore just relocate GHGs requires more analysis than what has been attempted with this research. However, this exploratory analysis[1] looks at the GHG emission levels in Washington State, the potential of a regional program to effectively reduce GHG emissions if carbon leakage exists, and the potential economic impact to the state if firms relocate.

The analysis is accomplished by first looking at the current levels of GHG emissions. An estimate of firms that may move outside the region is then derived from the likelihood of mobility—a likelihood based on educated estimates derived from research found in the literature. From that likelihood, an estimated amount of GHG emissions not abated but just relocated (that is, carbon leakage) is calculated. The analysis will then examine the potential economic impacts to Washington State because of this carbon leakage —or firms choosing to move outside the region to avoid GHG regulations.

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[1] An exploratory study is undertaken when not much is known about the situation at hand or no information is available on how similar problem or research issues have been solved in the past. In such cases, extensive preliminary work needs to be done to gain familiarity with the phenomenon in the situation and understand what is occurring before we develop a model and set up a rigorous design for comprehensive investigation. In essence exploratory studies are undertaken to better comprehend the nature of the problem since very few studies might have been considered in that area. Extensive interviews with many people might have be undertaken to get a handle on the situation and understand the phenomena. More rigorous research could then proceed (http://www.blurtit.com/q113463.html, 2011).

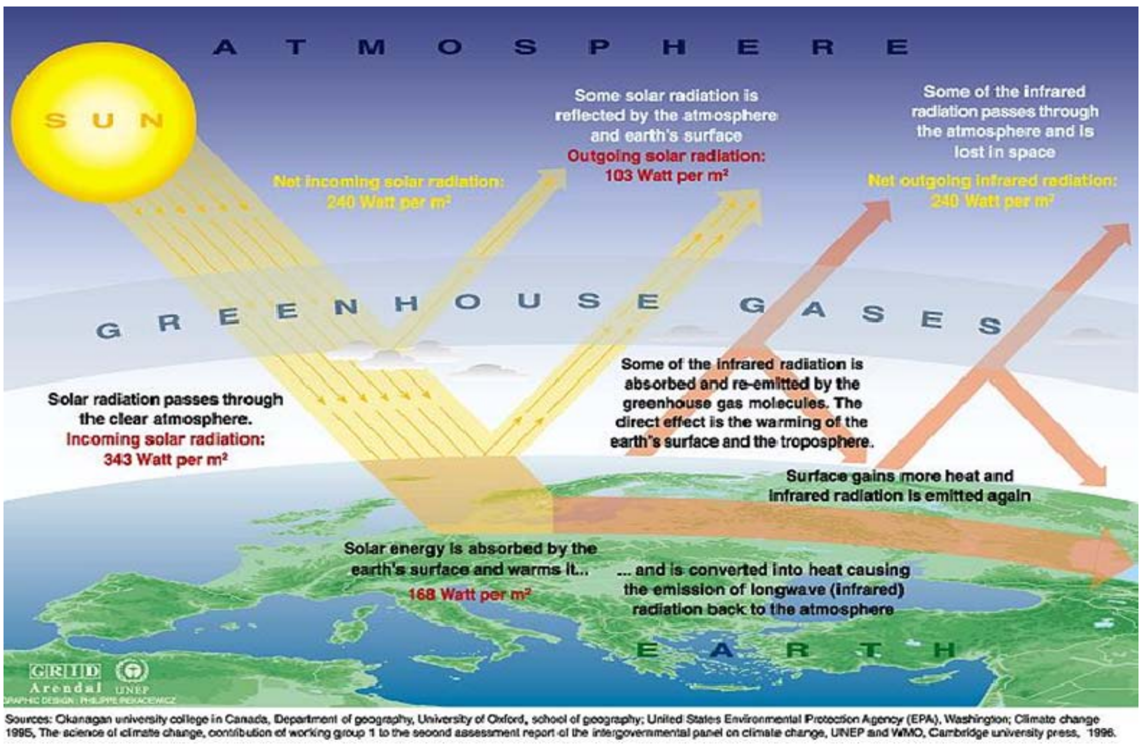
Information on carbon leakage exists in the literature, but it generally addresses carbon leakage on a more global scale. Ideally, information would exist for Washington State on the factors that drive firm mobility and the extent of carbon leakage caused by GHG emission regulations. However, such specific information or analysis on firm mobility is not available for Washington. Therefore, to determine potential carbon leakage caused by firm mobility, certain assumptions and best estimates based on national literature found are used. These estimates of firm mobility are used to assess the impact of GHG regulations because of carbon leakage on Washington in employment income and state tax revenues--from 2009 employment income and tax revenue data provided by the Washington State Employment Security Department.

Chapter 2. Background

Greenhouse Gas and Climate Change

The United States is the second largest emitter of the greenhouse gases (GHGs) that cause global warming in the world (second only to China). GHGs make up only about 1% of the atmosphere, but they act like a blanket around the earth, like a greenhouse, and they trap heat and keep the planet warmer (see Exhibit 1 below, "The Greenhouse Effect" from the United Nations Framework Convention on Climate Change [http://unfccc.int/essential_background/feeling_the_heat/items/2903.php, 2009]).

Exhibit 1. The Greenhouse Effect



Source: United Nations Framework Convention on Climate Change, 2009

Human activities are making the blanket "thicker" because natural levels of these gases are supplemented by emissions of carbon dioxide (CO_2) from the burning of coal, oil, and natural gas; by additional methane; and nitrous oxide. These changes are happening at unprecedented speed, and if emissions continue to grow at current rates, it is almost certain that atmospheric levels of CO_2 will double from pre-industrial levels during the 21st century (UNCC, 2009).

Global climate change has already had observable effects on the environment. Glaciers have shrunk; ice on rivers and lakes is breaking up earlier; plant and animal ranges have shifted; and trees are flowering sooner. Effects that scientists had predicted would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise, and longer, more intense heat waves. Future impacts expected from unabated climate change include more extreme sea-level increases, longer heat waves, unhealthy air quality, more unpredictable water availability, and reduced biodiversity as invasions of non-native species increase and local habitat moves northward and to higher elevations. These impacts can affect a wide range of people, ecosystems, and economic sectors.

Scientists have high confidence that global temperatures will continue to rise for decades, largely because of GHGs produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the U.S. and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century. According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change (NASA, 2011).

Mitigation of climate change, and its associated negative impacts, has been sought through the reduction in GHG emissions. That is why Washington Governor Christine Gregoire proposed legislation to meet statewide and regional GHG emission reduction targets by establishing a cap-and-trade (CAT) system beginning in 2012.

About 80 years ago, economists first proposed the use of corrective taxes—instead of command-and-control approaches to pollution abatement--to internalize environmental and other externalities. Fifty years later, the portfolio of potential economic-incentive instruments was expanded to include quantity-based mechanisms (such as tradable permits). Thus, economic-incentive approaches to environmental protection are clearly not a new policy idea. During the past two decades, they have held varying degrees of prominence in environmental policy discussions (Stavins, 1998).

The Governor Mandates Cap-and-Trade in Washington

In December 2008, Washington Governor Christine Gregoire proposed legislation to meet statewide and regional greenhouse gas (GHG) emission reduction targets by establishing a cap-and-trade (CAT) system beginning in 2012. Starting in 2012, the bill would cap emissions from electric utilities and major industrial facilities (such as cement, pulp and paper, and aluminum plants) that produce more than 25,000 metric tons of GHGs annually.. The program's second phase in 2015 would expand to smaller industrial emitters. Motor vehicles and residential and commercial buildings would be covered under the system indirectly, beginning in 2015, through regulation of the potential emissions from fuels. The proposed bill also established a new high-level oversight group to provide guidance to the Washington State Department of Ecology (Ecology) on rulemaking and to make a final recommendation to the governor on the timing and terms of Washington's participation in the regional program.

The Ecology department recommended implementing the Western Climate Initiative (WCI) Regional CAT Program. By capping GHG emissions according to the WCI program, the state could achieve the results needed to slow the rate of climate change. The WCI program was scheduled to begin in 2012 with coverage of emissions from electricity generation and major industrial sources (Washington State Department of Ecology, 2009).

In this capstone project, the focus is on the implementation of regional CAT programs in the absence of broader global agreements. Because GHGs and climate change are a global problem, this analysis considers a cost-benefit framework for regional regulation with a focus on the possibility that significant levels of regional GHGs may simply be moved outside the regulated jurisdiction because of carbon leakage.

Western Climate Initiative

The WCI Regional CAT Program—the central component of the WCI Partner jurisdictions' comprehensive strategy—is a flexible, market-based program that encourages cost-effective, reliable alternatives to reduce GHGs. It also can address some jurisdictional challenges associated with monitoring and enforcing reductions in GHGs.

The WCI Regional CAT Program is composed of the individual jurisdictions' CAT programs implemented through state and provincial regulations. Each Partner jurisdiction implementing a CAT program will issue an "allowance" to meet its jurisdiction-specific emissions goal. The total number of available allowances serves as the cap. A regional allowance market is created by the Partner jurisdictions accepting one another's allowances for compliance. The allowances can be sold between and among covered entities as well as by third parties.

The WCI has 11 partners: Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Ontario, Oregon, Quebec, Utah, and Washington. The WCI is one of three GHG initiatives in North America with action plans to achieve a transition to clean-energy economies. Others include the Regional Greenhouse Gas Initiative (RGGI) in the Northeastern and mid-Atlantic states and the Midwestern Greenhouse Gas Reduction Accord in the midwestern United States.

A unique feature of the WCI is the consensus achieved among its partner jurisdictions to develop a GHG emissions reduction strategy that accommodates the diverse economies and interests of its members and considers lessons learned from existing programs (WCI, 2010).

Chapter 3. Literature Review

History of Cap-and-Trade

In economics, a public good is one that is non-rivalrous and non-excludable. That means consumption of the good by one individual does not reduce availability of the good for consumption by others--and that no one can be effectively excluded from using the good. The atmosphere/air we breathe is a common good; thus, it does not have rules governing or limiting its use. So it is not surprising that because of human nature, the atmosphere is being polluted by users (that is, the people), and many users would choose to not do anything about the pollution assuming that others will.

By the 1950s, economists and policymakers had formed strong but opposing opinions about how pollution control policy should be conducted. Over the years, many economists have advocated for market-based instruments to control and abate pollution by putting a price on externalities such as air pollution. Those economists include Arthur Pigou, who advocated for the use of taxes to correct externalities, and John Dales, who advocated that the right to emit pollution should be fixed and tradable (Tietenberg, 2006).

One of these market-based instruments is a cap-and-trade (CAT) system. Under a CAT system, the governmental agency (the State of Washington in this case) would set an overall limit (cap) on greenhouse gas emissions. Based on that cap, quotas are then imposed on sources of emissions—such as utilities and factories. The state would allocate "allowances" to each facility that represents the volume of its quota. A facility must either reduce emissions to meet the quota or buy allowances from other facilities that have exceeded their required reductions (trade). In theory, companies that can easily reduce emissions for less cost will do so, achieving pollution reduction at the lowest cost to society. Washington's system would auction a portion of GHG credits and distribute the remaining credits at no charge (Marten Law Group, 2009).

A CAT system works like this: The "cap" is the quantitative limit of emissions imposed by a regulator or agency. That cap is broken into allowances, and those allowances are distributed to each entity that has a legal obligation to comply with the cap. Each allowance corresponds to one unit of emissions, and the objective is to set the cap to produce a shortage of allowances for what the companies' business-as-usual emissions will be. According to economic theory, the scarcity of allowances will set the price of emissions in the marketplace and allow a market to emerge. Though advocates argue that benefits are obtained even without trading, the primary benefit from carbon trading comes in the "trade" part: at the end of the predetermined emission period, each participating (polluting) entity must hold the number of allowances that matches its actual emissions for that set period (CNN, 2009).

In theory, the benefits of CAT are many. Economic theory would say the main benefit is that, when considering all the participants' overall costs of reducing emissions, a CAT approach will result in the least total cost to society of meeting the objective. The allowance trading of the CAT approach gives each participant the choice to reduce its emissions or to buy additional allowances from another entity—and the participants will likely choose whichever method is less expensive. Tietenberg (2006) posits that logic behind this kind of a system is straightforward and simple. It differs from command-and-control approaches to regulating pollution, in which the government sets the pollution reduction goals and the methods of reaching the goals. The market-based CAT approach, however, is considered a more cost-effective solution because participating firms will strive to minimize costs, which in turn leads to objectives being met at the least cost.

Much of the credit for the “birth” of CAT to Canadian economist John Dales, who in the late 1960s demonstrated that if the right to emit pollution were fixed and tradable, pollution would be reduced at the least cost to society. However, Ellerman and others also recognize that when this approach has been applied to a variety of environmental problems it has generally performed poorly overall. It has had higher than expected costs and disappointing results when the objectives were not met (Ellerman et al 2005).

Evolution of Cap-and-Trade

The opportunity to capitalize on the fact that command-and-control approaches to environmental regulation are not cost-effective came in 1976 when there were a number of “nonattainment areas” identified that would not meet the federal Clean Air Act’s ambient air quality standards (Tietenberg 2006). Interest in CAT has grown quickly since Title IV of the 1990 Clean Air Act amendments (the U.S. Acid Rain Program) established the first large-scale, long-term environmental program to rely on emission trading to reduce SO_2 emission (Ellerman et al, 2005). This growth seemed to accelerate in 1995 when Title IV was put into effect. Since then, multiple emissions trading programs have been introduced, and CAT has become a topic at almost every major environmental conference, meeting, or discussion. Ellerman states that on balance, Title IV was overall a success.

Tietenberg (2006) claims that two main innovative features resulted from the U.S. Acid Rain Program. The first was ensuring the availability of allowances by setting up an auction-based market. Until then, carbon emission markets had historically failed because of the absence of good information about prices and the market's sellers and buyers. The second innovative feature was a system enabling anyone to buy emission allowances. This change meant that environmental groups or individuals could buy emission allowances, thus taking those allowances off the market and reducing total emissions resulting in cleaner air.

Conceptual Framework of a Cap-and-Trade System/Market Design

Cole (2002) argues that all approaches to environmental regulation are property-based and that, consequently, the choice is not whether or not to use property-based approach to control pollution. Instead, the choice is which property-based approach to take. Cole claims there is no universal answer, that each approach has pros and cons, and that perhaps the best solution is a mixture of solutions because no single approach is perfect. Cole posits that an effective solution must consider the range of possible solutions based on property rights to combat problems that arise from common resources where no rules or regulations are in place to protect the resource. He argues that a comparative institutional analysis is needed to set up the appropriate framework to achieve pollution reduction goals.

Ellerman et al (2005) take a different tack on the framework and state there are two principal types of participants that need to be involved to regulate and control air pollution. The first key participant is the regulatory authority (such as the State of Washington). The regulatory authority has the responsibility to ensure acceptable air quality through laws and regulations. The second key participants are those managing the pollution sources (such as industries, power plants, manufacturers). These entities are responsible for taking the actions that ultimately reduce the pollution. Ellerman et all (2005) state that a successful system is designed to maximize outcomes by maximizing the efforts between participants. They also state that the main argument supporting CAT is that pollution abatement goals can be reached at least cost to society because (1) a market for pollution allowances exists and (2) the market is relatively efficient. Of course, to have an "efficient market," good information must be available to buyers and sellers; transaction costs should be low; and buyers and sellers should actively engage in the market by buying and selling the allowances. Before 1990, emission-trading results were not stellar in this regard. Title IV attempted to correct some of the problems with past programs by trying to meet the conditions of an efficient market. Those conditions include good information, low transaction costs, and allowance-trading activity.

Another key issue with markets is that—unlike other pollution reduction tools—companies with market power can manipulate them. Tietenberg (2006) discusses many ways in which markets can be manipulated, thus eroding the efficiency of the market-based system. He also discusses in detail where market power can arise, what the potential implications are, and when manipulation can be enough of a problem that it could possibly outweigh the benefits of the market-based system. In Washington, the entities with the largest number of allowances or the firms with the best technology and ability to reduce emissions at the lowest cost, could potentially have, (and wield) market power. Putting an ideal market program together, however, is difficult in practice: not all emissions are easily monitored; not all sectors are equally suited for an emissions market; and not all sources are created equally from a political vantage point.

First, the CAT system design must be tailored to address both transportation-related and other emissions, while considering the administrative and political limitations of the sectors and/or program. One of the main questions that needs to be answered is whether greenhouse gases should be regulated "upstream"—at the point where fossil fuels and other greenhouse gas-emitting agents are produced—or "downstream"—at the point where greenhouse gases are emitted into the air. Second, to create an efficient system, rules must be in place for the initial allocation and distribution of allowances; restrictions on trading allowances to prevent one firm from holding a large percentage of the market share; and what happens to a firm's emission allowances if a firm closes or exits the market.

The Challenges of Cap-and-Trade

There are a number of challenges associated with a CAT system, including enforcement, monitoring, and jurisdictional issues. Many opponents of CAT posit that after Europe adopted CAT systems in 2005, the results were far from stellar. In fact, the *Washington Post* once described it as "a bureaucratic morass with a host of unexpected and costly side effects and a much smaller effect on carbon emissions than planned." While many opponents argue that the economic performance might be better with a CAT/carbon emissions trading system, they say the environmental outcome is worse, and that the increased environmental degradation outweighs the gains in economic efficiency. However, in the article "Are Cap-And-Trade Programs More Environmentally Effective than Convention Regulation?" Ellerman (2003) discusses evidence from Title IV of the Clean Air Act, the Northeaster NO_X Budget program, and the Regional Clean Air Incentives Market (RECLAIM) trading programs for NO_X and SO_2 emissions that show market-based instruments may be both more effective at reducing pollution and more economically efficient than traditional command-and-control approaches. See Chapter 4 for more information regarding the challenges of implementing CAT.

While designed to begin in 2012, Washington's CAT program would not take effect unless and until it is linked with other state or regional programs to try to minimize such challenges as carbon leakage. Washington is a member of the WCI, and the state bill proposes a threshold of caps be placed on the majority of the emissions included in the WCI, or an equal amount through links to other regional programs. California's CAT program—also poised to begin in 2012—could alone account for a significant percentage of the emissions included in the WCI. The California governor may also delay the start of the program or its expansion to include fuels in 2015, or suspend the program altogether in an economic emergency.

The Costs and Benefits of Cap-and-Trade

There has been much debate about whether the benefits of CAT can be justified by the costs. A recent economic analysis entitled "Updated Economic Analysis of the WCI Regional Cap-and-Trade Program " posits that the WCI plan can achieve the regional GHG emissions-reduction goal and realize a cost savings of about $100 billion between 2012 and 2020. The economic analysis underscores that mitigation of GHG emissions and the move to a clean-energy economy is affordable, and can be achieved no negative impact on the regional economy (WCI, 2010b). Despite the WCI's claim, it remains to be seen as to whether the benefits can exceed the costs. This result is consistent with other recent state and federal analyses of climate mitigation programs.

WCI Partners recognized the need to take action to reduce these costs, and they are realizing the benefits of the transition to a clean-energy economy. In the United States, the seven WCI Partner states comprise 20% of the economy, yet the seven states garnered 60% of venture capital investments directed toward clean-technology businesses from 2006 to 2008. In 2007, the proportion of green businesses and green jobs in the economies of WCI Partner states was 20% higher than in the U.S. economy as a whole. British Columbia's green businesses contributed $15.3 billion (Canadian) to the provincial economy in 2008, and that number is expected to grow in the next decade.

While the precise cost of inaction is uncertain, it is likely to exceed the cost of undertaking well-conceived climate change mitigation activities. Analysis showed that the WCI Partner jurisdictions could achieve the goal of reducing emissions to 15% below 2005 levels by 2020 while realizing a modest net cost savings through an increase in energy efficiency and reduced fuel consumption. These savings would be in addition to the benefits the region would accrue from a cleaner environment and spin-offs from investment and innovation in a green economy (WCI, 2010).

Cost-Benefit Analysis

A balanced yet rigorous analysis of costs and benefits is an invaluable decision-making tool for legislators. To craft specific legislative language, to compare a bill with competing legislative alternatives, and ultimately to cast a rational, educated vote, legislators must understand the full range of consequences—both positive and negative—that their decisions will have on the economy, the environment, and public health. So far, in its study of climate change legislation, Congress has focused its information-gathering efforts much more on costs than benefits. Climate change is arguably one of the most complex issues to face Congress in recent memory.

H.R. 2454: American Clean Energy and Security Act of 2009 was a bill in the U.S. Congress originating in the House of Representatives and is the so-called "Waxman-Markey cap and trade bill." The direct benefits of climate change legislation like H.R. 2454 will result from reducing the emission of GHG pollutants (mostly carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons). Cutting national GHG emissions will mitigate the speed and severity of climate change effects, including the myriad impacts on the environment, the economy, public health, and national security.

The U.S. Environmental Protection Agency (EPA) has used two economic models to estimate the emissions reductions and costs of U.S. House Resolution 2454.20: The Applied Dynamic Analysis of the Global Economy (ADAGE) model is a dynamic Computable General Equilibrium model of the U.S. economy, including international trade. ADAGE offers a more complete representation of the full global economy, but it is less useful for conducting counterfactual policy experiments. The Intertemporal General Equilibrium Model (IGEM) models only the U.S. economy, but it has a more detailed representation of energy and environmental issues. Perhaps importantly, because it does not model international emissions, IGEM does not fully capture possible emissions leakage. A rough estimate of such benefits can be generated through a straightforward calculation: projected tons of GHGs avoided, multiplied by the monetary valuation of incremental damage from each ton of GHGs. The first figure (projected tons of GHGs avoid) has already been calculated by EPA and other agencies, as published in the various economic analyses of H.R. 2454. The second figure (monetary valuation of incremental damage)—also known as the "social cost of carbon"[2] (SCC)—has until recently been estimated by federal agencies only for specific purposes. The SCC assigns a net present value to the marginal impact of one additional ton of carbon dioxide‒equivalent emissions released at a specific point in time. The SCC estimates consider such factors as net agricultural productivity loss, health effects, property damages from a rise in the sea level, and changes in ecosystem services. NYU calculated the SCC to be $19 per ton, and researchers then used that figure to determine the total benefits that could accrue over the next 40 years (NYU, 2009).

The estimated costs of complying with H.R. 2454 may be compared with estimates of the benefits as measured by the social cost of carbon and ancillary benefits. This comparison will be used to predict whether the proposed bill and possible legislative alternatives are likely to pass a more thorough cost‒benefit analysis.

Exhibit 2 plots the estimated cumulative costs of H.R. 2454 (about $660 billion) against the projected direct benefits of the bill for a range of SCC values (from $5 per ton of carbon dioxide in 2007 to $68 per ton). The chart does not include any ancillary benefits, and it discounts costs and benefits at a 5% rate. Additionally, the benefits analysis does

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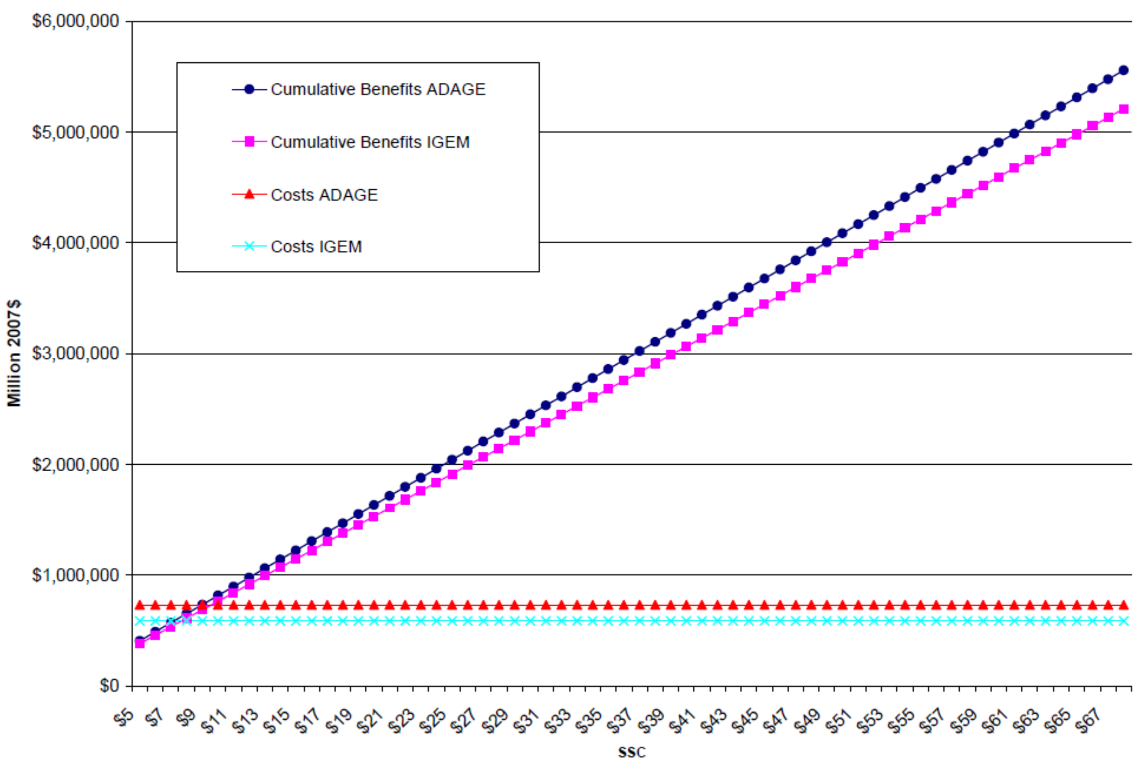
[2] The SCC is the estimated price of the damages caused by each ton of carbon dioxide (CO2) released into the atmosphere. The higher the SCC, the more stringent the standards. For example,if the SCC is $5, only regulations that cost less than $5 to implement would be deemed worthwhile; if the SCC is $500, the demands imposed on polluters could be correspondingly greater. (With no price on carbon emissions at all, of course, the effective price is $0, and no reductions are "worthwhile.") (http://rwer.wordpress.com/2010/04/27/what-is-the-social-cost-of-carbon/, 2011).

not include 39 billion to 40 billion metric tons of GHG abatement, because EPA excluded certain provisions from its cost estimates.

As calculated, the benefits increase with the SCC, but costs remain constant. Measuring benefits is more difficult than measuring costs because SCC estimates vary. For that reason, it is useful to calculate the SCC that will exactly equate the benefits (excluding ancillary benefits) of the bill with the estimated cost—in other words, the "breakeven social cost of carbon." If the actual SCC is above that value, benefits of H.R. 2454 will outweigh costs, and the legislation is justified. For ADAGE, the breakeven point is \$8.97, and for IGEM it equals \$7.70. The breakeven points are close, but that hides some differences in the results: ADAGE forecasts higher costs and larger emissions reductions, which cancel out each other in a cost-benefit framework. Because these values do not include potentially large ancillary benefits, they should be considered an upper bound on the true breakeven SCC.

Exhibit 2. Total Costs and Benefits at Different SCC Values



Source: NYU, 2009

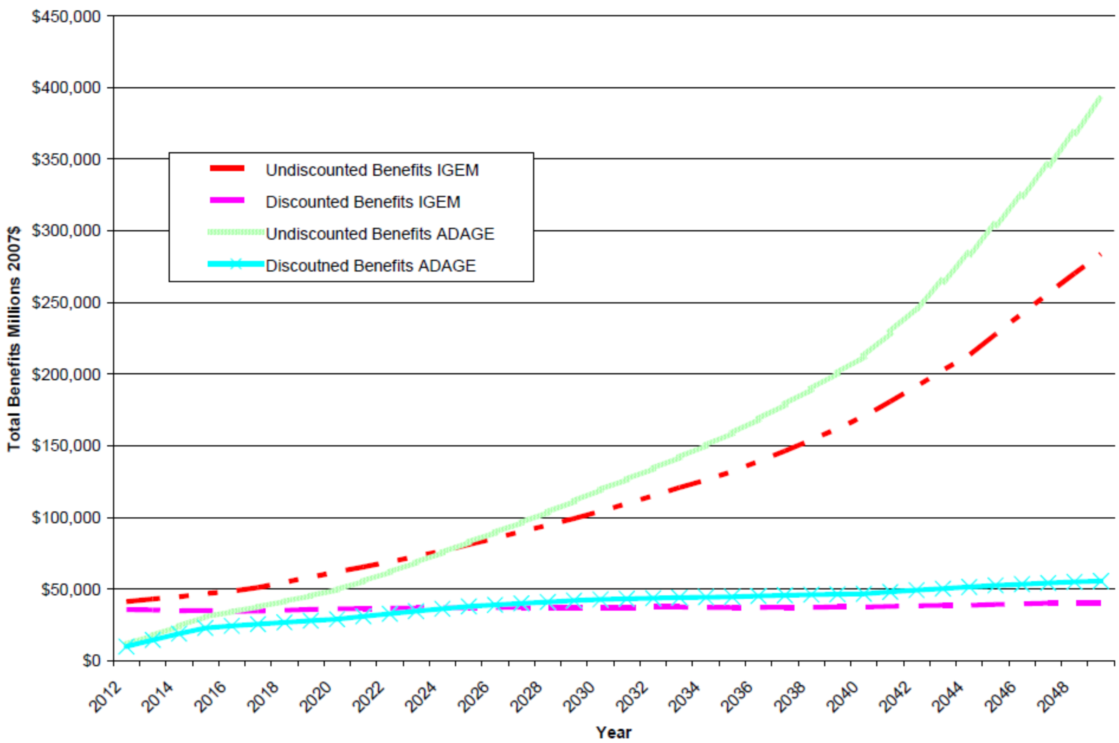
Benefits

Climate legislation like H.R. 2454 would achieve both direct and indirect benefits. The potential direct benefits result from capping GHG emissions, thereby mitigating the speed and severity of the myriad impacts of climate change on the environment, the economy, public health, and national security. Such benefits are approximated by the SCC, which assigns a specific monetary value to the marginal impact over time of one additional ton of carbon dioxide–equivalent emissions.

Cutting GHG emissions is also likely to generate several significant indirect benefits. For example, besides trapping heat in the atmosphere, carbon dioxide is absorbed by bodies of water and leads to ocean acidification. Ocean acidification threatens the balance of many marine ecosystems, yet it and its effects are not typically reflected in SCC approximations. Another significant category of ancillary benefits derives from the reduction of non-target, non–GHG co–pollutants as businesses make changes to decrease GHGs. Reducing such pollutants will achieve significant economic and health benefits, which are not otherwise included in the SCC estimates.

The first step in the benefits equation is to calculate the projected tons of GHG emissions that H.R. 2454's policies would prevent from entering the atmosphere. The figures were generated from the raw data available on the EPA website, and they represent net global emissions reductions under H.R. 2454, considering both domestic and international offsets. Exhibit 3 illustrates benefit streams at 0% and 5% discount rates.

Exhibit 3. Benefit Streams at 0% and 5% Discount Rates



Source: NYU, 2009

Exhibit 4 shows the range of SCC estimates developed by the interagency review process at these various discount rates. Calculating the direct benefits of H.R. 2454's cap on GHG emissions is simply a matter of multiplying the projected GHG emissions avoided by the social cost of carbon. The calculations show the projected GHG emissions under both ADAGE and IGEM, multiplied by all six SCC estimates in the range developed by federal agencies. In both calculations, the benefits have been discounted at a 5% rate (consistent with EPA's discounting of costs), above any discounting already factored into the SCC values, because the benefits of reducing future emissions do not begin accruing later.

The wide range of possible SCC values generates a wide range of benefit estimates; the variability in estimated benefits is purely a function of the SCC range. A starting social cost of carbon of $5 in 2007 generates benefits of about $409 billion over the life of H.R. 2454, while an SCC of $68 in 2007 generates benefits of about $5.5 trillion. Using the SCC figures preferred by the Department of Energy in its recent rulemaking, benefits total about $1.5 trillion. The benefit estimates are relatively small during the early years of the cap, but they rise as the cap's stringency increases and the SCC values grow. Despite being discounted, the benefits in 2050 are forecast to be more than twice as large as those in 2012.

Exhibit 4. Net Present Global SCC Estimates at 3% Growth Rate (in 2007$, per Metric Ton of CO2 Equivalent Emissions)

Year of Emission	Discount Rate					
	Constant (5%)*	Random-Walk (5%)	Average of 3% & 5% (Constant)†	Constant (3%)*	Random-Walk (3%)	Constant (2%)‡
2007	$5.00	$10.00	$19.00	$33.00	$55.00	$68.00
2010	$5.46	$10.93	$20.76	$36.06	$60.10	$74.31
2015	$6.33	$12.67	$24.07	$41.80	$69.67	$86.14
2020	$7.34	$14.69	$27.90	$48.46	$80.77	$99.86
2025	$8.51	$17.02	$32.35	$56.18	$93.63	$115.77
2030	$9.87	$19.74	$37.50	$65.13	$108.55	$134.20
2035	$11.44	$22.88	$43.47	$75.50	$125.84	$155.58
2040	$13.26	$26.52	$50.39	$87.53	$145.88	$180.36
2045	$15.37	$30.75	$58.42	$101.47	$169.11	$209.09
2050	$17.82	$35.65	$67.73	$117.63	$196.05	$242.39

Source: NYU, 2009

* Model-Weighted Mean Calculated by Interagency Process in 2009

† Department of Energy's Average of SCC Estimates at the Constant 3% and Constant 5% Discount Rates

‡ Central Estimate of Meta-Analysis Conducted by EPA in 2008

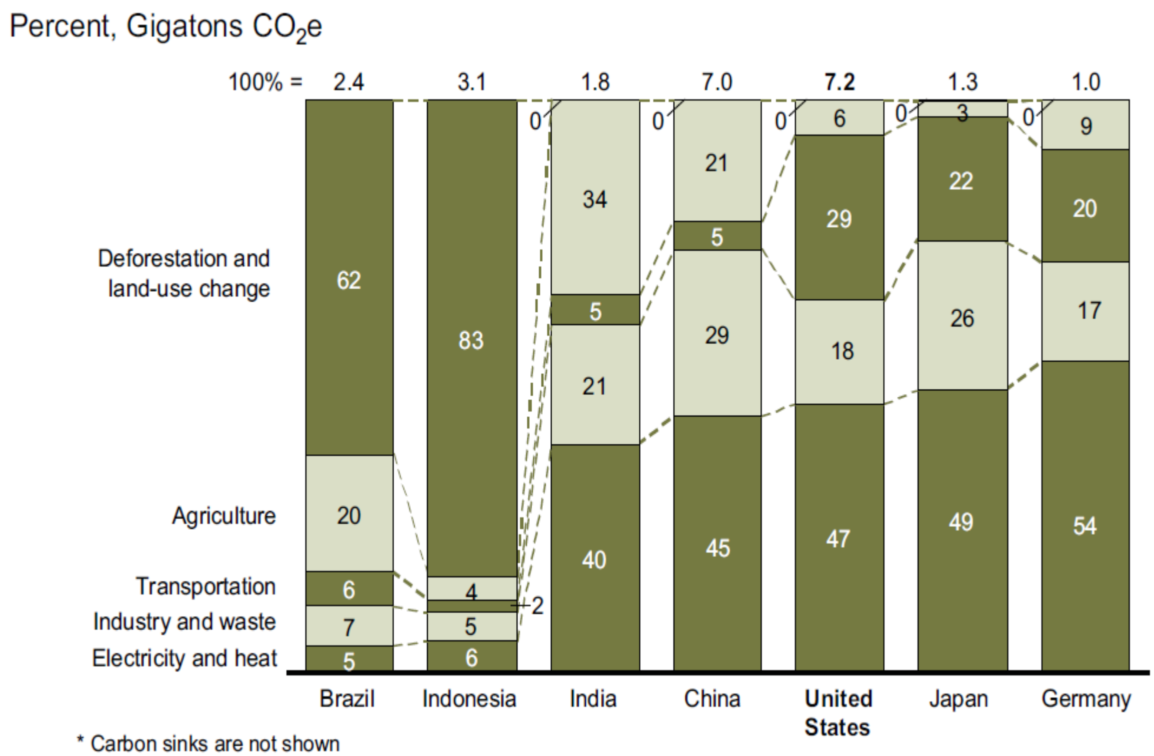
The IGEM model generates a similarly wide range of possible benefit values, reflecting the wide range of SCC estimates. The possible benefits run from $383 billion to $5.2 trillion, and they total nearly $1.5 trillion, also using the SCC values preferred by the Department of Energy. Those cumulative benefits are consistently smaller than those from the ADAGE model-- because of lower estimates of overall GHG reductions. The IGEM model projects larger benefits in the early years of the regulation but significantly smaller benefits during the final years covered under this cap. Even after discounting, those smaller benefits in future years lead IGEM to forecast smaller cumulative benefits over the life of H.R. 2454. The analysis illustrates the importance of selecting a discount rate when estimating the benefits (or costs) of a long-term policy such as H.R. 2454.

Undeniably, the SCC estimates do not yet reflect all impacts of climate change; those omissions must be rectified to accurately calculate direct benefits. However, the policies implemented by climate legislation like H.R. 2454 will also generate several ancillary benefits, wholly apart from any effect tied to climate change, and definitely not captured in the social cost of carbon. These benefits include reduced ocean acidification, increased forest preservation, and reductions in local air pollutants such as sulfur dioxide, nitrogen dioxide, and particulate matter. Such benefit estimates are not the primary goal of H.R. 2454, but they still provide benefits that must be considered when conducting a full economic analysis. That said, ancillary benefits can often be difficult to value accurately, and so in some cases they must remain un-quantified. Nevertheless, all ancillary benefits, whether monetized or not, deserve attention when determining if the benefits of proposed legislation outweigh the costs (NYU, 2009).

Costs

As a large nation physically with a highly developed, service-based economy, the U.S. emits a great proportion of GHGs from buildings, transportation, and electric sectors than do other industrialized nations that are more compact and have a denser population like Germany or Japan. Because the U.S. is less dependent on agriculture and forestry for economic growth than many large companies, its forest and agricultural lands represents a net carbon sink, which contradicts with countries like Brazil and Indonesia where deforestation , burning of biomass, and conversion of land to agriculture use contribute a large amount of GHGs (see Exhibit 5) (McKinsey, 2007).

Exhibit 5. Greenhouse Gas Emissions for Select Countries, 2005

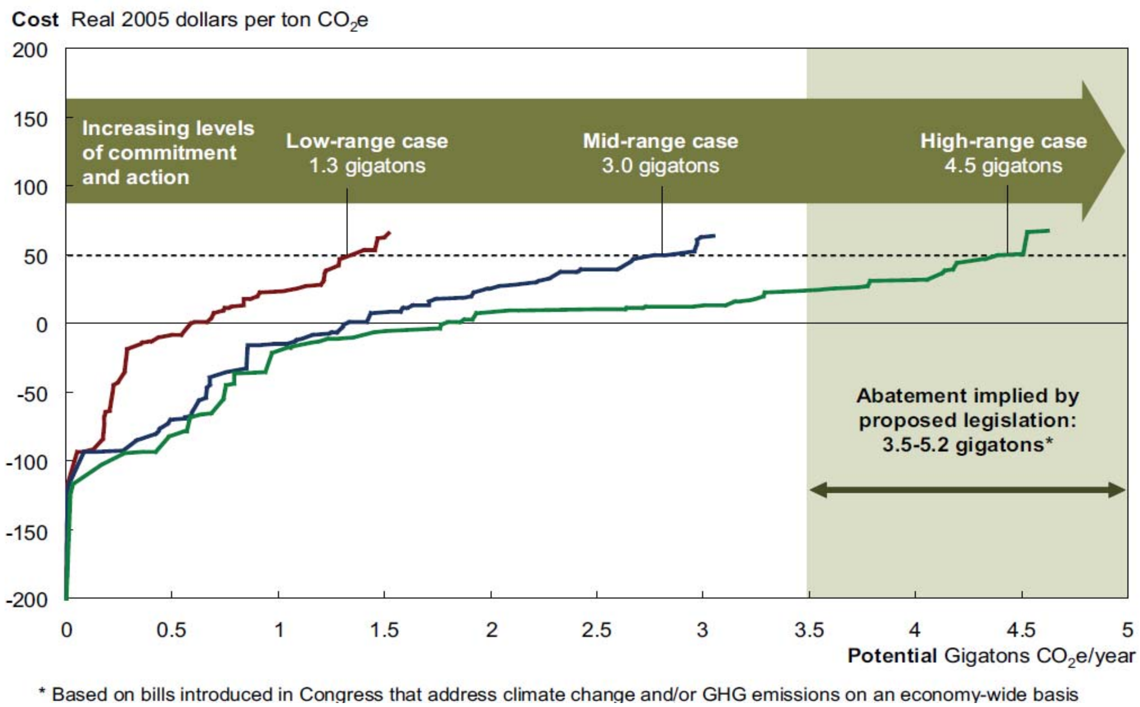


Source: McKinsey & Company, 2007

Exhibit 6 illustrates how McKinsey & Company estimated net costs and abatement benefit in terms of CO2 equivalent for more than 250 abatement options, grouping these options into abatement clusters that approximate the energy use patterns in technology fields in key sectors of the economy. It projected a range of three outcomes for each option and integrated the values into three abatement supply curves. These curves are not optimized scenarios; they represent different approximations of national commitment and different rates for innovation, learning, and adoption of various technologies. The three curves (or "cases") include the low-range case, which involves incremental departures from current practices; the mid-range case, which involves concerted action across the economy; and the high-range case, which involves urgent national mobilization.

Although research suggests that the net costs (benefits minus costs) of achieving these levels of GHG abatement could be quite low on a societal level, issues regarding allocation and timing may leave stakeholders to perceive the costs very differently—particularly during the initial transition to a lower carbon economy (McKinsey 2007).

Exhibit 6. U.S. Greenhouse Gas Abatement Potential – 2030



Source: McKinsey & Company, 2007

In its economic analysis, the EPA presents cost calculations as an average annual loss of consumption per U.S. household. Specifically, EPA estimates that under H.R. 2454, average annual household consumption will decline by $80 to $111 (in 2005 dollars) per year compared with the baseline scenario. Using the raw data available on EPA's website, it is possible to calculate the total cumulative costs nationwide from 2012 through 2050. Because costs and benefits fluctuate year by year with the stringency of H.R. 2454's provisions, it is more transparent to use annual and cumulative figures (rather than a single average) when comparing the costs and benefits.

According to EPA, these cost calculations "include the effects of higher energy prices, price changes for other goods and services, impacts on wages, and returns to capital." Importantly, the cost figures have been adjusted to reflect the value of emissions allowances that will be auctioned off under H.R. 2454's CAP scheme, with some revenues being returned to consumers and to lower- and middle-income families. On the other hand, notably, the cost estimates do not consider the benefits of avoiding the effects of climate change." Also, EPA's cost estimates do not include the government's costs of administering, monitoring, and enforcing H.R. 2454.

Some of ADAGE and IGEM's cost predictions for early years (2010 ‐ 2013) are negative because of investment spurred by the passage of the Act and the relatively high initial caps. Because the cumulative figures calculated exclude negative costs in years 2010 and 2011 (since the cap does not take effect until 2012), these cost estimates are higher than some of EPA's predictions that average costs from 2010 ‐ 2050. Several assumptions made by EPA for the sake of "simplicity" are likely to lead to "an overestimation of abatement costs." For example, EPA predicts that most emissions reduction measures will be implemented at costs below the marginal price of emissions allowances. More specifically, EPA believes the relationship between abatement costs and allowance prices will follow a convex curve, suggesting a factor greater than 2. However, for the sake of simplicity, EPA chose to approximate abatement costs by dividing allowance prices by two—an assumption that will inevitably lead to an overestimation of costs.

Finally, EPA's cost analysis does not model the effects of the bill's new source performance standards for methane emissions from landfills and coal mines-- or of H.R. 2454's separate cap on hydrofluorocarbon emissions. Therefore, these emissions will not be considered in the benefits analysis of this policy brief, despite the significant GHG reductions such provisions would achieve (NYU, 2009).

Limiting global climate change will entail substantially reducing the amount of greenhouse gases that accumulate in the atmosphere over the next several decades, but the benefits of doing so are largely independent of the annual pattern of those reductions. Consequently, a CAP program could achieve roughly the same level of benefits at a significantly lower cost if it provided firms with an incentive to make greater reductions in emissions when the cost of doing so was low and allowed them to lessen their efforts when the cost was high. Including features in a CAT program that provide that flexibility could also reduce the volatility of allowance prices. Experience with CAT programs has shown that price volatility can be a major concern when a program's design does not include provisions to adjust for unexpectedly high costs and to prevent price spikes.

The most cost-effective CAT design would encourage firms to make greater reductions when the cost of doing so was low and would allow them leeway to lessen their efforts when the cost was high. Providing firms with such flexibility could also prevent large fluctuations in the price of allowances that could be disruptive to the economy. The reduction in economic burden need not come at the cost of additional environmental risk: The flexibility to shift emission reductions across years could be designed to achieve any given cumulative reduction in emissions over the medium or long term.

One option for allowing firms flexibility in determining when to reduce emissions while also achieving compliance with a cumulative target would be through setting both a ceiling—typically referred to as a safety valve—and a floor on the allowance prices each year. The price ceiling would allow firms to exceed the annual target when the cost of cutting emissions was high, while the price floor would induce firms to cut emissions more than the annual target in low-cost years. The price ceiling and floor could be adjusted periodically to ensure that emission reductions were on track for achieving the long-run target. Another option would be to authorize firms to "borrow" future allowances for use in the current year or to "bank" allowances for use in future years. Firms would have an incentive to borrow allowances, though, only if it would be cost-effective—if they expected the price in the future to be sufficiently lower than the current price. Similarly, firms would have an incentive to bank allowances only if they expected the price in the future to be sufficiently higher than the current price. Most proposals for borrowing and banking would impose limits on the degree to which they could be undertaken.

The Carbon Market Efficiency Board described in U.S. Senate Bill 2191 would be authorized to transfer emission allowances across time periods. Regulators could try to shift allowances in a way that led to more reductions when costs were relatively low and fewer reductions when costs were high. An alternative approach, which may be easier for regulators to implement efficiently, would be to have the board set a ceiling and floor for allowance prices and be responsible for adjusting those price limits periodically as needed to achieve a long-term target for reducing emissions.

Policymakers' choices about whether to distribute the allowances without charge or to auction them—and if they are auctioned, how to use the proceeds—could have a significant effect on the overall economic cost of capping emissions. Evidence suggests that the cost to the economy of a 15% cut in U.S. emissions (not counting any benefits from mitigating climate change) might be half as large if policymakers sold the allowances and used the revenue to lower current taxes on capital that discourage economic activity. Alternatives could be giving the allowances to energy suppliers and energy-intensive firms or using the auction proceeds to reduce costs the policy could impose on low-income households. Using the allowances' value to lower the total economic cost could exacerbate the regressive effects of the program (Orszag, 2008).

Carbon Leakage

A major concern of policymakers involved with each of these initiatives is a phenomenon usually called carbon leakage: emissions reductions achieved by the firms covered in their scheme will be counteracted by emissions increases by firms located elsewhere. Leakage issues are potentially relevant to a wide range of emissions-intensive industries in which firms compete internationally and where only a subset of firms experienced tightened environmental regulation. The absence of a level playing field among firms can substantially undermine the effectiveness of such incomplete regulation. Indeed, global emissions could even rise as a result of the policy if the emissions increases by unregulated firms are sufficiently pronounced (Ritz, 2009).

There are several channels of sector-led carbon leakage initiated by uneven carbon constraints. Here are the three most important channels:

- the short-term competitiveness channel, where carbon-constrained industrial products lose market shares to the benefit of unconstrained competitors.
- the investment channel, where differences in returns on capital from unilateral mitigation action provide incentives for firms to move capital to countries (or regions) with less stringent climate policies.
- the fossil fuel price channel, where reduction in global energy prices caused by reduced energy demand in climate-constrained countries triggers higher energy demand and CO2 emissions elsewhere, all things being equal.

Hoel (1991) emphasized free-riding effects in showing that unilateral climate policy can lead to carbon leakage and increases in global emissions. A number of subsequent papers have estimated carbon leakage rates under the international Kyoto Protocol, typically using complex computable general equilibrium (CGE) modeling approaches with multiple regions and highly aggregated industries. While those approaches have obtained a wide range of leakage estimates, most of the estimates are fairly low and lie within the range 5-40% (Ritz, 2009). There are two main sources of leakage in these models: first, through the goods market, where regulated firms reduce production, so the market price increases and unregulated firms produce more; and second, through factor markets, where inside firms' energy demand decreases, so energy prices fall and outside firms may switch to dirtier production technologies. Much of the existing literature makes the simplifying assumption of perfect competition in product markets, combined with an elasticity structure that governs substitution patterns between domestic production and imports.

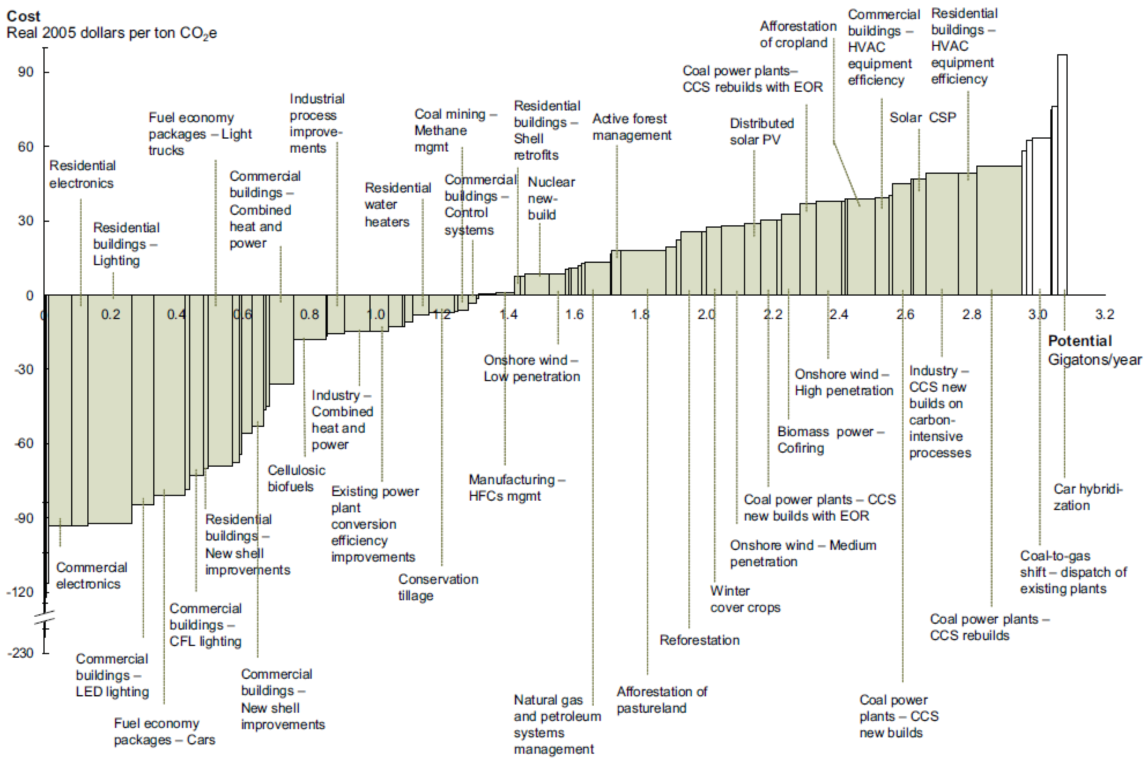
Ritz (2009) discusses a CGE model with imperfect competition in product markets and free entry and exit of firms. It shows that the relocation of energy-intensive production facilities away from Organization of Economic Cooperation and Development (OECD) countries can lead to significantly higher carbon leakage rates of 50-130% in CGE modeling. Fowlie (2009) examines carbon leakage in a partial-equilibrium, Cournot-Nash model that is simulated to analyze the impact of state-level environmental regulation on the Californian electricity industry. She also argues that carbon leakage can significantly undermine climate policy effectiveness, and she shows that incomplete regulation can lead to an increase in global emissions only if unregulated firms are sufficiently dirtier than regulated firms (Ritz, 2009).

Within the existing research on sectoral carbon leakage, none of the simulations focusing on sectoral leakage show a leakage rate near 100%, so it is highly unlikely that carbon leakage would entirely eradicate an effort to reduce emissions in an industry. The notion that a cap in a country or region will lead to even more emissions globally is contradicted by some quantitative studies. However, there are only imprecise and uncertain ranges of leakage estimates for some but not all sectors potentially exposed to such a risk (IEA, 2008).

One of the main causes of carbon leakage is that the cost of reducing GHGs can significantly vary by both industry and by region. However, Mckinsey posits that almost 40% of abatement could actually be achieved at a negative cost. In other words, 40% of emissions could be abated where the economic returns outweigh the cost of abatement. Exhibit 7 illustrates the McKinsey & Company (2007) mid-range abatement curve[3] in 2030 by industry in the United States.

[3] A Marginal Abatement Cost Curve is a set of options available to an economy to reduce pollution. They are valuable tools in understanding emissions trading, driving forecasts of carbon allowance prices, prioritizing investment opportunities, and shaping policy discussions.

Exhibit 7. U.S. Mid-Range Abatement Curve - 2030

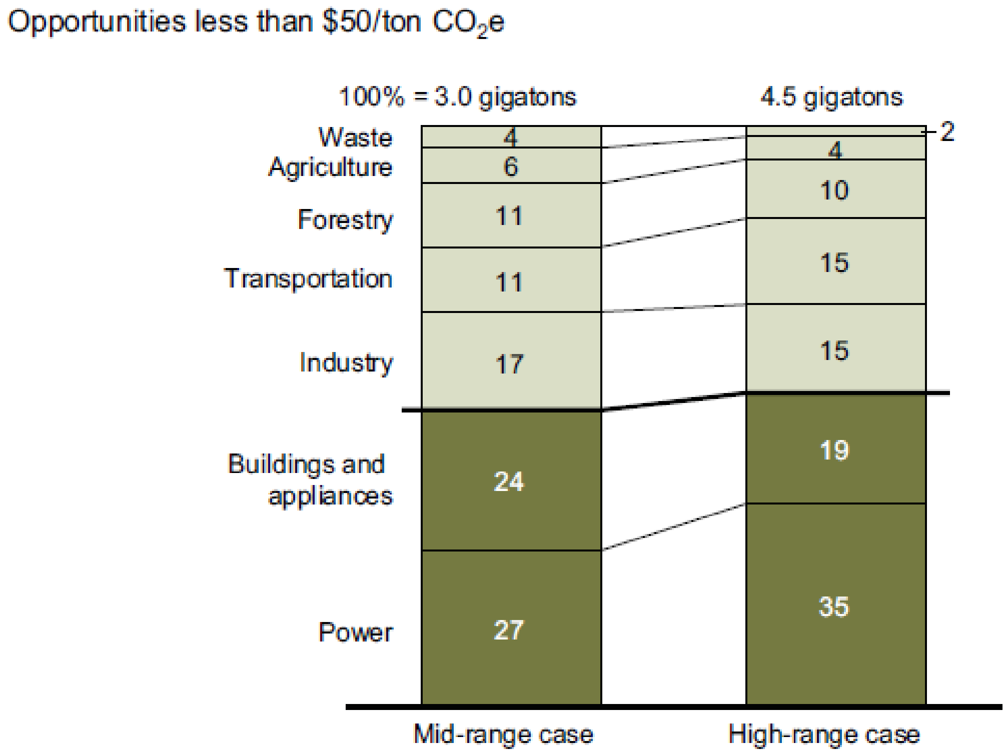


Source: McKinsey & Company, 2007

Exhibit 8 illustrates the abatement potential by sector with opportunities to reduce for $50 or less per ton of CO2. For those industries with higher abatement costs, the probability of carbon leakage increases. Exhibit 9 illustrates the geographic differences in abatement cost by region. The dashed line represents the emissions that can be abated for $50 per megaton. The areas under the curves show that in the United States the South can reduce emissions at the least cost followed by the West, Midwest, and Northeast.

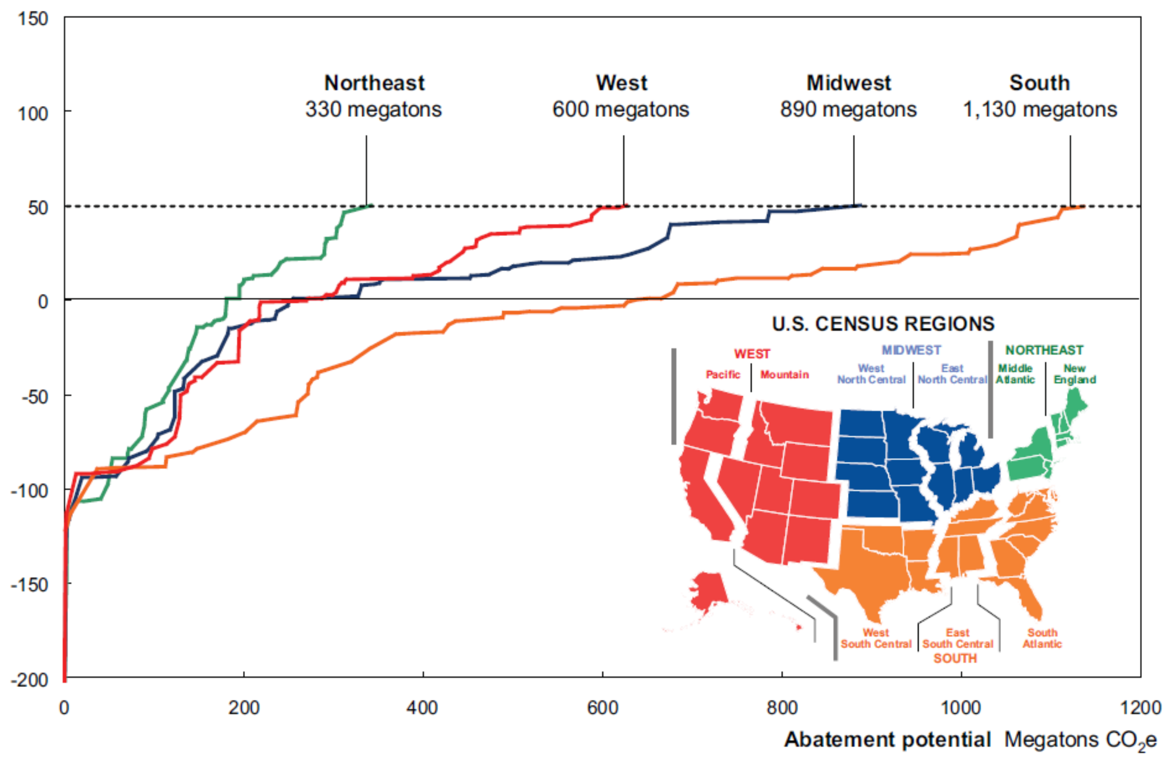
Each region has substantial abatement potential, although the cost and potential of individual options will vary by up to $50/ton when pursued in different locations. Disparities reflect regional differences in population growth and/or density, carbon intensity of local power generation, energy productivity, climate, availability of renewable energy resources, forest cover, agricultural orientation, concentration of industrial activity, and other factors.

Exhibit 8. Abatement Potential by Sector



Source: McKinsey & Company, 2007

Exhibit 9. Geographic Differences in Abatement Cost



Source: McKinsey & Company, 2007

Assessing the potential for carbon leakage is a central piece in the evaluation of the CAT and its chances of success. However, this is not an easy task. The leakage effects are the result of complex interactions between energy and non-energy markets. In the absence of direct empirical evidence, an option is to rely on model simulations. However, existing global models have failed so far to provide a coherent view on the magnitude and the regional distribution of the carbon leakages that could emerge (Burniaux et al, 2000). Determining the rate of leakage requires a comparison of the industry market equilibrium before the introduction of CAT with the market equilibrium after CAT has been implemented. In general, performing this comparison is difficult because it involves dealing with some complicated expressions for which closed-form expressions are usually not available, thus making them hard to interpret (Ritz, 2009).

Many argue that the "race to the bottom line" is most likely to arise in situations where regulation in one jurisdiction imposes costs on firms that competitors in other places do not have to bear. It has often been claimed, for example, that enacting strict labor and environmental regulations will spur businesses to move their production to states or countries with laxer rules. However, taken as a whole, studies suggest that differences in the regulatory burden seldom cause significant numbers of firms to relocate.

There are several reasons for this result. First, the cost of more stringent rules may not be large enough relative to other costs that matter for location decisions. Second, regulatory regimes usually consist of complex bundles of rules that may simultaneously affect firms' competitiveness in very different ways. Third, stricter regulatory standards may have benefits that offset their costs. Fourth, context matters, and the same law can have different consequences depending on where (and when) it was passed (Carruthers, n.d.).

Chapter 4. Challenges of Implementing Cap-and-Trade in Washington State

Global treaties, the most logical place to conduct regulation, are at a negotiating impasse.

Several alternatives are now being debated in Congress that would define U.S. responsibilities globally. The Bingaman-Specter and Udall-Petri bills would keep U.S. emissions near current levels; the Lieberman-McCain, Feinstein, Kerry-Snowe, Sanders-Boxer, and Waxman bills specify emissions reductions goals of 50% to 80% below the 1990 level by 2050. Current U.S. emissions are about 15% above their 1990 level (Paltsev et al, 2008).

The purpose of U.S. mitigation measures is to substantially reduce the amount of climate change we would otherwise experience. Absent controls on greenhouse gas emissions, many scientists assert global temperatures could rise by 3.5 to 4.5 °C by 2100 (WCI, 2010b). To meet temperature or greenhouse concentration goals, many countries must make a concerted, coordinated, long-term effort. With rapid growth in developing countries, failure to control their emissions could lead to a substantial increase in global temperature even if the United States and other developed countries pursue stringent policies.

It is useful to evaluate the global costs and global benefits of achieving such targets, as difficult as that is to do. However, it is not possible to connect specific U.S. policy targets with a particular global concentration or temperature target, and therefore the avoided damages, because any climate gains depend on efforts in the rest of the world. In addition, unfortunately, absent a global agreement a country's best strategy for its own self-interest is to do little and hitch a free ride on the actions of other countries. Of course, if all countries behave that way, very little mitigation will be achieved. If a cooperative solution is possible, a major strategic consideration in setting U.S. policy targets should be their value in leading other major countries to make similar efforts.

Also at issue is the equitable sharing of the cost burden of emissions-reduction. Such equity concerns are inextricably linked to the strategic objective of getting other countries to mitigate their greenhouse gas emissions. Poorer countries see the U.S. and other developed countries that have freely emitted CO_2 over the history of fossil use; thus, those countries are responsible for the level of concentrations we see today. In addition, poorer countries see economies of developed nations with far higher incomes that are in a better position to afford the burden of mitigation. Thus, a perception of the U.S. taking on an equitable share of the burden of abatement is probably essential if the U.S. policy is going to serve the strategic goal of moving climate policy forward elsewhere. These issues are well beyond the scope of this analysis, but consideration of them is essential in determining the best policy for the U.S. (CEEPR, 2007).

So, in the absence of federal action to address climate change, Partner jurisdictions in the Western Climate Initiative (WCI)believe it is important for state and provincial governments to keep moving forward on the transition to a clean-energy economy and continue to lead in demonstrated areas of expertise, including energy innovation, efficiency, and conservation. The WCI Partner jurisdictions are committed to continuing to develop affordable, innovative clean-energy solutions that will create new jobs and reduce dependence on imported oil, thus helping to protect consumers from volatile petroleum prices. The WCI Partner jurisdictions have developed a comprehensive initiative to reduce regional greenhouse gas (GHG) emissions to 15% below 2005 levels by 2020 and spur investment in and development of clean-energy technologies, create green jobs, and protect public health (WCI, 2010b).

Benefits are global and costs are local; a challenging economy will make implementing a cap-and-trade system harder.

The economic and environmental effects of a cap-and-trade (CAT) system depend on its features within the U.S. and on activities in other countries through the influence of trade in energy, non-energy goods, and emissions allowances (CEEPR, 2007).

In 2009, Washington Governor Christine Gregoire's CAT bill directed the state Department of Ecology to establish annual GHG caps beginning in 2012. Overall emissions under the cap would be reduced every three years to reach 1990 levels by 2020. Starting in 2012, the bill would cap emissions from electric utilities and major industrial facilities that produce more than 25,000 metric tons of GHGs annually, such as cement, pulp and paper, and aluminum plants. The program's second phase in 2015 would expand to smaller industrial emitters. Motor vehicles and residential and commercial buildings would be covered under the system indirectly, beginning in 2015, through regulation of the potential emissions from fuels (MacCurdy, 2009).

However, both the state House and Senate balked at adopting a CAT system that would force industries to either cut GHG emissions to fall below a cap or buy an extra permit. While a climate-change bill passed in the state Senate and was headed for the House, it barely resembled the legislation Gregoire unveiled—disliked by the state Legislature because of fears it could hurt the state's economy. Gone is the mandatory program regulating pollution from big factories, electric utilities, and fuel such as gasoline. In its place, state agencies were supposed to come back to the 2011 Legislature with a menu of approaches for regulating GHG. That change marked a win for major Washington businesses and a setback for environmentalists and Gregoire, who had made the legislation a top environmental priority. It is also the clearest sign that in this difficult economy, environmentalists face an uphill battle (Cornwall, 2009).

Companies that anticipate falling under the cap are opposed to an auction, believing the economic impact would be substantial and would place Washington businesses at a competitive disadvantage. They project the allowances for baseline emissions in 2020, when Washington hopes to have returned to 1990 emission rates, would cost $2.7 billion annually (Macurdy, 2009).

CAT systems generally define a set of accounting periods and allocate allowed emissions separately for each period. An important design feature is whether entities under the cap can shift their obligations across periods. If higher costs are expected in the future, firms have an incentive to over-comply early and "bank" the excess for use in meeting future obligations. Alternatively, companies might be allowed to under-comply, "borrowing" from the future by shifting the deficit forward to add to the obligation in later periods. Many CAT systems allow banking (CEEPR, 2007).

To ensure compliance with the overall cap, the CAT program includes a rigorous emissions reporting requirement, which would have to be followed consistently across participating jurisdictions. Each WCI Partner will require annual emissions reports (using equivalent measurement protocols and verified by a third party) from entities and facilities covered by the cap. Regulated entities not in compliance would be required to obtain, through the secondary market or offsets, three allowances for each one that is due. Since each allowance covers just one metric ton of emissions—and with regulated industrial facilities emitting more than 25,000 tons of GHGs annually—any significant shortfall in allowances could produce a substantial civil penalty. Failure to comply with other provisions of the legislation could expose entities to civil penalties of up to $10,000 for each day in violation (MacCurdy, 2009).

The New York University Law School Institute for Policy Integrity has released a study that details the economic benefits of proposed CAT legislation and determines that the benefits "far outweigh" the costs (NYU, 2009). To come up with this finding, NYU researchers first had to determine the social cost of carbon (SCC) or "how much a ton of carbon not emitted to the atmosphere is worth to society in terms of avoiding climate change." The SCC assigns a net present value to the marginal impact of one additional ton of carbon dioxide−equivalent emissions released at a specific point in time. The SCC estimates consider such factors as net agricultural productivity loss, health effects, property damages from a rise in the sea level, and changes in ecosystem services. NYU calculated the SCC to be $19 per ton, and researchers then used that figure to determine the total benefits that could accrue over the next 40 years. Depending on a number of variables, that number could be as low as $382 billion or as high as $5.2 trillion. By using the midpoint of that range, roughly about $1.5 trillion, and comparing it with a $660 billion cost estimate in the H.R. 2454 Waxman-Markey legislation, analysis shows that the bill will provide $2.27 in benefits for every $1 spent.

As flawed as it may be, this result seems to indicate the Waxman-Markey climate bill makes economic sense, offering benefits worth at least twice as much as it costs, if not more. "From almost any perspective and under almost any assumption, H.R. 2454 is a good investment for the United States to make in our own economic future and in the future of the planet," the NYU paper concludes. If these figures are given any weight, they will provide some ammunition to supporters of the bill when the Senate debates it in the coming months. Opposition to the bill is strong, especially in states where fossil fuels are major businesses. Little abatement will be provided without an agreement on international cooperation. It is not possible to connect U.S. policy targets with a particular global concentration or temperature goal, or the avoided damages, because any climate gains depend on efforts in the rest of the world (Paltsev et al, 2008).

How does WCI plan to address nonpoint pollution? How important is nonpoint pollution to the solution?

A significant amount of U.S. water pollution originates from nonpoint sources, which are "scattered, diffuse sources of pollutants, such as runoff from farm fields, golf courses, or construction sites." The regulation of these sources, particularly agricultural nonpoint sources, is a complex issue now facing policy makers. Nonpoint sources have been regulated substantially less than point sources, which are "specific locations of highly concentrated pollution discharge, such as factories, power plants, sewage treatment plants, underground coal mines, and oil wells." Earlier efforts at controlling nonpoint source pollution have been unsuccessful, mainly because individual polluters were not held accountable for the pollution they emitted. For most polluters, the cost of polluting without restraint has often been lower than the cost of self-regulation.

Regulators have investigated traditional command-and-control regulatory schemes for nonpoint-source pollution control. That approach applies uniform standards to all individual polluters. Although it achieves a certain level of accountability, its centralized approach to solving environmental problems has proven costly for polluters (Dewan, 2004).

Many current proposals differ on the points in the economic system where the cap is applied (upstream or downstream) and the method of allowance distribution (for free or auction). The primary effect of this choice of point of regulation is to determine which entities must comply with the regulatory system by monitoring emissions, maintaining records, and submitting allowances. The direct cost of emissions abatement may not be incurred at those stages in the production process. For example, in an upstream system where one point of regulation likely would be at oil refineries, emissions abatement would come mainly from reductions in fuel use downstream (CEEPR, 2007).

No state can do this on a go-it-alone basis if hoping to achieve significant GHG reductions.

On July 27, 2010, the partner jurisdictions of the WCI released a comprehensive strategy designed to reduce climate-warming GHG, stimulate development of clean-energy technologies, create green jobs, increase energy security and independence, and protect public health. The WCI program design recognizes that variations in jurisdictional authority, regulatory procedures, and administrative requirements will lead to different approaches of implementation. While not all WCI partner jurisdictions will be implementing the CAT program when it begins in January 2012, those jurisdictions expected to move ahead produce roughly two-thirds of total emissions in the WCI jurisdictions. That is a critical mass and a robust market for achieving significant GHG emissions reductions.

From the beginning, the WCI partners' strategy for addressing climate change has recognized the need for broad collaborative action to reduce GHG emissions. All the WCI Partner jurisdictions have adopted climate action plans and are taking steps to reduce emissions. Besides efforts to implement a CAT program, the WCI is working to advance other policies needed to reduce GHG emissions. WCI Partner jurisdictions are also working closely with the U.S. and Canadian federal governments to promote national and international action and ensure coordination among state, provincial, regional, and national programs (WCI, 2010b).

A`s mentioned above, while designed to begin in 2012, Washington's CAT program would not take effect unless and until it is linked with other state or regional programs to avoid carbon leakage. Other regional GHG-reduction partnerships around the nation are critical and do exist. The Regional Greenhouse Gas Initiative (RGGI) is a CAT program that covers a single sector—electricity generation—in 10 northeastern and Mid-Atlantic States[4]. The program aims to achieve a 10% reduction in emissions from power plants by 2018. The program's most notable aspect is that states unanimously chose auctioning to distribute the vast majority of emission allowances. Six of the 10 states will auction nearly 100% of their allowances. The auctions of the other four states include fairly small portions of fixed-price sales or direct allocations. The first multistate auctions occurred on September 25 and December 17, 2008, and included allowances from only six states. The first auction raised $38.5 million, and the second raised $106.5 million. States and electric utilities (which represented 47% of emissions in 2005) will invest the majority of those funds in energy efficiency and renewable technologies, with an emphasis on reducing demand for fossil fuel–based electricity and saving money.

On November 15, 2007, the governors of Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin, as well as the premier of the Canadian province of Manitoba, signed the Midwestern Regional Greenhouse Gas Reduction Accord. Participants agreed to establish regional targets for reducing global warming emissions, including a long-term target of 60–80% below today's levels, and to develop a multi-sector CAT system to help meet the targets. Participants would establish a system for tracking emissions, and implement other policies to help reduce them. The governors of Indiana, Ohio, and

[4] New Jersey Governor Chris Christie announced in May 2011 that New Jersey would withdraw from the Regional Greenhouse Gas Initiative; New Jersey is the first state to withdraw from RGGI.

South Dakota joined the agreement as observers. The regional accord for reducing such emissions is the first in the Midwest. The governors and premier assembled an Advisory Group of more than 40 stakeholders to advise them, and as conceived, the cap would take effect January 1, 2012 (Union of Concerned Scientists, 2010).

McKinsey and Company (2007) posit that the United States could reduce GHG emissions in 2030 by 3.0 to 4.5 gigatons of CO2 using tested approaches and high-potential emerging technologies. These reductions would involve pursuing a wide array of abatement options with marginal costs less than $50 per ton, with the average net cost to the economy being far lower if the nation can capture sizable gains from energy efficiency. Achieving these reductions at the lowest cost to the economy, however, will require strong, coordinated, economy-wide action that begins soon.

Although research suggests the net cost of achieving these levels of GHG abatement could be quite low on a societal (overall) basis, issues of timing and allocation would likely lead various stakeholders to perceive the costs very differently—particularly during the transition to a lower carbon economy. Costs will tend to be more concentrated in some sectors than others and involve real upfront cost outlays that could be offset by future avoided cost outlays. Given the timing of investment relative to savings, the economy might well encounter periods of significant visible costs, with the costs and benefits shared unequally among stakeholders (McKinsey, 2007).

Often the question arises as to whether state or regional CAT programs should be preempted by federal policy (like the Waxman-Markey bill). States led the way on progressive climate policy during the eight years under President George W. Bush. They enacted renewable portfolio standards (29 states), greenhouse gas emissions caps (covering more than half the states), utility performance standards (four states), and auto emissions standards (California plus 15 states set to follow California's lead before President Barack Obama announced a stringent new national standard). Many believe states should be rewarded for their climate leadership with continued authority to regulate. Perhaps more importantly, independent state authority is important to retain if that the federal government backs away from sufficiently stringent carbon policy, or political leadership changes in Congress or the Executive branch.

But should states retain authority to enact or continue CAT programs if Congress enacts a national CAT scheme? State CAT programs could be meaningful in at least two instances: if they cover more sources or impose a tighter cap than a comparable federal program. Similarly, if federal legislation contains provisions that significantly undermine its effectiveness (for example, a far too generous safety valve or generous borrowing provisions) a more stringent state CAT program could produce additional emissions reductions within the state. And will they affect overall U.S. emissions reductions? If a federal cap is in place, then a more stringent cap within a state will simply require in-state sources to meet the state cap without producing any real net decrease in U.S. emissions. Why? Because the in-state sources will simply help the rest of the country meet the federal cap more easily, requiring fewer reductions by sources throughout the rest of the country. Thus, state CAT programs simply redistribute the allocation of emissions reductions and may increase the overall costs by limiting the freedom of a carbon market to distribute reductions efficiently (Carlson, 2009).

Achieving benefits from the program is going to be difficult because of 'free riders.'

Many climate negotiators recognize that fundamentally the climate problem is a free-rider problem—regionally or globally. Every region and country would prefer that the others do more. Externalities are unintentional side effects of an activity that affect people other than those directly involved in the activity. A negative externality creates side effects that could be harmful to the public directly or through the environment, such as air pollution that may pose health risks for nearby residents or degrade the quality of the air or water (Environmental Literacy Council, 2011).

GHG emissions cause an externality—an effect that is not priced by private markets—and consequently GHG abatement is a global public good. Because each country is only a small part of the global economy, the resulting free-rider incentives can dominate national strategies. Little abatement will be provided without an agreement on international cooperation (Stoft, 2010).

Two methods of controlling negative externalities loosely related to property rights include CAT and individual transferable quotas (ITQs). The CAT approach sets a maximum amount of emissions for a group of sources over a specific period. The various sources are then given emissions allowances that can be traded, bought or sold, or banked for future use. Over the course of the specified period, overall emissions cannot exceed the amount of the cap and may even decline. Therefore, individual sources or facilities, can determine their level of production, the application of pollution reduction technologies, the purchase of additional allowances or a combination of the three methods (Environmental Literacy Council, 2011).

Who bears the ultimate burden of the costs of abatement depends on the complex interaction of markets. In an idealized "neoclassical" model of the economy, the burden of the mitigation costs under a CAT program is independent of the point of regulation. One implication of this principle is that while upstream regulation would create incentives for abatement, the costs of abatement need not be borne upstream. Thus, free distribution of allowances to upstream entities can create an inequitable outcome where they get a valuable asset but ultimately pass on most of the cost to downstream fuel users. To the degree the distributional impacts of the policy are a concern, the focus needs to be on who bears the economic burden of the policy, not on who happens to be given the task of turning in allowances or who is responsible for abating emissions.

On equity grounds, the revenue from auctioning permits or the distribution of free allowances could be directed to those who ultimately bear the cost of abatement, whether it is low-income consumers, coalmine owners, coal miners or other groups. Correctly assessing the cost implications for different groups requires a detailed representation of the economy, including representation of features such as cost-of-service regulation as in some U.S. electric utilities (CEEPR, 2007).

Some analysts believe the United States' share of climate effects will be comparatively small, because of the country's "relatively temperate climate, the small dependence of its economy on climate, the positive amenity value of a warmer climate in many parts of the United States, its advanced health system, and its low vulnerability to catastrophic climate change." In short, the "cost of carbon" is a global cost, and the U.S. doesn't face the same risk from climate change as other nations, so the benefits are similarly global, even if the costs are not: "A large portion of benefits might not be felt directly or immediately within U.S. borders" (NYU, 2009).

Carbon leakage: Reductions achieved in one area are offset by increases elsewhere.

Carbon leakage is caused by the movement of firms away from regions where carbon constraints exist to where they do not. Leakage is more likely in cases where a subset of regions or firms experience tightened regulation-- and many critics believe emissions could actually rise as a result. Carbon leakage can be defined as the ratio of emissions increase from a specific sector outside a country (or region) over the emission reductions within the sector (again, as a result of the policy). When handling this issue, the aim is to address environmental effectiveness, not industrial policy.

Following the international Kyoto Protocol, some countries introduced (or are planning to introduce) a CAT system to curb CO2 emissions from power generation and large industry. In most of the rest of the world—especially emerging economies—such a broad carbon cost is not necessarily imminent, and they therefore may benefit from a distortion of competition. Globally, as countries move toward building a low-carbon global economy, the issue of competitiveness stands as a potential barrier to progress. This barrier is linked to fears of carbon (or emissions) leakage, whereby emission reduction efforts in one country would be offset by emission increases in non- carbon-constrained regions.

An unintended consequence of emission mandates to reduce GHG emissions is carbon leakage. As noted above, carbon leakage occurs when there is an increase in carbon dioxide emissions in one country (or region) as a result of an emissions reduction by a second country (or region) mandated by a strict climate policy. This carbon leakage is likely to occur if the emissions policy of a country raises local costs relative to another country with a more relaxed policy. This cost factor may result in the area with the relaxed policy having a trading advantage over the area that has reduced GHG emissions. Additionally, environmental policies to reduce GHG emissions in one area may add a premium to certain fuels or commodities, possibly causing demand to decline and price to fall (Chatham House, 2009).

Emissions trading potentially offers lowest-cost solutions for the economy. However, companies with higher marginal abatement, the introduction of a cap, and visibly pricing CO2 emissions in a subset of the world regions may distort the playing field. That would create a risk of carbon leakage and job and income losses for sectors (or regions) exposed to GHG abatement regulations. The question for countries designing policy is how to ensure that the transition toward a low-carbon economy occurs with only limited carbon leakage.

Chapter 5. Approach/Methodology

The analysis conducted is exploratory in nature for the purposes of identifying the factors which may affect the extent carbon leakage that may occur in Washington as a result of a regionally enacted cap-and-trade (CAT) program intended to limit greenhouse gas (GHG) emissions. This analysis proposes that more research is needed to identify possible methods of reducing the uncertainties surrounding the possible negative impacts associated with this carbon leakage.

This analysis is accomplished by first looking at the current levels of GHG emissions in the state. Washington State data used in the analysis is tracked and available from the state Department of Ecology, and the GHG levels are delineated by industry sectors. An estimate of firms that may move outside the region is then derived based on the likelihood of mobility—a likelihood based on educated estimates derived from research found in the literature. From that likelihood, an estimated amount of GHG emissions not abated but just relocated (that is, carbon leakage) is calculated. The analysis will then examine the potential economic impacts to Washington State because of this carbon leakage —or firms choosing to move and operate outside the region to avoid GHG abatement regulations.

Information on carbon leakage exists in the literature, but the literature is lacking in many cases because it generally addresses carbon leakage on a more global—rather than regional—scale. Ideally, information on the factors that drive firm mobility and the extent of carbon leakage because of GHG emission regulations would exist for Washington State. However, such state-specific information or analysis on firm mobility is not available for Washington. For example, Carruthers states, "Businesses often greet attempts to pass new regulatory legislation with dire forecasts about the large number of enterprises that will leave the jurisdiction if the rules are imposed. Such forecasts are an example of what Albert Hirschman has termed "voice." They are attempts to influence the course of political action and prevent the regulations from being adopted. If the attempts are unsuccessful, business enterprises may or may not actually "exit," but whether they will is something that policy makers need to be able to predict (Carruthers, n.d.).

Therefore, for the sake of this analysis, some assumptions based on the literature have been made to determine the potential carbon leakage because of firm mobility. These estimates of firm mobility are used to assess the impact of GHG regulations because of carbon leakage on Washington employment income and state tax revenues--from 2009 employment income and tax revenue data provided by the Washington State Employment Security Department.

Determining Carbon Leakage

A major concern of policymakers involved with each of these initiatives is a phenomenon usually called carbon leakage: emissions reductions achieved by the firms covered in their scheme will be counteracted by emissions increases by firms located elsewhere. Leakage issues are potentially relevant to a wide range of emissions-intensive industries in which firms compete internationally and where only a subset of firms experienced tightened environmental regulation.

The exact probability that a firm will choose to move outside a region versus comply with GHG-abatement standards is complex and outside the scope of this paper. In order to calculate possible leakage for this analysis, some assumptions must be made about the extent and degree to which an industry or activity may be mobile in response to GHG regulations. Here are some of the assumptions regarding factors that may drive mobility. For each factor, additional research could be undertaken to try to estimate an "index" of captial costs as compared to assets, sales revenue, or other. These indices then may be used to provide us with an approximate probability of relocation by applying them to the cost of a firm's GHG abatement costs.

- Capital Investment –The firms would have to consider the capital investment already expended in the current location and the capital investment needed to move to a new location. The higher the capital expense, the less likely the entity may move if the relative cost of regulation is not large enough to justify a move.
- Dependence on Local/Regional Specific Resources –Unique resources or labor may be obtained more economically in the current location. This factor may influence an entity to stay where it is and not move outside the region if the cost of inputs/labor in a different region is greater than the cost of reducing GHGs.
- Transportation Costs of Products or Services –Higher costs of transporting an entity's products or services produced outside the region to within the region may encourage the entity to stay in place if the new cost is greater than the cost of compliance with GHG abatement policies.

- Cost of Abatement–Higher costs of implementing measures that reduce GHGs may influence an entity to move outside the region, to a location where these measures are not required. However, there may be benefits that offset the costs of meeting the regulatory standards.

Existing data does not measure the extent to which these potential mobility factors influence a specific sector on a regional basis. For this analysis, a "rating" (possibility of relocation) was applied to the GHG emissions data outlined in the Washington State Department of Ecology's report (December, 2007) to estimate leakage. Assumptions were made about the relative influence of these factors on a scale of 1-3. On this scale, a rating of 1 for a particular factor shows the sector is relatively inflexible concerning mobility, a 2 represents somewhat flexible, and a 3 represents very flexible. These relative scores for the mobility factors for each sector are in Exhibit 10. The results in Exhibit 10 provide an evaluation of each sector's likelihood to move in response to GHG regulations. The assumptions and rationale for the ratings are explained below:

- Electricity–Capital Investment was rated low (inflexible) due to high costs for contruction of electricity generation (power plants) outside the region. Region-Specific was rated medium (somewhat flexible) due to the reasonable capability for electicity to be transmitted from within or outside the region using an existing power grid. Similar to Region-Specific rationale, Transportation Costs were rated medium (somewhat flexible). Cost of Abatement was rated high (very flexible) due to significant emissions produced from electicity generation and the expected high costs of abatement.
- Residential/Commercial/Industrial–All factors were rated as medium (somewhat flexible) based on assumptions that this sector would require moderate capital investment to move, the activities and products are moderately region-specific, and transportation costs are also moderate. The costs of abatement are also presumed to be moderate due to the wide range of activities within this sector.
- Transportation–The factors of Capital Investment, Region-Specific and Transporation Costs were rated high (very flexible) due to the presumed mobility of these emission sources. Cost of Abatement was rated medium (somewhat flexible) due to an assumption that abatement costs would be incurred but on a lessor scale than heavy industry.

- Fossil Fuels–Similar to Electricity sector reasoning, Capital Investment was rated low (inflexible), and Cost of Abatement was rated high (very flexible). Region-Specific and Transportation Costs were rated medium (somewhat flexible) and Transportation Costs were rated low (inflexible) due to higher costs of moving fossil fuels.
- Industrial Processes–Capital invesment was rated high (very flexible) due to the presumed ability of plants to move outside the region or to start up outside the region rather. Region-Specific was rated medium (somewhat flexible) because it is assumed that a moderate amount of inputs and outputs, across the sector are local to the region. Cost of Abatement was rated high (very flexible) due to the extensive abatment measures needed to reduce emissions for heavy industry.
- Waste Management–Capital Investment was rated as medium (somewhat flexible) due to similarities with but not quite as extensive as the Industrial Processess sector. Region-Specific was rated low (inflexible) due to the necessity of locating this sector's activities within the region in order to receive regional waste. While it is more economical to move waste within the region, it would be somewhat reasonable to move waste across regions; thus, this factor was rated medium (somewhat flexible). Cost of abatement was rated as high (very flexible) due to similiarities with heavy industry on costs of abatement.
- Agriculture–Capital Investment was rated low (inflexible) due to the assumed higher costs of land outside the region and the start-up costs in a new area. Due to land constraints, the Region-Specific factor was also rated low (inflexible). Tranportation Costs were rated medium (somewhat flexible) because agriculture products could resonable be transported to the region from outside. Costs of abatement were assumed to be less than heavy industry and similar to the Residential/Commercial/Industrial so rated medium (somewhat flexible).

The scores in Exhibit 10 were summed to produce a total score for each sector to represent the likelihood of relocation and therefore the overall mobility of the sector. Using this determination of mobility, a percentage of estimated GHG leakage was derived. Based on estimates of leakage rates found in literature (Ritz, 2009: 5-40% and Burniaux, 2000: 2-5%), a rate of leakage estimte was assigned to the sector with the lowest mobility. The percentage of leakage for the other sectors was detemined through interpolation.

Exhibit 10. Estimated Percentage of Carbon Leakage

	Relative flexibility to move outside the region: 1=inflexible, 2=somewhat flexible, 3=very flexible.								
Sector	**Capital Invest-ment***	**Region-Specific***	**Trans-port Costs***	**Cost of Abate-ment***	**Total Score***	**Likelihood of Mobility in Response to GHG Cap***	**Estimated % of Carbon Leakage (low, medium, high)***		
Electricity	1	2	2	3	8	Somewhat likely	3	7	12
Residential/ Commercial/ Industrial	2	2	2	2	8	Somewhat likely	3	7	12
Transportation	3	3	3	2	11	Very Likely	5	10	15
Fossil Fuels	1	2	2	3	8	Somewhat Likely	3	7	12
Industrial Process	3	2	3	3	11	Very Likely	5	10	15
Waste Management	2	1	2	3	8	Somewhat Likely	3	7	12
Agricultural	1	1	2	2	6	Unlikely	1	6	10

Source: Sectors according to Washington State Department of Ecology, 2011.
*These data are calculations/estimations based on assumptions presented in this analysis.
These codes did not correspond exactly to the seven sectors, so select NAICS data were chosen to produce the estimated potential loss of tax revenue and earnings.

Determining the Economic Impacts of Carbon Leakage

The next step in the analysis was to estimate the economic impacts of carbon leakage. If firms decide to leave the state because of stricter environmental regulations, the effects on tax revenue and wages could be significant. To calculate of impact, the potential lost taxes and wageswere estimated by multiplying the taxes and wages for the seven sectors used in the Ecology GHG emissions (Electricity, Residential/Commercial/Industrial, Transportation, Fossil Fuel, Industrial Processes, Waste Management, and Agriculture) by the percentage of possible leakage. Washington tax revenue data came from the Department of Revenue, and the employment and earnings data came from the state Employment Security Department. Both tax revenue and wage data were identified by selecting codes of the North American Industry Classification System (NAICS) that were applicable to the seven sectors listed above.

Chapter 6. Results and Discussion

Carbon Leakage

As discussed above, a major concern of policymakers involved with cap-and-trade is that emissions reductions achieved by the firms covered in their scheme will be counteracted by emissions increases by firms located elsewhere. Leakage issues are potentially relevant to a wide range of emissions-intensive industries in which firms compete internationally and where only a subset of firms experienced tightened environmental regulation. The absence of a level playing field amongst firms can substantially undermine the effectiveness of incomplete regulation. Indeed, global emissions could even rise as a result of the policy if the emissions increases by unregulated firms are sufficiently pronounced (Ritz, 2009).

The estimated carbon leakage, by sector, is presented in Exhibit 11. Using Department of Ecology GHG emissions data, an educated estimate of an industry's likelihood to relocate was based on the mobility factors in Exhibit 11. This analysis estimates that the annual estimated range of carbon leakage from all sectors could be roughly 5.5 million (low case) to 44.7 million (high case) metric tons (MMT) annually.

Exhibit 11. Estimated Carbon Leakage for the State of Washington

(Million Metric Tons [MMT] CO2)	2010 MMT CO2	% of Total	Estimated % - Low*	Potential Leakage (MMT) - Low*	Estimated % - Medium*	Potential Leakage (MMT) - Medium	Estimated % - High*	Potential Leakage (MMT) – High
Electricity, Net Consumption-based	**20.2**	**19.6**	**4.7**	**0.9**	**18.7**	**3.8**	**37.3**	**7.5**
Coal	15.9							
Natural Gas	4.2							
Petroleum	0.1							
Biomass	0							
Residential/ Commercial/ Industrial	**21.3**	**20.7**	**4.7**	**1.0**	**18.7**	**4.0**	**37.3**	**7.9**
Coal	0.3							
Natural Gas	11							
Oil	9.7							
Wood (CH4 and N2O)	0.4							
Transportation	**48.5**	**47.1**	**6.4**	**3.1**	**25.7**	**12.5**	**51.3**	**24.9**
Onroad Gasoline	26.2							
Onroad Diesel	8.8							
Marine Vessels	3.3							
Jet Fuel and Aviation Gasoline	8.1							
Rail	0.8							
Natural Gas , LPG, Other	1.3							
Fossil Fuel Industry	**1**	**1.0**	**4.7**	**0.0**	**18.7**	**0.2**	**37.3**	**0.4**
Natural Gas Industry (CH4)	0.9							
Coal Mining (CH4)	0.1							
Industrial Processes	**4.2**	**4.1**	**6.4**	**0.3**	**25.7**	**1.1**	**51.3**	**2.2**
Cement Manufacturing (CO2)	0.5							
Aluminum Production (CO2, PFC)	0.4							
Limestone and Dolomite Use (CO2)	0							
Soda Ash (CO2)	0.1							

ODS Substitutes (HFC, PFC, and SF6)	3							
Semiconductor Manufacturing	0							
Electric Power T & D (SF6)	0.2							
Waste Management	**2.8**	**0.0**	**4.7**	**0.1**	**18.7**	**0.5**	**37.3**	**1.0**
Solid Waste Management	2							
Wastewater Management	0.8							
Agriculture	5.1							
Enteric Fermentation	1.5							
Manure Management	1							
Agricultural Soils	**2.6**	**2.5**	**3.5**		**14.0**	**0.5**	**28.0**	**0.7**
Total Gross Emissions (MMT)	**103**			**5.5**		**22.5**		**44.7**

Source: Washington State Department of Ecology, 2007

*These data are calculations/estimations based on assumptions presented in this analysis.

The range of estimated leakage calculated in Exhibit 11 was then applied to published Washington State emissions data. That percentage of potential leakage was then applied to 2009 Washington State annual earnings for the industries below and revenue from the sales and business and occupation (B&O) taxes. That calculation reveals the annual revenue (wages and taxes) that could be lost--from $117 million in the low case to $936 million in the high case-- if the seven industries analyzed moved out of Washington State to avoid a CAT system (see Exhibits 12-14). That loss of revenue may make it difficult for many Washingtonians to justify local spending in an attempt to solve a global problem using local funding.

Exhibit 12. Estimated Economic Impact to the State with Carbon Leakage – Low Case

Sector	Estimated % of Carbon Leakage*	Annual Sales and B&O Tax	Potential Sales and B&O Tax Loss*	Annual Earnings	Potential Earnings Loss*	Total Potential Revenue Loss/Year*
Electricity	4.7	$178,741	$8,341	$7,328,125	$341,979	$350,320
Residential/ Commercial/ Industrial	4.7	$878,711	$41,007	$394,741,197	$18,421,256	$18,462,262
Transportation	6.4	$151,500,749	$9,721,298	$516,964,647	$33,171,898	$42,893,196
Fossil Fuel	4.7	N/A	N/A	N/A	N/A	
Industrial Process	6.4	$3,629,349	$232,883	$112,120,233	$7,194,382	$7,427,265
Waste Management	4.7	$364,537	$17,012	$23,975,467	$1,118,855	$1,135,867
Agricultural	3.5	$3,922,448	$137,286	$1,330,202,329	$46,557,082	$46,694,367
TOTAL		**$160,474,535**	**$10,157,826**	**$2,385,331,998**	**$106,805,451**	**$116,963,278**

Source: Washington State Department of Ecology, 2011, U.S. Census Bureau, 2007,
Washington State Employment Security Department, 2009
Note: Not all industries had published earnings or B&O tax data. The estimated percentage of leakage in the literature range from 5-40%, however, some of the percentages presented here are less than or greater than that due to calculating the relative percentages using the total flexibility scores from Exhibit 11.
*These data are calculations/estimations based on assumptions presented in this analysis.

Exhibit 13. Estimated Economic Impact to the State with Carbon Leakage – Medium Case

Sector	Estimated % of Carbon Leakage*	Annual Sales and B&O Tax	Potential Sales and B&O Tax Loss*	Annual Earnings	Potential Earnings Loss*	Total Potential Revenue Loss/Year*
Electricity	18.7	$178,741	$33,365	$7,328,125	$1,367,917	$1,401,282
Residential/ Commercial/ Industrial	18.7	$878,711	$164,026	$394,741,197	$73,685,023	$73,849,049
Transportation	25.7	$151,500,749	$38,885,192	$516,964,647	$132,687,593	$171,572,785
Fossil Fuel	18.7	N/A		N/A	N/A	
Industrial Process	25.7	$3,629,349	$931,533	$112,120,233	$28,777,526	$29,709,059
Waste Management	18.7	$364,537	$68,047	$23,975,467	$4,475,421	$4,543,467
Agricultural	14.0	$3,922,448	$549,143	$1,330,202,329	$186,228,326	$186,777,469
TOTAL		**$160,474,535**	**$40,631,306**	**$2,385,331,998**	**$427,221,806**	**$467,853,112**

Source: Washington State Department of Ecology, 2011, U.S. Census Bureau, 2007, Washington State Employment Security Department, 2009
Note: Not all industries had published earnings or B&O tax data. The estimated percentage of leakage in the literature range from 5-40%, however, some of the percentages presented here are less than or greater than that due to calculating the relative percentages using the total flexibility scores from Exhibit 11.
*These data are calculations/estimations based on assumptions presented in this analysis.

Exhibit 14. Estimated Economic Impact to the State with Carbon Leakage – High Case

Sector	Estimated % of Carbon Leakage*	Annual Sales and B&O Tax	Potential Sales and B&O Tax Loss*	Annual Earnings	Potential Earnings Loss*	Total Potential Revenue Loss/Year*
Electricity	37.3	$178,741	$66,730	$7,328,125	$2,735,833	$2,802,563
Residential/ Commercial/ Industrial	37.3	$878,711	$328,052	$394,741,197	$147,370,047	$147,698,099
Transportation	51.3	$151,500,749	$77,770,384	$516,964,647	$265,375,185	$343,145,570
Fossil Fuel	37.3	N/A	N/A	N/A	N/A	
Industrial Process	51.3	$3,629,349	$1,863,066	$112,120,233	$57,555,053	$59,418,119
Waste Management	37.3	$364,537	$136,094	$23,975,467	$8,950,841	$9,086,935
Agricultural	28.0	$3,922,448	$1,098,285	$1,330,202,329	$372,456,652	$373,554,938
TOTAL		**$160,474,535**	**$81,262,612**	**$2,385,331,998**	**$854,443,612**	**$935,706,223**

Source: Washington State Department of Ecology, 2011, U.S. Census Bureau, 2007, Washington State Employment Security Department, 2009
Note: Not all industries had published earnings or B&O tax data. The estimated percentage of leakage in the literature range from 5-40%, however, some of the percentages presented here are less than or greater than that due to calculating the relative percentages using the total flexibility scores from Exhibit 11.
*These data are calculations/estimations based on assumptions presented in this analysis.

Chapter 7. Conclusions and Recommendations

Current climate change impacts include rising temperatures and changing precipitation patterns that are causing higher sea levels, longer droughts, increased flooding, more wildfires, and less water availability. Future impacts expected from unabated climate change include more extreme sea-level increases, longer heat waves, unhealthy air quality, more unpredictable water availability, and reduced biodiversity as invasions of non-native species increase and local habitat moves northward and to higher elevations. These impacts will affect a wide range of people, ecosystems, and economic sectors, including electricity generation, health care, agriculture, and tourism.

We are now witnessing a major push toward market-based mechanisms for addressing environmental issues including greenhouse gasses (GHGs), with several emerging regional initiatives. In the United States and in Washington, legislation for a cap-and-trade (CAT) scheme for GHG emissions has been proposed.

In a CAT system, the "cap" is the quantitative limit of emissions imposed by a regulator or agency. That cap is broken into allowances, and those allowances are distributed to each entity that has a legal obligation to comply with the cap. Each allowance corresponds to one unit of emissions, and the objective is to set the cap to produce is a shortage of allowances for what the companies' business-as-usual emissions will be. According to economic theory, the scarcity of allowances will set the price of emissions in the marketplace and allow a market to emerge. Though advocates argue that benefits are obtained even without trading, the primary benefit from carbon trading comes in the "trade" part: at the end of the predetermined emission period, each participating (polluting) entity must hold the number of allowances that matches its actual emissions for that set period.

A major concern of policymakers involved with each of these initiatives is an unintended consequence called carbon leakage: emissions reductions achieved by the firms covered in their scheme will be counteracted by emissions increases by firms located elsewhere. Carbon leakage occurs when there is an increase in carbon dioxide emissions in one country (or region) as a result of an emissions reduction by a second country (or region) mandated by a strict climate policy. This leakage is likely to occur if the mandated emissions policy raises local costs significantly.

Leakage issues are potentially relevant to a wide range of emissions-intensive industries in which firms compete and where only a subset of firms experience tightened environmental regulation. Leakage is most likely to occur for industries that are mobile and have high GHG-abatement costs. Any nationally oriented approach to GHG reductions must consider regional and industry sector differences because financial considerations are some of the primary reasons for companies to relocate.

This capstone research focused on implementation of a regional program to reduce GHGs considering that GHG emissions/climate change is a global issue. It examined the challenges of regional regulation of a global problem with a focus on the possibility that significant levels of GHGs may simply be moved outside the regulated region due to carbon leakage. This paper estimates that the percentage of estimated leakage from all sectors in the State of Washington could be roughly 6-45 million metric tons annually.

The analysis was accomplished by first looking at the current levels of GHG emissions. An estimate of firms that may move outside the region was then derived from the likelihood of mobility—a likelihood based on educated estimates derived from research found in the literature. From that likelihood, an estimated amount of GHG emissions not abated but just relocated (i.e., carbon leakage) was calculated.

Information on carbon leakage exists in the literature, but it generally addresses carbon leakage on a more global scale. Ideally, information would exist for Washington State on the factors that drive firm mobility and the extent of carbon leakage caused by GHG emission regulations. However, such specific information or analysis on firm mobility is not available for Washington. [Therefore, for the sake of this analysis, some assumptions based on the literature have been made to determine the potential carbon leakage because of firm mobility. These estimates of firm mobility are used to assess the impact of GHG regulations because of carbon leakage on Washington employment income and state tax revenues--from 2009 employment income and tax revenue data provided by the Washington State Employment Security Department.

The percentage of potential leakage was also applied to Washington State annual earnings and revenue from the sales and business-and-occupation (B&O) taxes for industries that emit GHGs. That calculation reveals the range of annual revenue (lost wages and lost taxes) that could be lost if the seven industries analyzed moved out of Washington State to avoid a CAT system: about $117 million (low case)/year to $936 million (high case)/year. There is also the "multiplier effect" to consider, which means that the relocation of firms could not only result in lost wage revenue and sales and B&O tax revenue, it could also result in a greater loss of revenue. That is, employees from the relocated firm would spend less on local goods and services. That possible loss of revenue may make it difficult for many Washingtonians to justify local spending in an attempt to solve a global problem.

This analysis provides a range of possible lost revenue to the state, which means that the high end (and low end) estimates are not highly probable, but could happen. And while the high loss estimate would not necessarily be catastrophic, it would certainly be consequential. And with the State of Washington facing a $5 billion budget shortfall—which would make a loss of $1 billion extremely difficult to absorb—this effect again illustrates the need to take a close look at the "social cost of carbon" versus the "social benefit of reducing GHGs" to determine what level of GHG abatement is the right level for society. Unfortunately, absent a national agreement, a state or region's best strategy may be to do little and "free ride" on the actions of other states or regions. Of course, if all entities behave that way, very little mitigation will be achieved and failure to take action or failure to get involved could lead to substantial global warming and higher costs in the long run.

This exploratory analysis has attempted to present an estimated range of carbon leakage and lost earnings and tax revenue using estimates and data found elsewhere. A lot is not known about firm mobility so further research is needed to more accurately identify what percentage of firms—and therefore—revenue might leave in the state, the region, or even the nation. The actual loss of revenue and earnings could be much lower or higher in reality and the actual number of industries (using codes of the North American Industry Classification System) that may be affected by stricter environmental regulations/CAT could be much fewer and greater. That would mean that the lost revenue to the State of Washington could be much lower or higher. As firms move outside the region, many employees could also relocate.

The analysis in this paper shows that despite using a CAT approach on a large-scale regional basis as a means to reduce GHG emissions, a significant quantity of these emissions may simply be relocated because of carbon leakage. This analysis also highlights the fact that while we may choose to dedicate state resources to reduce GHG emissions regionally, the emissions may not even be reduced on a global level if firms simply move. Moreover, if the costs (i.e., cost of technology required plus the lost wages/tax revenue) outweigh the benefits of abatement, it will be difficult for policymakers to justify a CAT system. Therefore, while regional changes can be effective in reducing local or regional GHG emissions, it will be a challenge to address a global issue through regional action alone. In summary, while this exploratory study has not outlined all of the possible causes and effects of carbon leakage caused by carbon leakage, it clearly illustrates the need for further research and analysis. Ultimately, the challenge for those designing policy is how to encourage the transition toward a low-carbon economy while considering the benefits and the costs while limiting carbon leakage.

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