Southwest Region University Transportation Center

Impacts of Pending Federal Greenhouse Gas Legislation on the Texas Transportation Sector

SWUTC/10/161021-1

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Technical Report Documentation Page

1. Report N SWUTC/10/161021-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle IMPACTS OF PENDING FEDERAL GREENHOUSE GAS LEGISLATION ON THE TEXAS TRANSPORTATION SECTOR		5. Report Date May 2010 6. Performing Organization Code
6. Author(s) Leigh B. Boske and James T. Woodward		8. Performing Organization Report No. 161021-1
9. Performing Organization Name and Address Center for Transportation Research University of Texas at Austin 1616 Guadalupe, Suite 4.202 Austin, Texas 78701		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 10727
12. Sponsoring Agency Name and Address Southwest Region University Transportation Center Texas Transportation Institute Texas A&M University System College Station, Texas 77843-3135		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes Supported by general revenues from the State of Texas		

16. Abstract

This 2010 study, funded by the Southwest Region University Transportation Center, assesses current regulatory attempts to mitigate climate change and how such proposed action would impact the Texas transportation sector economically. Social and political trends suggest the United States may soon join other United Nations Framework Convention on Climate Change (UNFCCC) countries in drafting substantive, national climate change policy. After providing a brief overview of past and present climate efforts taken both nationally and internationally, this paper explores different economic solutions to address the externalities of fossil fuel emissions. Alternatives include command-and-control regulation, a carbon tax, and a cap-and-trade program. Several factors, including the difficulty of quantifying and constraining greenhouse gas emissions downstream at the vehicle tailpipe, suggest a carbon tax levied upon upstream refiners is the most promising market-based alternative to reduce carbon emissions within the United States's transportation sector. Texas business leaders and lawmakers have repeatedly voiced their disapproval of mandatory national carbon controls over the past decade. A crucial factor why much of the Lone Star State's populace remains opposed to climate change action is Texas leads the nation's energy industry, which is decidedly fossil-fuel based and therefore carbon intensive. Prevailing thought is a carbon tax would only elevate fuel prices increasing the cost of residential and commercial activity heavily dependent on motor vehicles. This paper articulates how greenhouse gas legislation may financially impact transportation within the Lone Star State and concludes with ways energy and environmental policymakers can build consensus within Texas to address the carbon externality.

17. Key Words Climate Change, Greenhouse Gas, Carbon Tax, Transportation, Railroad, Truck, Texas	18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161		
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 55	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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SWUTC/10/161021-1

May 2010

Sponsored by:

Southwest Region University Transportation Center
Texas Transportation Institute
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ACKNOWLEDGEMENTS

The authors recognize that support for this research was provided by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Southwest Region University Transportation Center, which is funded, in part, with general revenue funds from the State of Texas. The authors wish to thank Dennis Kearns and Stevan Bobb of the Burlington Northern Santa Fe Railway for sharing information critical to this climate change-transportation assessment.

ABSTRACT

This 2010 study, funded by the Southwest Region University Transportation Center, assesses current regulatory attempts to mitigate climate change and how such proposed action would impact the Texas transportation sector economically. Social and political trends suggest the United States may soon join other United Nations Framework Convention on Climate Change (UNFCCC) countries in drafting substantive, national climate change policy. After providing a brief overview of past and present climate efforts taken both nationally and internationally, this paper explores different economic solutions to address the externalities of fossil fuel emissions. Alternatives include command-and-control regulation, a carbon tax, and a cap-and-trade program. Several factors, including the difficulty of quantifying and constraining greenhouse gas emissions downstream at the vehicle tailpipe, suggest a carbon tax levied upon upstream refiners is the most promising market-based alternative to reduce carbon emissions within the U.S. transportation sector. Texas business leaders and lawmakers have repeatedly voiced their disapproval of mandatory national carbon controls over the past decade. A crucial factor why much of the Lone Star State's populace remains opposed to climate change action is that Texas leads the nation's energy industry, which is decidedly fossil-fuel based and therefore carbon intensive. Prevailing thought is a carbon tax would only elevate fuel prices increasing the cost of residential and commercial activity heavily dependent on motor vehicles. This paper articulates how greenhouse gas legislation may financially impact transportation within the Lone Star State and concludes with ways energy and environmental policymakers can build consensus within Texas to address the carbon externality.

EXECUTIVE SUMMARY

On June 26, 2009, the U. S. House of Representatives for the first time approved comprehensive federal climate legislation that included binding greenhouse gas (GHG) emissions reductions. Passage of the American Clean Energy and Security (ACES) Act, sponsored by Representatives Henry Waxman of Connecticut and Edward Markey of Massachusetts, was the latest achievement of a multi-year legislative effort to produce substantive climate policy. Through this act, Congress has signaled its intent to move forward to curb national GHG emissions. Of all greenhouse gases considered, carbon dioxide (CO2), sometimes colloquially labeled "carbon," is the most prevalent and most significant in terms of the global warming debate. The consequences of such proposed legislation are far reaching, and evaluation of the associated economic impacts is critical prior to implementation.

Constraining greenhouse gas emissions within the United States will have prolonged effects on numerous sectors of the economy, most notably electricity generation and transportation. Climate legislation considered to date is decidedly long-term in scope, with the American Clean Energy and Security Act and related bills generally mandating emission reductions that extend to the middle of the twenty-first century. Stationary, high-volume sources of CO2 and other greenhouse gases associated with fossil-fuel burning power plants largely characterize the electricity sector, which presently accounts for approximately 40 percent of U.S. carbon emissions.[1] Present technology suggests that constraining these carbon emission point sources is more feasible than mitigating vehicle and other mobile point sources of CO2 common in the transportation arena. Therefore, most legislation targets the electricity industry to achieve 75 percent of emission reductions during the first half of the compliance period before 2030.[2] The distributed nature of emissions within the transportation sector presents issues to harnessing economies of scale to deal with the carbon pollution problem from mobile point sources. However, collectively the transportation sector does account for approximately one-third of all GHG emissions within the U.S.[3] Any comprehensive climate change legislation will need to target cuts in transportation as well as the electricity sector. Some supporters of significant carbon mitigation efforts within the transportation arena claim simpler policy instruments can realize significant reductions in CO2 from mobile point sources than from high volume fixed sources that largely define the electricity industry. Specifically, a carbon tax may be better suited for the transportation sector than cap-and-trade frameworks generally discussed for electricity generation.

After providing a brief overview of past and present climate action taken both nationally and internationally, this paper explores different economic solutions to address the externalities of fossil-fuel emissions including command-and-control regulation, a carbon tax, and a cap-and-trade program. Several factors, including political sentiment, suggest that a cap-and-trade framework is the most promising alternative for the electricity sector. However, differing points of compliance may limit cap and trade's applicability to transportation. Therefore, a carbon tax will be explored more in depth.

Following discussion of carbon reduction policy instrument suitability, the anticipated financial effects such a greenhouse gas tax framework will have on Texas transportation will be explored. The second-most populous state in the nation, Texas leads the nation in total petroleum consumption. In 2007, Texans used 5,887 trillion British thermal units (Btu's) of gas, nearly 50 percent more than the second-highest state, California.[4] The Lone Star State has a vast array of multimodal networks. This paper will focus on vehicular and railroad traffic from both a residential and commercial perspective. In addition to the financial costs such carbon reductions could impose on Texas transportation, the paper will identify potential opportunities for Lone Star economic investment should the climate change regulatory landscape become more certain. Attention given to the associated costs and benefits underscores CO_2 restrictions will have disparate impacts on Texas stakeholders.

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Chapter One: Climate Change Policy Early Action

INTERNATIONAL EFFORTS

The current global trend to constrain greenhouse gas emissions has its origins within the United Nations Framework Convention on Climate Change (UNFCCC), an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil in June 1992. Leading up to the Conference, policymakers were confronted with empirical evidence suggesting anthropogenic activity was responsible for a steady increase in the worldwide levels of atmospheric carbon dioxide throughout the twentieth century. They learned that CO2's ability to trap heat imparts a warming, greenhouse effect on the atmosphere. Climate forecast models indicated that if the rise in carbon dioxide continues unabated, world temperatures could increase between three and seven degrees Fahrenheit by the close of the twenty-first century.[5] Such a temperature rise could have adverse effects on precipitation patterns and induce sea-level rise due to the melting of polar ice caps. Although global warming critics called such projections alarmist, the UNFCCC initiated adoption of international regulations seeking to stabilize "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[6]

The resulting Kyoto Protocol of 1997 represented the first global accord designed to reduce the annual amount of greenhouse gases emitted to the atmosphere. Through the Kyoto Agreement, the UNFCCC designated countries of the world as either Annex I or non-Annex I nations. Annex I nations generally comprise developed counties in Europe, North America, Japan and Australia belonging to the Organization for Economic Cooperation and Development (OECD), whereas industrializing countries in Latin America, Africa, and Asia constitute the bulk of non-Annex I countries.

From its inception, the Kyoto Protocol incited controversy given the starkly different requirements the Accord imposed on Annex I versus non-Annex I states. On average, Annex I nations were required to reduce their emissions five percent below their respective 1990 levels during the first commitment period (2008-2012) or face stiff emissions penalties.[7] In contrast, non-Annex I countries only had to report their respective emissions.[8] During the ratification process of the late 1990s, the United States repeatedly cited flaws in the Protocol including the lack of emissions limits placed on such major GHG emitters as China and India.[9] Kyoto critics argued not only would the Accord negatively impact the economies of Annex I nations, but its failure to curtail third world emissions would render the treaty environmentally useless.[10] As a result, when the agreement came into force in February 2005, thirty-six Annex I countries had signed and ratified the document, whereas Australia and the United States had signed but not ratified the Protocol. Australia later ratified Kyoto after its Labor Party won control of the country's parliament in 2007.[11]

Not deterred by U.S. reluctance to support mandated GHG reductions, the European Union (EU) inaugurated its emissions trading scheme (ETS) to implement its Kyoto commitments in early 2005. This cap-and-trade mechanism unitizes volumes of anthropogenic carbon dioxide known as equivalent metric tons of CO2 (tCO2e). Covered firms are required to account for the amount of greenhouse gases emitted in a given year by furnishing an equivalent number of tCO2e or carbon credits.[12] Unfortunately, during the first year of trading, the EU allocated too many emissions credits, effectively crashing the tradable price of carbon.[13]

Lessons learned from the European ETS endeavor will be helpful to the United States should it develop its own greenhouse gas reduction framework.

The limited progress achieved by Europe's efforts under the Kyoto Protocol may be fleeting. As of February 2010, significant uncertainty remains regarding the structure of any new international agreement to constrain greenhouse gas emissions. The Kyoto Protocol is set to expire in 2012, and world leaders convened in Copenhagen, Denmark, in December 2009 to negotiate a successor mechanism. Although the two weeks of deliberations garnered much media fanfare, the anticipated binding successor treaty to Kyoto did not materialize. Industrialized and industrializing countries did reach some accord on OECD nations financially assisting the developing world with climate change adaptation. Additionally, parties to the conference reaffirmed their agreement that all feasible efforts should be made to avoid anthropogenic activity from causing global temperatures to rise more than two degrees Celsius, which is the maximum allowable thermal increase before irreversible effects of climate change ensue according to the UNFCCC. However, hopes for any compulsory extension to Kyoto will have to wait until the sixteenth session of the UNFCCC convenes in Mexico City in December 2010.[14]

Much has changed on the global stage since the Kyoto agreement was drafted twelve years ago. While still a major carbon emitter, the United States is no longer the world's largest GHG producer. China assumed that dubious distinction in 2008, reigniting claims that any viable international effort to stem global warming will require mandatory GHG reductions by industrializing nations.[15] To complicate matters, the Copenhagen Conference occurred as the world economy is emerging from the severe 2007-09 global recession. Projections for anemic economic growth, particularly in the developed world, in the short term may have dissuaded political stakeholders from committing to the sharp carbon cuts advocated by the UNFCCC.[16]

UNITED STATES REGIONAL CLIMATE FOCUS

The U.S. stalemate over the Kyoto Protocol has essentially blocked passage of comprehensive, nationwide climate legislation during the first decade of the twenty-first century. Certain regions of the United States, however, have moved forward to fill this void in the interim. Action in California and the Middle Atlantic and New England states deserves particular mention.

To date, California leads the nation in legislative action to curtail climate change. California is also the only state with a climate change action plan that specifically targets the transportation sector. In September 2006, California Governor Arnold Schwarzenegger signed into law the California Global Warming Solutions Act of 2006, otherwise known as AB32. The Global Warming Solutions Act mandated a series of requirements that would help bring the State of California into near compliance with the Kyoto Protocol by 2020. By December 11, 2008, the state had approved a 2020 greenhouse gas cap that would return state emissions to 1990 levels.[17] The cap covers significant sources of carbon emissions focusing on the electricity and transportation sectors. The California Air Resources Board (CARB), the agency founded in 1967 to regulate air quality in the state's metropolitan regions,[18] administers the carbon emissions program. Cognizant that compliance with the global warming mitigation requirements will require time and technological innovation, AB32 established a twelve-year timeline to transition the state's industries to a low-carbon economy. CARB, in turn, released mandatory emissions reporting rules in 2008 requiring covered entities, such as the elecrtic utilities Pacific Gas & Electric and Southern California Edison, to submit their annual emissions to the state agency beginning in 2009.[19]

Cognizant that passenger vehicles are responsible for nearly 30 percent of emissions within the Golden State, CARB detailed a three-prong strategy for reducing transportation GHG emissions in its Climate Change Scoping Plan released in December 2008. The state's Air Resources Board announced plans to encourage best available technology (BAT) standards beginning with 2009-model-year passenger vehicles to reduce GHG emissions. Additionally, CARB planned to reduce the carbon content of the fuel that light-duty vehicles burn while decreasing the number of miles these vehicles travel.[20]

Elaborating on BAT standards, CARB signaled its willingness to move forward including Pavley greenhouse gas vehicle standards to achieve near-term emissions reductions. Pavley regulations utilize both performance standards and market-based mechanisms, but require CARB to apply to the U.S. Environmental Protection Agency (EPA) for a waiver under the federal Clean Air Act to implement the regulation. This necessary interaction between state and federal agencies has politicized California's climate change action. In December 2007, the EPA under the Bush Administration denied CARB's waiver request to implement Pavley standards. In response, California and other states proceeded to challenge the EPA's denial in federal court. Although the election of President Obama in 2008 signaled a thawing of relations between Sacramento and Washington, D.C., the multi-year judicial wrangling brought about by California's attempt to modify passenger vehicle technology underscores a fundamental weakness in state solutions to global warming. Critics of CARB's climate change regulations claim California does not have explicit control to mandate what sorts of vehicles are sold within the state and is therefore in violation of the Interstate Commerce Clause.[21] CARB has investigated "feebate" regulation as a contingency measure if the EPA logjam prevents implementation of the Pavley standards. Feebates would include a rebate program for low emission vehicles with additional fees for high-emitting passenger cars and light-duty trucks.[22]

The second component of AB32's GHG reduction strategy within the transportation sector is adoption of a statewide low carbon fuel standard (LCFS). Mandated by Governor Schwarzenegger in separate Executive Order S-01-07, the LCFS would reduce the carbon intensity, or units of GHGs emitted per unit of fuel combusted, by at least 10 percent by 2020. CARB conservatively estimated a 10-percent reduction in transportation fuel carbon intensity would yield a reduction of 15.0 million tCO2e in 2020, exclusive of any additional cuts realized by implementation of the Pavley GHG standards.[23] To achieve net reductions in total passenger vehicle-miles-traveled (VMT) while accommodating additional population growth within the Golden State, on September 30, 2008, Governor Schwarzenegger signed Senate Bill (SB) 375, which laid out California's smart growth strategy as called for by AB32. SB 375 requires CARB to consult with the state's metropolitan planning organizations (MPOs), including San Diego, Los Angeles, and the Bay Area, to establish passenger vehicle GHG emissions reduction targets for 2020 and 2035 by September 30, 2010. CARB will have final authority in setting regional emissions reduction targets. Individual MPOs will then modify their regional transportation plans (RTPs) to foster a "sustainable communities strategy" to reach the regional GHG target provided by CARB. While still a work in progress, many California MPOs are expected to levy financial incentives to encourage mixed use development, develop or grow mass transit systems, and promote teleworking and other labor practices designed to minimize commuting. SB 375 exempts MPOs from some of the costly and time consuming environmental permitting processes required in the California Environmental Quality Act (CEQA) to assist California metropolitan areas grow in a more sustainable manner.[24]

Contemporaneously, the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) undertook an eighteen-month study for CARB investigating how best to return the state's emissions levels to 1990 amounts by 2020. In

October 2008, the joint taskforce issued its final recommendations supporting a mix of command-and-control and market mechanisms.[25] Specifically, the state's electricity sector would be included in a multi-sector GHG cap-and-trade framework starting in 2012.[26] A cap-and-trade framework, which is discussed in greater detail in Chapter Three, allocates a number of emissions credits to each covered entity. One credit allows a firm to emit one tCO2e. Entities are then able to trade GHG credits in an emissions market. Under a declining cap, utilities and other covered entities will receive fewer carbon credits each successive year. Companies are expected to account for their allowance shortfalls by either reducing their emissions through investment in clean technology or purchasing additional credits from other firms that have managed to lower GHG output below their respective caps.[27]

Beginning in 2012, 80 percent of allowances or carbon emission permits within the State of California would be allocated free of charge with the remaining 20 percent auctioned. The percentage of credits auctioned would increase by 20 percent each successive year ensuring 100 percent auctioning of all allowances by 2016.[28] California's relatively rapid transition from majority free allocation to total auctioning of credits is grounded in the CPUC's and CEC's belief an emissions allowance auction is the most economically efficient credit distribution mechanism.[29]

AB32 primarily utilizes command-and-control measures to reduce transportation GHG emissions while relying on more of a market-based approach to curtail carbon within the electricity sector. Chapter Three will examine both strategies and highlight why different methodologies will likely be needed to curtail CO2 in transportation and electricity. California is credited with being an early combatant against climate change by attempting to reduce GHG emissions at the lowest possible cost.

On the other side of the country, ten northeastern states--Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont--have elected to cap and reduce greenhouse gas emissions at least 10 percent within their respective power sectors by 2018. The pact now known as the Regional Greenhouse Gas Initiative (RGGI) took shape in 2005 when governors of seven of the ten states signed a memorandum of understanding establishing a market-based solution to mitigate global warming.[30] Under RGGI, utilities within the participating states are required to participate in a cap-and-trade program that began in September 2008.[31] RGGI guidelines dictate that utilities bid for emissions allowances in carbon auctions held quarterly throughout the year. The five auctions held to date, between September 2008 and 2009, witnessed total revenue decline from approximately $107 million in December 2008 to $68.5 million during the ninth month of 2009.[32] However, RGGI supporters emphasize the regional carbon market continuing to function in the midst of the worldwide financial crisis and bleaker prospects for a Congressional climate change bill is testament to its success. Unlike AB32, RGGI has no component that specifically targets GHG emissions within the transportation sector.

Although California's and the Northeast's early action to combat potential global warming is admirable, the state and regional nature of AB32 and RGGI, respectfully, limit the ability of both programs to achieve their intended results. The biggest hurdle to addressing climate change on a local or state level is leakage. Leakage refers to entities, which are covered under an emissions cap, outsourcing operations or production beyond the domain of the particular climate program.[33] For example, California utilities have been criticized for attempting to purchase electricity from coal-fired power plants in Arizona and Utah, beyond the confines of AB32.[34] In addition, New Jersey utilities buy carbon-intensive power from Pennsylvania,[35] which is considered a RGGI observer and not required to participate in the cap-and-trade program.[36]

The regulatory resistance California encountered when it attempted to unilaterally mandate more advanced vehicle emissions technology underscores states have enjoyed limited success trying to regulate economic activity across their borders. The Dormant Commerce Clause, deduced from the United States Constitution's Commerce Clause, categorizes such cross-border activity as inter-state commerce, which generally falls under the sole dominion of the U.S. Congress.[37]

Regarding Texas, a state solution to the greenhouse gas problem is inadequate because the current political landscape of the Lone Star State is responsible for Texas being one of only fourteen states in the country that have no intentions to develop a climate action plan as of the end of 2009.[38] Texas is the traditional home of the carbon intensive U.S. energy sector. Energy companies and their lobbyists would and have quickly preempted any attempt by the Texas Legislature to draft a bill penalizing fossil-fuel generators and distributors for their climate-altering emissions. A concerted federal approach to climate change is therefore necessary to harmonize different state policies that run the gamut from California's endeavors to Texas's no action.

Chapter Two: Evolution of Federal Climate Policy

Despite the need for coordinated federal action to effectively address carbon emissions, a reluctance to engage in any climate policy that required mandatory reductions in greenhouse gas emissions characterized the eight years of the Bush Administration. President Bush repeatedly warned a mandatory emissions cap would impart an undue burden on the national economy.[39] Instead, the executive branch advocated voluntary carbon reductions on behalf of industry and argued carbon intensity is a better metric to gauge feasible GHG reductions than direct emissions cuts. Carbon or greenhouse gas intensity divides a nation's carbon emissions by its gross domestic product (GDP). On February 14, 2002, President Bush launched his Global Climate Change policy, "committing to reduce the greenhouse gas intensity of the U.S. economy up to 18 percent by 2012."[40] Lower greenhouse gas intensity suggests the country's economic output is more carbon efficient but does not guarantee a decline in overall emissions; the carbon intensity ratio can decrease due to either a drop in emitted tCO2e or an increase in GDP.[41]

Following relative inaction on a federal greenhouse gas emissions cap, the election of Barack Obama for the Presidency of the United States in November 2008 signaled potential for a comprehensive, nationwide climate policy. Throughout his campaign, Mr. Obama indicated his support for constraining GHG emissions.[42] No longer would the executive branch primarily function as a roadblock to Congress, which had spearheaded efforts to enact substantive, national climate policy during the Bush Administration. On a national level, either the executive or legislative branches could lead political action to combat global warming. Legal scholars argue the executive branch derives its authority from a recent judicial decision. In April 2007, the U.S. Supreme Court ruled in Massachusetts v. U.S. Environmental Protection Agency that the EPA has implied authority under the Clean Air Act (CAA) to regulate greenhouse gases as air pollutants.[43] Until this historic decision, the CAA only applied to sulfur dioxide, nitrogen oxides, ozone, carbon monoxide, lead, and particulate matter.[44] Collectively, twelve states, including Massachusetts and California, wished to impose tighter emissions standards for new motor vehicles that would limit the quantity of GHGs emitted into the atmosphere.[45] Although Massachusetts was the primary plaintiff, California's attempt to implement its Pavley standards was a primary catalyst for the case. General Motors, Ford, and other vehicle manufacturers opposed these state initiatives claiming such statutes could require the companies to develop and market state-specific automobiles.[46] From a cost perspective, satisfying emissions requirements that varied state-by-state was untenable for the car companies. Federal action on the issue was necessary.[47]

Observers within the Council on Environmental Quality suggest President Obama could cite Massachusetts v. EPA as justification for directing EPA Administrator Lisa Jackson to regulate CO2 under the 1990 Amendments to the CAA.[48] In this instance, the EPA would promulgate a rulemaking setting a GHG national ambient air quality standard. However, opponents of an EPA-CAA mechanism for addressing climate change suggest a high probability exists that greenhouse gas rulemakings will become ensnared in subsequent court battles. Utilizing the Clean Air Act, the EPA would direct development of state implementation plans (SIPs) for abating CO2. Conceivably, states could then promulgate fifty different SIPs for carbon emissions, opening the door for one state taking legal action against another because of perceived disparity in SIP stringency.[49]

The litigation drawbacks associated with an EPA rulemaking that constrains carbon emissions is a primary reason why the fifteen-month-old Obama Administration has continued to let Congress take the lead on federal climate action. On June 26, 2009, the U.S. House of Representatives narrowly passed the American Clean Energy and Security Act (ACES) sponsored by Representatives Henry Waxman of California and Edward Markey of Massachusetts by a vote of 219 to 212.[50] Although both chambers of Congress have considered a growing number of global warming bills in recent years, including the Lieberman-Warner Climate Security Act in 2008,[51] the ACES Act represented the first time either the House or Senate approved comprehensive climate and energy legislation. The Act would constrain national electricity and transportation emissions to 97 percent of 2005 levels beginning in 2012. The carbon cap would steadily decline each successive year until U.S. emissions dropped 83 percent below 2005 levels in 2050.[52]

Like California's AB32 cap-and-trade framework, the ACES Act would initiate a cap-and-trade system whose credit allocation is a hybrid auction-grandfathering framework. Grandfathering is synonymous with free credit allocation among covered entities based upon prior years' emissions rates or some other system of initial allowance dispersion. However, unlike California's aggressive transition to 100-percent credit auctioning during the first four years of its program, ACES features a more disproportionate, initial auction-grandfathering ratio of 15 to 85 percent. The duration of time free allocation will continue varies by sector. Petroleum refineries would receive only 2.0 percent of available credits in a given year with giveaways not phased out until the 2026 to 2030 time period. [53] Critics of the ACES Act maintain such a credit allocation leaves the domestic refinery industry vulnerable to international competitors not operating under analogous emissions constraints. For comparison purposes, the ACES Act distributes approximately 30 percent of yearly available allowances to the electricity sector.[54] Prior to the House approving ACES, petroleum interests actively lobbied an increase of the annual allotted allowances earmarked for transportation fuel.

Following passage in the House, the U.S. Senate's Environment and Public Works Committee took up deliberation of the Waxman-Markey bill in July 2009. Subsequent revisions have yielded the Clean Energy Jobs and American Power Act,[55] the Senate's equivalent to Waxman-Markey, sponsored by Senators Barbara Boxer of California and John Kerry of Massachusetts. The political dynamic of the 111th Congress suggests it may be more difficult to draft and pass climate policy that dictates mandatory GHG emissions cuts in the more conservative Senate. As recently as November 5th, Senator Max Baucus of Montana, an influential moderate Democrat, signaled opposition to near-term GHG cuts imposed by the current Kerry-Boxer climate bill. Baucus believes the amendment's 20-percent reduction in carbon dioxide emissions by 2020 would impose undue negative economic impacts and plans to instead seek a 17- percent carbon cut in future legislation.[56] In addition to the economic concerns expressed by Max Baucus, other moderate Democrats and Republicans in the Senate, any legislative initiative to address global warming faces a second hurdle. Observers believe that climate policy may prove to be a victim of Congress's ambitious 2009-2010 agenda. As of late-April 2010, tension between Democrats and Republicans, and even within the Democratic party itself, remains high in Congress due to the excessive political wrangling associated with the approval of landmark healthcare legislation. Chances appear slim the Senate will approve any version of Kerry-Boxer in the near term.[57] From the perspective of advocates for a comprehensive climate policy, postponing climate deliberations past spring 2010 appears risky due to yet another increase in partisanship that will likely develop leading up to next year's mid-term elections.

Chapter Three: Greenhouse Gas Reduction Alternatives

Potential political consensus on substantive federal climate policy is largely dependent on how mandatory carbon reductions would be enacted. The federal government has three main options for mitigating global warming by reducing anthropogenic greenhouse gas emissions. Alternatives include command-and-control regulation, a carbon tax, a cap-and-trade system, or some combination thereof.

COMMAND AND CONTROL

Under a command-and-control approach, the public sector would mandate that specific industries, namely large electricity generators, oil refiners, and natural gas providers, cut GHG emissions a given percentage by a given year. The government would also stipulate what technologies or methodologies covered firms would follow to achieve these reductions. Indeed, there is precedent for this approach: Command-and-control procedural rules for the private sector characterized the federal government's handling of environmental issues back in the 1970s and 1980s. Under the 1977 Clean Air Act, the U.S. Environmental Protection Agency approved a specific control technology, a smoke stack scrubber, to reduce the levels of sulfur dioxide (SO2) emitted by manufacturers.[58] SO2 emissions had been identified as a leading cause of acid rain, which was poisoning ecosystems and deteriorating building facades throughout the central and eastern U.S. A command-and-control approach works when the technology required to correct a problem is mature and relatively inexpensive, and the SO2 scrubber mandate proved generally effective during its first decade of existence because initial sulfur dioxide reductions ascribed to the largest industrial polluters proved economical given the size of emission cuts realized. However, by the end of the 1980s, the high cost of scrubbers proved impractical for smaller factory and manufacturing outlets that had to comply with federal regulations in order to lower national SO2 emissions below 13.6 million tonnes (15.1 million English tons) annually. The CAA regulation prevented these smaller entities from utilizing lower cost alternatives to smoke stack scrubbers to reduce SO2 emissions. Critics of the 1977 CAA used this evidence to argue command and control specifically runs counter to the philosophy that private industry can develop more efficient, less expensive technological solutions to problems through creative research and design during the 1990 CAA reauthorization debate. As will be discussed later, adoption of a cap-and-trade mechanism to further reduce SO2 levels in 1990, enabled a sulfur dioxide emissions decrease to approximately 2.7 million tonnes (3.0 million tons) annually by 2000.[59]

The technology to reduce greenhouse gas emissions, in contrast, is decidedly not mature. Unlike the heavier, bulkier sulfur dioxide molecules, no scrubber-type apparatus is commercially available to strip lighter, smaller carbon-dioxide molecules out of power plant or petroleum refinery emissions. The intense resistance California encountered from car companies when the state tried to adopt its Pavley standards, reflects few if any alternatives to capture CO2 from vehicle tailpipes exist commercially either.[60] Both a carbon tax and a cap-and-trade methodology account for this difference by allowing for greater ingenuity regarding emission reductions to develop within the private sector. The two alternatives are only viable, however, if the carbon intensity of a particular covered sector is known.[61] Carbon intensity refers to the number of units of emissions required to produce one unit of output, such as a kilowatt hour of electricity. Emissions intensity varies geographically within certain sectors. For example, gasoline sold at retail in California is significantly cleaner burning than other regions of the country due to a 1996 mandate issued by CARB to deal with the state's chronic smog problem.[62]

CARBON TAX

A carbon tax is an excise or unit tax that assesses a cost per tCO2e to control GHG output. Occasionally, the term Pigouvian tax is used as a descriptor since this unit cost is levied to compensate for the negative externalities (i.e., air pollution) associated with industrial activity.[63] If this excise tax is relatively modest, industrial producers will elect to pay the additional fee and continue business as usual. Generally, however, GHG covered entities will not internalize this cost increase but pass the cost on to the firms' customers in the form of higher prices. Consumers must then decide whether or not to purchase the item at this higher price. The change in demand for a good based upon the good's change in price refers to customer elasticity. Individuals who scale back consumption to offset a product's increased cost are said to be elastic, whereas purchasing habits largely unaffected by the varying price of a good are characteristic of inelastic customers. The more inelastic an industry's consumer base, the less a carbon price hike will negatively impact sales, and the less firms will work to lower their associated GHG output at that particular carbon tax price. Covered entities will instead funnel up to 100 percent of the added cost through to customers. Emission reductions will finally occur when the assessed price per ton of carbon dioxide rises to a threshold high enough to effectively curtail demand for the given good. At this juncture it is more economical for covered sector entities to invest in clean technology and reduce their associated carbon output.[64] Continuing the practice of simply passing through all of the carbon cost would result in those firms permanently losing market share in the given sector.

Given the challenges presented by inelasticity of demand, an emissions tax must be high enough to encourage covered sector entities to invest in clean technology or clean fuel development that will reduce long-term emissions. However, critics maintain the fee must also be low enough so as not to impose too large of a financial burden or shock to the affected industry in the short term.[65] This assertion proved to be a key criticism of Kyoto and likely will help frame the context of current climate discussions given anemic growth following the 2007-09 global economic recession.[66] However, the revenue generating nature of a carbon tax is one appealing characteristic that could lessen such negative economic impacts.[67] Fees collected by the government can be allocated to those private sectors most burdened by a transition to a clean energy economy. Utilities, mining, and petrochemical producers are some of the likely beneficiaries of this hypothetical double dividend. The degree of assistance a given industry would receive, however, constitutes an important question requiring resolution prior to potential tax implementation.

The idea of an emissions tax is not a recent development. In January 1991, the Scandinavian country of Sweden implemented a carbon tax or eco-tax on both residential and industrial use of oil, coal, natural gas, liquefied petroleum natural gas, petrol, and aviation fuel for domestic travel.[68] Initially the Swedish government assessed a $100 U.S. dollar price per ton of CO2-equivalent, later raising the tonnage price to $150 in 1997.[69] The Swedish populace, accustomed to relatively high taxation and concerned with the dire repercussions of significant Arctic warming due to climate change, generally accepted the emissions charge with little protest. Swedish industry proved to be more vocal in opposition, claiming the financial tax liability would cause Swedish goods to rise in price and be less competitive in overseas markets. As a result, for much of the 1990s, Swedish commercial entities only paid 25 to 50 percent of the tax and some industries, such as mining and paper production, were exempted completely.[70] Crediting the Swedish eco-tax with an explicit emissions reduction quantity is difficult due to contemporaneous advancements in energy efficiency, which help to make energy consumption less energy intensive. However, a 1997 Swedish Ministry of the Environment report indicated the eco-tax would have removed 20 to 25 percent more emissions by the year 2000, compared to a business-as-usual scenario.[71]

The Swedish carbon tax case study may have little application to the United States, where the most substantial hurdle to domestic eco-tax implementation is the anti-tax cultural bias.[72] Within the United States, residential customers and industry alike are generally opposed to tax increases, and politicians may be loathe to levy such a fee for fear of retribution come the next election.

CARBON CAP AND TRADE

A properly executed greenhouse gas cap-and-trade system can achieve similar results as a carbon tax without the anti-tax criticism, which alone makes this the most politically viable option for widespread U.S. implementation. Instead of using a carbon price to restrict the quantity of greenhouse gases emitted, a physical cap is imposed on the total annual CO2-equivalent output from covered sectors. Initially, this GHG limit would probably be set high and steadily lowered over time to facilitate a transition to less carbon intensive production. Like the carbon tax, affected companies would be free to follow the least expensive strategy to comply with government standards.[73]

By restricting the allowable quantity of GHG output, a cap-and-trade framework creates a shadow price for carbon emissions, which is the quantity a firm is willing to pay for a government issued credit that allows the company to emit one additional metric ton of carbon dioxide. In theory, the carbon shadow price should equal the carbon tax tonnage price. The government would distribute the total number of credits for a given year using two methods: grandfathering and auctioning. Grandfathering allocates carbon credits free of charge to point source emitters based upon historical emissions data of those companies. Covered entities submit baselines, emissions from a single or multi-year reference period, to regulators to determine the percentage of the given sector's GHG output for which each firm is responsible. The public sector agency holding the credits then distributes allowances proportionally to the said companies. Credits allocated free of charge reduce a company's financial compliance burden.[74] In contrast, the auctioning method requires covered entities to bid on carbon credits. Ideally, the minimum carbon allowance price equals the maximum cost a company would spend on efficiency retrofits, clean technology, or some other procedure to reduce its emissions by one tCO2e.[75] While auctioning does increase GHG compliance costs for covered sectors, this distribution method generates revenue analogous to a carbon tax. Auction proceeds can be returned to covered entities in such a manner as to assist sectors particularly burdened by their emissions reduction obligation. Additionally, this climate revenue can fund a number of different climate assistance programs not specific to covered industries, such as public works projects designed to protect coastal regions from rising sea levels attributed to climate change.

Initial review suggests the grandfathering method is preferable to auctioning since the former technique achieves the same reduction in GHG output with an apparently lower financial burden imposed on covered sector entities and their customers. However, closer inspection suggests this inference is only half true. An allowance has an associated opportunity cost whether or not a given company pays for that carbon credit. In a mature market, a carbon credit's opportunity cost equals the cost of technology investment to abate an additional metric ton of carbon dioxide from escaping into the atmosphere. The opportunity cost equivalence of a carbon allowance mirrors the logic used to set the carbon auction price. Therefore, a carbon credit has the same value for a firm whether the entity purchased this right to emit at auction or received the authority free of charge. From an economic perspective, companies can charge their customers for the value of CO2 allowances even if the firms did not pay a fee for the certificates.

Assuming pass-through opportunity costs are legitimate, grandfathering or auctioning all credits realizes the same cost burden for the consumer. However, opportunity cost pass through of grandfathered carbon credits constitutes a revenue stream for covered entities.

Supporters of cap-and-trade argue the tradable nature of carbon credits makes this the most economical of the three greenhouse gas reduction alternatives discussed. Whether or not the government auctions or grandfathers a given year's carbon credits, those allowances can in turn be traded among both covered and non-covered entities within the private sector. As the GHG cap declines in future years, mandating deeper emissions reductions, the added cost of preventing a larger tCO_2e quantity will cause the opportunity cost of a carbon allowance to rise.

Once distributed, the European Union emissions trading scheme, and other existing cap-and-trade programs, allow both covered and non-covered firms to trade carbon credits in secondary markets. Increasing the number of entities able to trade carbon through a secondary market will help lower the going tCO_2e allowance price.[76] For example, if five utility companies must each spend $30 to reduce their associated GHG emissions by one tCO_2e, the going carbon credit price would be approximately $30, assuming only those covered entities could trade allowances. However, if a non-covered firm only needs to spend $25 to lessen its carbon emissions by one tCO_2e, the going credit price would decline to approximately $25 if the non-covered entity were allowed into the carbon market. For example, certain big-box retailers have recently begun installing solar panels atop their roofs to harvest solar energy. Clean electricity generated from solar power can diminish electricity consumption from other fossil fuel sources, including coal power plants. If cap-and-trade regulations allow, the carbon equivalent of the offset electricity originating from coal combustion can be unitized into carbon credits. Utilities, petroleum refiners, or other covered entities can purchase from the retailer the rights to these prevented emissions.

Complementing their purported cost savings, cap-and-trade programs have also proven effective in the United States when applied to other environmental problems. Figure 1 illustrates that, during the last fifteen years, the EPA has successfully employed a cap-and-trade approach to reduce atmospheric sulfur dioxide levels in the central and eastern United States to a level tolerated by most ecosystems. As was previously discussed, SO_2 is the critical reagent in acid rain, which the EPA had been unable to adequately ameliorate using a command-and-control approach through the late 1980s. Title IV of the 1990 Amendments to the Clean Air Act created the Acid Rain Trading Program to lower annual SO_2 emissions below 9.1 million tonnes (10.0 million English tons).[77] The following emissions quantities are reported using the convention: metric tons (English tons). During Phase I, between 1995 and 1999, an initial national target of 10.9 million tonnes SO_2 (12.0 million) was set by capping the emissions of the 263 electricity generation units releasing the largest per capita volume of sulfur dioxide to 2.5 pounds SO_2 per million British thermal units (Btu's) of heat input.[78] Coal-fired power plants comprised the majority of these covered entities. Phase II of the program, which commenced in 2000, expanded the list of covered entities to include essentially all fossil-fuel electricity generation facilities. The goal of Phase II was to reduce collective SO_2 emissions to 8.2 million tonnes SO_2 (9.0 million), roughly half the annual U.S. SO_2 volume during the early 1980s. By 2000, the 2.7-million-ton annual emissions were approximately 67 percent below the 8.2-million-ton target level.[79] The EPA, as program administrator, distributed tradable allowances that gave covered entities the right to emit one English ton of sulfur dioxide. Some 97.2 percent of allowances were grandfathered according to each electricity generation facility's average annual heat input during the 1985-87 baseline period. The remaining 2.8 percent of SO_2 credits were auctioned with revenues returned to owners of existing units on a pro rata basis. The auction component provided available allowances to new generating units.[80]

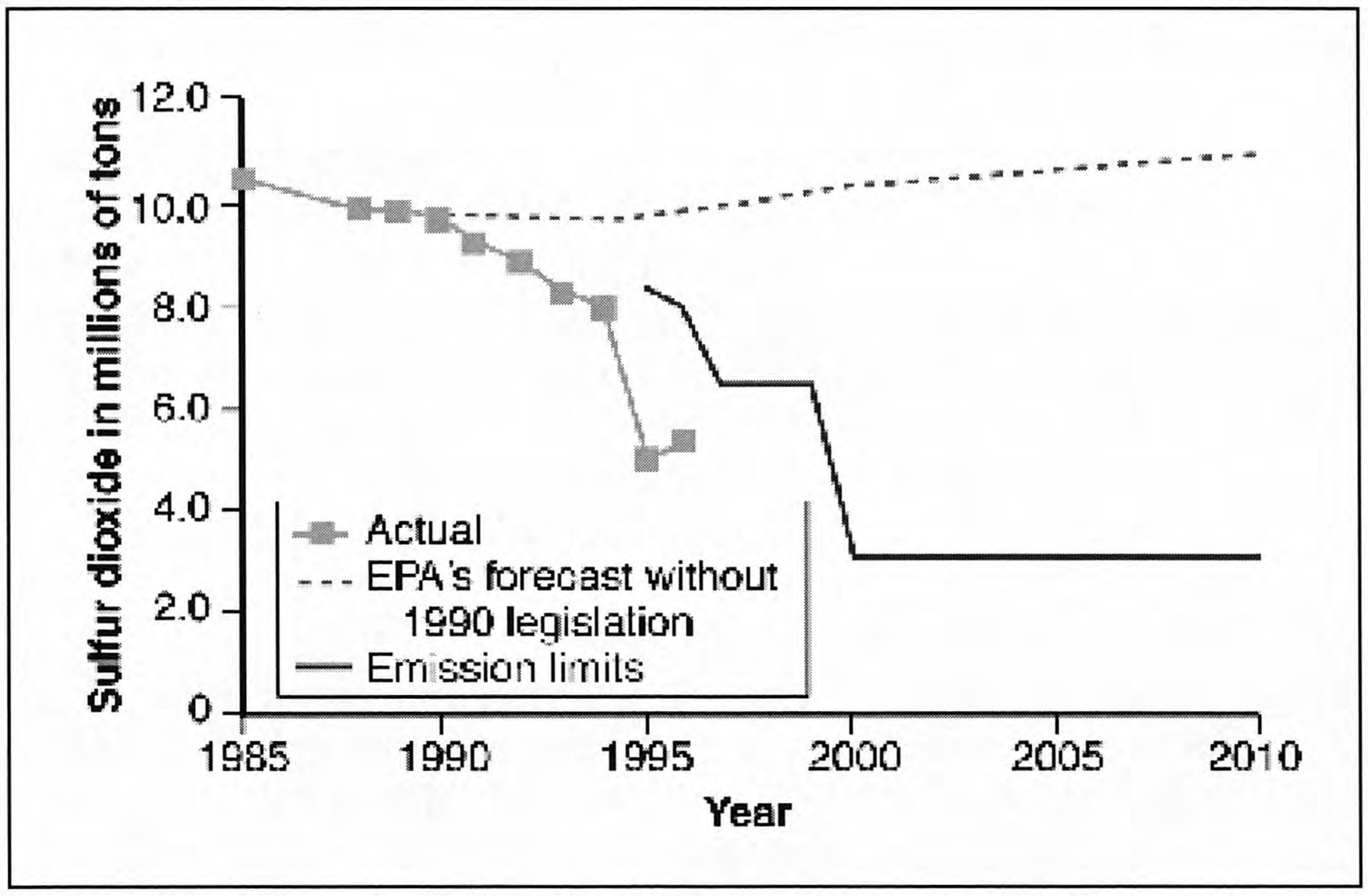

Figure 1: U.S. Sulfur Dioxide Emission Levels, 1985-1998[81]

This cap-and-trade exercise garnered praise from economists and environmental groups prior to its official 1995 start date. SO2 trading among covered entities, which developed in tandem with the public-private emissions grandfathering and auctioning, largely explained an almost 2.7-million-ton drop in sulfur dioxide emissions between 1994 and 1995. In 1995 dollars, the projected abatement cost of the cap-and-trade program between 1995 and 2007 totaled $14.88 billion. This sum is approximately $20.05 billion or 57 percent less than the estimated $35.93 billion cost of obtaining similar results without an SO2 trading component.[82] Caution should be exercised, however, when determining how an SO2 cap-and-trade strategy impacted electricity prices over the same thirteen year period. Stating a simple percentage increase in utility rates fails to separate the effects of SO2 reduction from other contemporaneous causations of rate increases. For example, during the 1990s, coal power plants in the eastern United States largely switched to low sulfur coal. Subsequent analysis suggests this fuel switch may have occurred even if there were no sulfur dioxide regulation. Plentiful low sulfur coal mined in Wyoming's Powder River Basin became affordable for eastern destinations after the Staggers Act deregulated freight railroads in 1980.[83] Had the availability of a low-sulfur fuel alternative not existed, any acid rain solution, including a cap-and-trade framework, would have likely carried a higher financial cost.

CARBON REDUCTION POLICY INSTRUMENTS FOR THE TRANSPORTATION SECTOR

To date, greenhouse gas emissions reductions have emphasized the electricity sector over transportation partially because these two economic segments are best suited for different policy instruments. With its large point source emissions that are relatively straightforward to quantify at the combustion stage, electricity generation is better suited to the more politically palatable cap-and-trade framework. In contrast, a carbon tax or something akin to an emissions excise fee may be the best tool to regulate GHG output within the transportation sector. Hypothetically measuring GHGs emitted from all motor vehicle tailpipes would be unwieldy both from a regulatory and cost perspective. The much more efficient alternative to police transportation emissions is to regulate upstream at the point of fuel generation. Just as electricity generators would constitute covered entities in a cap-and-trade system, petroleum refiners would need to pay for GHG emissions based upon the carbon intensity of the fuels they manufacture. The important difference between transportation fuel refiners and power plants is the carbon content of gasoline and other motor fuel derivatives is not released upstream at the refinery but downstream at the vehicle tailpipe. Transportation fuels, including gasoline and diesel, have different carbon intensities. The EPA or another regulatory body could levy a specific dollar amount per tCO2e against the carbon intensity of a unitized volume of a refiner's fuel. Refiners would most likely then pass the resulting cost per fuel volume onto their distributors and ultimately motorists as a surcharge per unit volume of fuel.

The conceptual model of a transportation carbon tax is quite similar to the national and state gas taxes, which are currently used to replenish highway trust funds. In this case, the carbon tax could minimize administrative costs since there would be little need to develop a new tax collection procedure. The carbon content of the predominant gasoline blend in each region of the country would be calculated and a corresponding price per gallon of fuel would be charged to internalize the carbon externality associated with combusting that gallon of petroleum. The magnitude of the gas tax already varies significantly by state because, in addition to the $0.184 per gallon Federal gasoline tax, states are allowed to charge their own excise taxes and environmental fees. As of July 1, 2009, New York and California had the highest gas taxes in the country at $0.425 and $0.399 per gallon, respectively. For comparison purposes, Texas' gasoline tax is roughly half, $0.20 per gallon.[84] An end-user carbon tax would entail an additional per gallon markup but may provide a leveling effect for nationwide gasoline prices since higher gas tax states tend to mandate cleaner fuel blends (ex. California). If a carbon tax were assessed according to the GHG content of the fuel, motorists in Texas would experience a greater climate change induced price increase at the pump compared to their California counterparts. Throughout the U.S., the details of a carbon tax, specifically the excise price that should be charged to achieve a specific reduction in GHG emissions, remain more topics of economic discussion than serious political debate. However, just as it has been an early mover in other aspects of the climate change movement, deliberations in the California legislature provide some estimation of the tax magnitude that could be expected. Concurrent with the House of Representatives voting on the Waxman-Markey ACES Act in June 2009, the California legislature considered a $0.19-per-gallon carbon tax on all gasoline sold within the state. Supporters of the action claimed the excise tax translated to a proposed tax rate of $20 per tCO2e and would generate revenues estimated between $5 and $10 billion per year.[85]

Of the three carbon reduction alternatives discussed, a carbon tax is the most simplistic. Once the regulating body approves an excise price, that fee is levied on relevant sectors. Carbon reductions follow due to a combination of demand destruction, buyers reducing consumption of a given good due to the product's higher carbon content affected price, and clean technology implementation.[86] However, one aspect of a carbon tax requiring further investigation is the regressivity of this GHG reduction policy mechanism. Most middle- and low-income households spend a larger percentage of their income on gasoline than do wealthy households. The top 20 percent of Americans spend just 2.3 percent of their after-tax earnings on gasoline whereas the bottom 20 percent of U.S. households spend 9.1 percent of their post-tax income on fuel consumption.[87] Allocating revenue from a carbon tax to assist lower income wage earners transition to the clean energy economy is necessary given the working class's relatively high degree of exposure to transportation costs. Early attempts to implement carbon taxes, such as the British Columbia model discussed in Chapter Five, have attempted to ameliorate this regressivity through various mechanisms including the environmental tax being revenue neutral. To develop a sense of a proposed carbon tax's economic impact on the Texas economy, Chapter Four describes the transportation sector and relevant social demographics of the Lone Star State. Knowledge of the existing transportation landscape is vital for gauging the degree of greenhouse gas taxation and subsequent revenue distribution best suited for Texas.

Chapter Four: Texas Transportation Sector Overview

Texas owes much of its economic development to the energy industry because the state has a wealth of fossil fuel resources. The state's petroleum production and refining industries matured during the third quarter of the twentieth century and were largely responsible for its post-World War II population explosion. Today, Texas is the second most populous state in the country, behind only California.[88] The vital role that the energy industry has played in economic development also explains why many sectors within the state, particularly transportation, are so fossil-fuel dependent. The Lone Star State holds the dubious distinction of having a per capita residential usage of petroleum significantly higher than the national average. The state's large land area and numerous sprawling urban and suburban population centers promote long commutes. In addition, mass transit does not play as integral a role in the metropolitan areas of Houston, Dallas-Fort Worth, and San Antonio as it does in cities of comparable size in the Northeast and Midwest. These factors exacerbate an automobile-centric, fossil-fuel dependent, and therefore carbon intensive, transportation sector. Relevant transportation statistics follow a brief summary of the Texas petroleum production and refining industry.

PETROLEUM PRODUCTION AND REFINING WITHIN THE LONE STAR STATE

Texas leads the nation in both crude oil production and refining capacity. The state's first major oil boom began in 1901 with the discovery of the Spindle Top oil field in the upper Gulf Coast basin. Since then, major discoveries have been made in East Texas, West Texas, and offshore in the Gulf of Mexico. Oil production increased until 1972, when it peaked at more than 3.4 million barrels per day. Afterward, production declined rapidly, and in recent years Texas crude oil output has fallen to less than one-third of its 1972 peak.[89]

Although oil production is in decline, the state's signature type of crude oil, known as West Texas Intermediate (WTI), remains the major benchmark of crude oil in the Americas. Much of this crude oil is refined in the Gulf Coast region. Texas' twenty-seven petroleum refineries can process more than 4.7 million barrels of crude oil daily, and they account for more than one-fourth of total U.S. refining capacity. Most of the state's refineries are clustered near major ports along the Gulf Coast, including Houston, Port Arthur, and Corpus Christi. These coastal refineries have access to local Texas production, foreign imports, and oil produced offshore in the Gulf of Mexico, as well as to the nation's Strategic Petroleum Reserve, which operates two large storage facilities in Bryan Mound and Big Hill, Texas. The Texas Gulf Coast city of Baytown has the largest single refinery and the Houston Metropolitan Area, of which Baytown is a part, is the largest refinery center in the United States. Refined-product pipelines spread out from Houston across the country, allowing Texas petroleum products to reach virtually every major consumption market east of the Continental Divide. This network includes the Colonial Pipeline system, which is the largest petroleum product pipeline network in the United States, connecting the Texas Gulf Coast with the Southeast and Eastern seaboard.[90]

The state's total petroleum consumption is the highest in the nation, and it also leads in consumption of asphalt and road oil, aviation gasoline, distillate fuel oil, liquefied petroleum gases (LPG), and lubricants. Separate motor gasoline blends are required in four different regions to meet The Lone Star State's diverse air quality needs. Houston and the Dallas-Fort Worth Metroplex generally have the worst air quality necessitating reformulated motor gasoline blended with ethanol, which cuts down on residual emissions.[91] Figure 2 below illustrates the diversity of Texas's energy holdings. Oil production, holding, and refinery facilities are denoted in purple.

Texas' status as both a large energy producing and consuming state helps make the electorate wary of any environmental regulation that could pose a financial threat to existing jobs and entrenched personal behavior. Educating stakeholders of the positive aspects of fighting climate change is perhaps as important as ensuring a regulatory framework that efficiently and equitably distributes the economic burden of the carbon externality. Chapter Six elaborates on the positive outcomes a carbon tax could bring to Texas. Detailing both the advantages and drawbacks is critical in developing a cost-benefit analysis of what climate change policy could pose for the nation as a whole and the Lone Star State in particular.

Figure 2: Energy Generation, Receiving, and Refining Facilities within Texas[92]

TEXAS TRANSPORTATION INFRASTRUCTURE

A prevalence of inexpensive gasoline during the latter half of the twentieth century served as a primary factor spurring the post-World War II baby boom and explosive growth of suburbs across the country. Ironically, if the development patterns of most urban areas during the late nineteenth and early twentieth centuries still predominated nationwide, the U.S. would face a much smaller emissions crisis with respect to its transportation sector. Electric streetcars were commonplace in most Northeast and Midwest cities, like New York City and Chicago, in 1900. Even the early suburbs, like Philadelphia's Main Line communities, developed around established commuter train lines linking these neighborhoods with downtown business districts.

In general, most Texas metropolitan regions acquired their large populations during the American migration to Sunbelt states beginning in the 1950s and 1960s.[93] This time period coincided with the heyday of the large tract community heavily reliant on the automobile for transportation. Sprawling infrastructure and development built so extensively around motor vehicles impeded any subsequent modal shift toward greater mass transit. A profile of today's transportation sector within the Lone Star State reflects a heavy reliance on the automobile and therefore gasoline.

Texas ranks second in the country in both population, behind California, and area, behind Alaska. Although the Lone Star State encompasses 261,797 square miles, 80 percent of Texans live in urban areas, primarily in the eastern third of the state.[94] In fact, 65 percent of Texas' projected 2010 population of 25.4 million people resides within the four metropolitan statistical areas (MSAs) of Austin, Dallas-Ft. Worth, Houston, and San Antonio.[95] These four urban centers comprise the so-called Texas Triangle, which is bound by Interstates 10, 35, and 45 on the south, west, and east, respectively.

The freeway reference indicates limited access highways play a very important role in the movement of people and goods within the Lone Star State. As of 2000, Texas had a total of 301,035 miles of public roads, of which 11,330 miles were termed freeway or limited access highway. The dominance of automobiles as the preferred mode of travel is underscored by the apparent lack of transportation alternatives. Despite Houston, Dallas, and San Antonio all being among the top-ten most populous cities in the country, commuter rail transit is quite limited within the state. No heavy-rail commuter transit (i.e. subways) exist. The Dallas Area Rapid Transit (DART) system contains 47 miles of track, which accounts for 84 percent of the entire 56 miles of light rail transit within the state. As of 2000, the state's only longer distance commuter rail network, akin to Washington, D.C.'s and Baltimore's MARC train and Chicago's Metra system, was the Trinity Railway Express in Dallas having 34 miles of track.[96]

Unlike passenger railways, freight railroads do currently play a dominant role in Texas commerce. As of 2000, a total of 562 individual railroad companies operated within the U.S.[97] Of this pool, the largest and most influential entities are the five U.S. Class I carriers: BNSF Railway, CSX Transportation, Kansas City Southern Railway, Norfolk Southern Railway, and the Union Pacific Railroad. Class I carriers are designated as those entities generating more than $250 million in inflation-adjusted operating revenues annually. Forty-four different railroads, of which three are Class I carriers, operate within Texas. The three Class I carriers operating within the Lone Star State are the Union Pacific Railroad, operating 6,190 miles of track within Texas; BNSF Railway (formerly called the Burlington Northern Santa Fe), operating 4,806 miles; and Kansas City Southern Railway, operating 381 miles. Of the 172,101 miles of total U.S. railroad track and 120,597 miles of total U.S. Class I track, Texas has 14.4 percent and 16.6 percent, respectively.[98]

TEXAS TRANSPORTATION BEHAVIOR

The state's extensive highway network has influenced commuter behavior over the past several decades. Of the 9,265,187 Texans commuting to work in 2000, 79.4 percent drove alone while just 12.5 percent carpooled. At first glance, this statistic seems heavily biased against vehicle ride sharing. By comparison, Texas numbers are only slightly more lopsided than national statistics, where 76.3 and 11.2 percent of workers drove alone and carpooled, respectively. However, the state's lack of commuter alternatives is more apparent when one examines mass transit ridership. Only 1.9 percent of Texans took public transportation compared to 5.2 percent of Americans overall.[99]

In 2000, 14,257,270 motor vehicles were registered in Texas, which is approximately 6.3 percent of the U.S. total of more than 225 million automobiles.[100] Texas ranks second behind California in total vehicle miles traveled (VMT). In 2000, Texans registered a total of 220,064 million miles or approximately 10,613 VMT per capita. The per capita figure for Texas is approximately 8.2% above the nationwide average of 9,811 VMT per capita and 17.2 percent higher than California's per capita figure of 9,053 VMT.[101] The comparative lack of conservation when it comes to individual energy usage is also apparent when considering petroleum consumption. In 1999, Texans consumed 1,252.3 trillion Btu's of motor gasoline and 479.2 trillion Btu's of diesel. This is second behind only California, whose citizens consumed 1,749.0 and 373.3 trillion Btus of gas and diesel, respectively.[102] However, once again a per capita comparison better illustrates personal behavior exercised by Texas drivers. Texans on average consumed 123.5 million Btu's of petroleum in 1999, 42.1 percent more than the average consumption of Californians, which was roughly 86.9 million Btu's. Only residents in Alaska, Wyoming, Louisiana, and Mississippi consumed more per capita than those in Texas.[103] Transportation fuel usage in Texas is disproportionally large compared to the rest of the nation given per capita data. Texas ranks second in terms of population, whereas Louisiana with a larger per capita fuel usage, ranked 22nd in terms of population in 2000.

The heavily fossil-fuel dependent Texas transportation sector would logically be at a marked disadvantage, at least in the short term, should a national carbon tax cover the transportation industry as part of a multi-sector carbon reduction plan. Texans' reliance on automobiles has developed over multiple decades and is a reflection of land use patterns and economic development that have failed to develop viable transit alternatives to the automobile on a broad scale. Chapter Five will explore how a carbon tax could potentially impact the Texas transportation sector from both a residential and commercial standpoint. Comprehensively integrating Texas into a carbon reduction strategy that seeks to benefit the state economy instead of solely penalizing the Lone Star State's traditionally fossil-fuel dependent industry is critical to boost support for comprehensive national climate change legislation. New and innovative ways will need to be explored to balance the stae's economic growth while demonstrating effective environmental stewardship.

Chapter Five: Carbon Tax Impacts on the Texas Transportation Sector

Chapter Four previously described the Texas transportation sector and the relatively carbon-intensive nature of economic activity stemming from the Lone Star State's extensive energy industry. Potential climate change regulation would levy different impacts upon different transportation activities. A formal numerical analysis of the financial impacts is difficult as Congress has yet to agree upon legislation. However, general trends can be articulated assuming a carbon tax would be levied upon fuel refiners and those refiners would pass the added cost onto their customers in the form of an additional charge per unit of fuel. This chapter treats this per-gallon increase in fuel prices on residential activity and transportation sector commerce separately.

RESIDENTIAL ACTIVITY

Forecasts of how entities will react to an economic perturbation are often based upon analog events, whose causes may be different but which result in similar effects. Though a nationwide climate change tax in the form of a surcharge on each gallon of fossil fuel has never before been implemented in the United States, the price drivers pay for gasoline at the pump is the sum of the cost to produce and transport the fuel along with various state and federal taxes. These taxes are levied for various reasons including payment for federal highways, which necessitates the current national gas tax. Although much debate and criticism often surround the initial implementation of a tax measure, once the tax is approved covered entities generally move forward, dutifully pay the fee, and focus their attention on other matters. Regulatory certainty explains this behavior. Assuming the new tax does not drastically inflate the cost of a said good, most consumers are able to adjust their behavior in order to afford the higher priced item. As discussed in Chapter Three, if demand for the good is relatively elastic, customers are more likely to switch to substitutes and decrease their consumption of the item so that their expenditure for the product does not change significantly. As will be discussed, studies have shown gasoline consumption to be quite inelastic, particularly in the short term. In this situation, as the price of gasoline rises due to additional taxes or insufficient supplies, drivers will decrease their purchase of other goods in order to afford the significantly higher cost of similar quantities of gasoline. Despite higher prices due to more taxes, consumers can plan for these higher prices and make adjustments in their purchasing habits as described. The regulatory *uncertainty* associated with deliberation of a tax measure is much more deleterious since entities that will be potentially affected by the additional fee have no way of knowing for sure whether the higher cost scenario will actually materialize. This uncertainty negatively impacts the consumer's ability to plan for additional expenses.

A significant advantage of a carbon tax is if and when Congress decides to move forward with such a measure, the nature of greenhouse gas mitigation should afford a relatively predictable carbon excise fee, at least during the 2012-2020 timeframe. The American Clean Energy and Security Act, Kerry-Boxer discussion draft, and related bills all include a timetable for economy-wide GHG reductions that typically stretch from 2012 through 2050. Efforts currently being undertaken by the U.S. Environmental Protection Agency will seek to account for practically 90 percent of all carbon emissions within the U.S. economy over the next two years.[104] These accounting measures will determine with relatively high accuracy how much carbon each sector contributes. At this point, regulators could apply the percentage year-to-year GHG reductions to the transportation sector to estimate how much refiners will need to abate carbon emissions going forward in order for transportation to adequately contribute to the economy-wide reductions. As the carbon market matures, a given GHG reduction within the transportation sector will equate to a particular cost of abatement. This cost of abatement can be recovered from motorists in the form of a carbon tax. At this early stage, economists disagree on the tax magnitude required to achieve the desired GHG cuts within transportation. However, most concur the tax would start relatively small and gradually rise over the coming decade.

The Canadian province of British Columbia (BC) is currently the largest governmental entity in North America to have enacted a carbon tax. Lessons learned from Canada's west coast could help approximate how a carbon tax could impact U.S. motorists overall and Texas drivers in particular. British Columbia implemented its carbon tax in July 2008. Criticism of the tax was especially vehement prior to its inauguration because the GHG surcharge's scheduled start date coincided with historically high gas prices observed during the summer of 2008. However, in the intervening two years, BCers have grown accustomed to the fee and the tax has garnered praise from many economists for its broad coverage, gradual implementation, predictable price increases, and revenue recycling to assist low-income citizens. Between 2008 and 2012, the carbon tax increases from \$10 to \$30 Canadian per tCO2e in annual incremental rises of \$5 per tCO2e. British Columbia's carbon tax is relatively modest when compared to other excise charges. Fuel forecasts for 2008 to 2012 project the GHG fee to initially total approximately 1.6 percent of the price of a liter of gasoline and gradually rise to 4.7 percent of the price four years later. Initially the BC carbon tax is dwarfed by other per liter taxes already levied by federal and provincial authorities including a 6-percent federal sales tax, a \$0.10 per liter federal fuel tax, and a \$0.145 per liter BC fuel tax.[105]

In addition to the tax's modest magnitude, British Columbia's carbon fee structure is designed to minimize the financial burden of the tax on motorists. The carbon tax is revenue neutral in that the fee does not result in additional income for the provincial government. Instead, tax revenue is reapportioned. In this scenario, negative externalities--namely GHG emissions resulting from the combustion of gasoline in catalytic converter engines--are taxed and the proceeds are shifted to individuals and businesses through various tax cuts and rebates, including a climate action dividend distributed annually and special rebates for low-income households.[106] Proponents of the tax argue its revenue neutral nature actually affords customers a cost savings if they employ various conservation and efficiency measures. In 2008, a two-person household that received \$200 in tax reductions and rebates saved overall if it purchased less than 2,100 gallons of vehicle and heating fuel annually.[107] The savings per unit of fuel conserved increases as the carbon tax rate rises over the five-year period. Awareness of the carbon tax and its forecast financial implications up to a half decade in advance affords British Columbia motorists the opportunity to make choices that will increase their gasoline consumption elasticity over the intermediate (i.e., three- to five-year) term. Choices and lifestyle changes include purchasing a more fuel-efficient vehicle, such as a hybrid car, and weatherizing one's home through such measures as adding insulation.

The advantages of such a carbon tax structure would impact Texas motorists in similar ways. However, the higher energy intensity of Texas residents implies the populace would need to execute more stringent conservation measures earlier in order for the same percentage of Texas residents as British Columbia residents to benefit from a net financial savings from such an environmental measure. Energy intensity differences aside, Texans would likely follow their British Columbia counterparts and most voice their opposition to a carbon tax prior to tax implementation. The regulatory certainty argument already described would suggest anti-carbon tax sentiment would wane once motorists made the necessary adjustments to their purchasing habits to account for the marginally higher cost of gas.

The British Columbia case study proves that a North American governmental entity can implement a carbon tax and that its residents can eventually accept the added excise fee and perhaps even financially benefit from the tax assuming the climate change surcharge is revenue neutral. However, would this market-based, carbon-reduction initiative achieve its policy goal of reducing climate changing GHG emissions? Imposing a carbon tax is not worthwhile, no matter how mild its financial impacts, if the regulation does not succeed in reducing the amount of fossil fuel motorists consume. Whether or not sustained higher fuel prices can alter consumer behavior and the nature of those adjustments constitute important questions that policymakers should ideally answer prior to implementing a carbon tax.

While laudable for its early action, British Columbia cannot yet provide guidance for other governments on what to do and not do. The BC carbon tax is less than two years old plus the historical time during which the tax has been in effect makes it very difficult to determine whether changes in customer behavior are directly attributed to the initiative. The severe 2007-2009 global recession significantly depressed consumer demand for energy and fuel. An economic retrospective examination would likely reveal consumption of fossil fuel within British Columbia declined around the time the carbon tax was implemented. However, this decrease was likely more attributed to the overall economic slowdown instead of a 1.6-percent increase in the per-liter price of gasoline due to the levying of the carbon tax in 2008.[108] A more appropriate analog scenario that may provide insight as to how higher fuel prices associated with a carbon tax would change driver behavior is the six-year run up in gasoline prices due to increased worldwide fuel demand that generally characterized the period from December 2001 to July 2008. Burgeoning global demand pushed up fuel prices for a long enough period of time such that associated customer behavior changes may be applicable to the study of a carbon tax's effects, at least in the intermediate term of half a decade.

Numerous studies suggest the six-and-a-half-year period of steadily increasing gasoline prices between 2002 and 2008 only precipitated a noticeable change in customer petroleum consumption and driving behavior during the final year of the timeframe. Economists generally concur the primary reason drivers in Texas, and throughout the nation, were slow to alter their purchasing preferences despite paying ever higher prices at the pump is gasoline consumption elasticity has actually decreased, or become more inelastic, since the last period of comparatively high petroleum prices in the 1970s. Hughes, Knittel, and Sperling conclude short-run price elasticities differ considerably between the 1970s and 2000s. Estimates of gasoline demand elasticity range from -0.21 to -0.34 for the 1975 to 1980 period while corresponding elasticities drop to between -0.034 and -0.077 for the 2001 to 2006 five-year period. Short-run price elasticity is a reflection of the change in driving behavior versus the change in the price of a gallon of gasoline. Interpretation of these numbers indicates for every $1 increase in the price of a gallon of gas, 1970s-era motorists would consume up to a third of a gallon less in fuel. However, by the 2000s, the drop in the amount of gas consumed by those same motorists was only one-tenth as large given the same $1 price increase. Fewer gallons of gasoline consumed is achieved by a reduction in the amount of driving (i.e., vehicle miles traveled or VMT) and an increase in fuel efficiency.[109]

Possible reasons for the greater inelasticity of customer petroleum demand include U.S. consumers now being more dependent on automobiles than in previous decades. Greater motor vehicle dependence stems from continued migration from inner-city, urban areas to suburbs where suburbanites drive 31 to 35 percent more than their urban counterparts.[110] Exacerbating the American motorists' current car dependence is the share of transit-passenger miles relative to individual, vehicular transport modes has steadily decreased over the past thirty years.[111] Denser, inner-city land-use patterns that predated the far-flung exurbs of the late twentieth century allowed 1970s-era drivers greater access to mass transit as a substitute to individual automobile commuting if gasoline prices spiked. Ironically, an increase in Corporate Average Fuel Economy (CAFÉ) standards may have made 2001-06 more inelastic than 1975-1980. CAFÉ standards increased from 15 mpg in 1980 to about 20 mpg in 2000. If price fluctuations cause drivers to decrease vehicle miles traveled, vehicles with higher CAFÉ standards will result in a smaller drop in gasoline consumed if those cars are driven fewer miles. Older vehicles with lower CAFÉ standards will yield a greater drop in gasoline consumption if driven fewer miles resulting in the 1970s era data appearing more elastic than current-day figures.[112]

Closer inspection of the 2002-to-2008 period of escalating fuel prices reflects that motorists' dissatisfaction with the current automobile-centric transportation model can predate actual behavior change by several years. As an attribute of consideration when purchasing a new automobile, fuel economy ranked utmost in importance in the early 1980s, a result of the 1970s energy crises. However, the subsequent two decades' worth of cheap fuel helped relegate this factor to fourth most important behind automobile dependability, safety, and quality in 2001.[113] The ensuing six years of increasing gas prices caused gas mileage to reclaim the top spot as the primary factor in purchasing an automobile by January 2008. Although high gas prices appeared to reverse consumer sentiment regarding automobile purchasing, which had previously favored sport utility vehicles (SUVs) and trucks over smaller sedans, actual purchases of smaller vehicles only began to outpace their larger counterparts by the end of 2007 and 2008.[114]

One likely reason for the apparent disconnect between customer viewpoints about fuel prices and buying behavior is the relationship between fuel economy and purchasing decisions is not easy to establish. The consumer response to gasoline price and fuel economy cannot simply be explained by systematic and logical economically-driven actions, as many customers do not even know how to estimate fuel cost savings.[115] The economic assumption of competitive markets that consumers operate with perfect information regarding substitutes and complements is simply not valid. Therefore, to overcome this model limitation the price signal associated with a carbon tax or some other market-based carbon reduction schema must be of significant magnitude so as not to get lost in the noise. If gasoline prices more than doubling over six years fail to encourage long-term purchasing preferences supporting smaller, fuel efficient vehicles, a carbon tax akin to British Columbia's version that is responsible for increasing gasoline prices just one to five percent over a span of five years is simply not large enough to alter customer behavior in a climate friendly manner.[116] U.S. customer anti-tax sentiment that is particularly pervasive within Texas would make it difficult enough to impose a carbon tax proportional to British Columbia's let alone a tax that is orders of magnitude greater.

Evaluating the residential transportation market in terms of customer vehicle choice suggests a carbon surcharge alone will be insufficient to decarbonize the transportation sector. Additional regulatory mechanisms, such as higher CAFÉ standards or hybrid-electric vehicle production quotas will likely be required to bolster the modification of customer preferences.[117] The following section examines whether commercial transportation markets will be as reluctant to change operations in a carbon constrained economy.

COMMERCIAL OPERATIONS

Commercial movement of goods occurs primarily via trucks, railroads, and waterborne ships within the United States. Although air freight is the preferred mode of transport for certain high-end goods, jet airliners' market share is sufficiently small compared to the land and river/coastal modes to disregard. Furthermore, although shipping dominates global transport of goods, particularly bulk commodities, the effects of a carbon tax on trucks and railroads will be emphasized over ships since this paper focuses on the Southwest region, particularly intrastate transport among Texas markets.

Figures 3 and 4 illustrate the primary rail and highway networks linking major metropolitan areas within the Lone Star State, respectively. It is readily apparent that many lines owned by the Class I rail freight carriers are coterminous with Texas interstate highways. For example, the Union Pacific Railroad, highlighted in red, operates lines that roughly parallel both the Interstate 10 and 20 corridors extending east-west. The BNSF Railway, the second-most extensive Class I rail carrier within Texas, has more of a southeast to northwest orientation, stretching from the greater Houston area in southeast Texas up to Lubbock and Amarillo in the Panhandle. With its Texas operations headquartered in Fort Worth, BNSF also provides good coverage throughout the Dallas-Ft. Worth Metroplex.

Figure 3: Class I Railroads and Affiliates Operating within Texas[118]

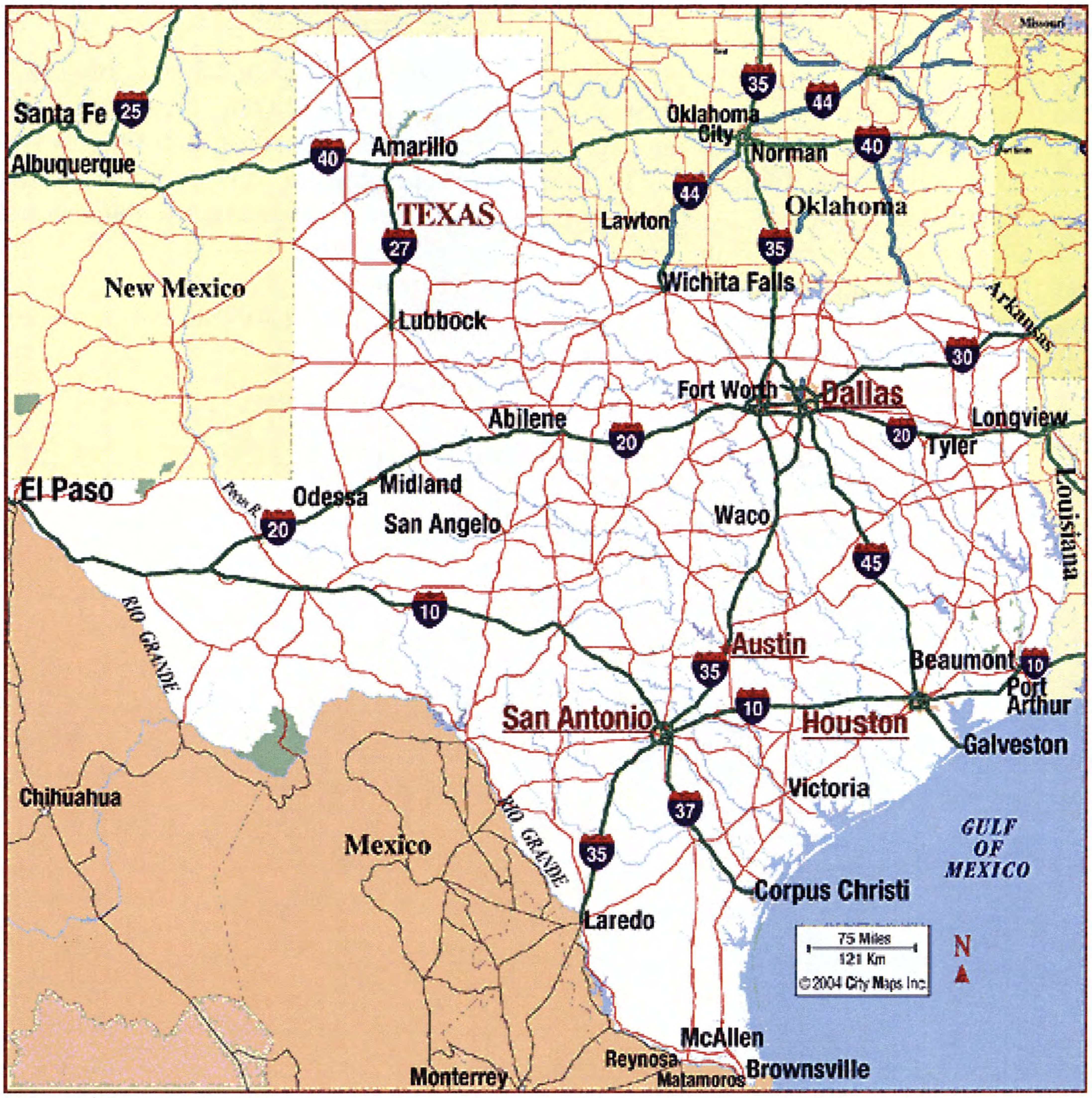

Figure 4: Texas Highway Map[119]

The layout of rail and highway systems within Texas suggests that freight railroad companies and trucking firms can be both partners and competitors in the commercial transportation business. Tractor trailers are free to utilize both primary and secondary highway arterials and therefore afford much better coverage than railroads to different communities within a larger urban area. For example, trucking firms like J.B. Hunt can better service Pasadena, Missouri City, Sugar Land, and other cities surrounding Houston than BNSF, whose trunk lines connect the Bayou City with points north and west. However, trucking's freight dominance ebbs when distances to cover exceed 600 to 800 miles or the good being transported is of the bulk commodity variety. For example, rail is the natural choice moving subbituminous coal from Wyoming's Powder River Basin south to Texas power plants.[120] In a non-carbon constrained economy, whether rail and trucking are shipping competitors or partners in intermodal operations depends on two factors: physical market accessibility and the fuel cost per unit of good shipped.

Trucking and rail firms may fair differently if greenhouse-gas costs are factored into shipping prices.

Greater environmental consciousness the last several years has spurred some rail companies to try and capture additional market share from their trucking competitors by touting the increased fuel mileage railroads afford. The BNSF, Union Pacific, and other Class I railroads have developed advertising campaigns based upon the way rail and truck fuel efficiencies are calculated. Railroads apparently have a fuel efficiency advantage because the common miles-per-gallon metric, widely applied to personal automobiles and trucks, is not relevant to railroads. Dividing distance traveled by volume of diesel fuel consumed, multi-ton railroad diesel engines would get much worse mpg ratings compared to lighter trucks. Instead, the ton-miles-per-gallon metric, which divides the product of payload (in tons) and distance (in miles) by fuel (in gallons), is used to compare railroad and truck fuel efficiency.[121]

Tables 1 and 2 and Figures 5 and 6 reflect the weight pulled by a typical freight railroad train, ranging from 3,000 to 8,000 tons,[122] dwarfs the hauls of tractor trailers, generally 23 to 37 tons.[123] The freight tonnage disparity resulted in railroads demonstrating significantly greater fuel efficiency than trucks in a 2009 study conducted by the Federal Railroad Administration (FRA). The FRA examined rail and truck performance under twenty-three different freight movements and determined railroads were between 2.0 and 5.5 times more fuel efficient than their truck counterparts.[124] Railroad advocates assert studies similar to the FRA's findings support a modal switch from truck to rail should GHG emissions become priced, thus raising fuel costs. Truck supporters argue such statistics as ton-miles-per-gallon are misleading. On a trip-for-trip basis, a given percentage increase in the number of railroad turns would result in a significantly greater rise in carbon emissions compared to an equivalent number of additional truck trips. Furthermore, the physical access problem previously discussed would present a major hurdle to any large switch over from truck to rail transport. Virtually all freight reaches its final destination by truck and 80 percent of communities rely solely on trucks for freight transportation.[125] Trucking is a much more geographically flexible transportation mode than railroading.

Table 1: Typical Freight Railroad Train Characteristics[126]

Train Type	Number of Movements	Number of Cars	Trailing Weight (tons)
Double-Stack	11	27 - 85	4,243 – 8,107
TOFC	1	39	4,854
Mixed	8	36 - 105	4,026 – 7,695
Auto	3	45 - 65	3,132 – 4,281
Total	23	27 - 105	3,132 – 8,107

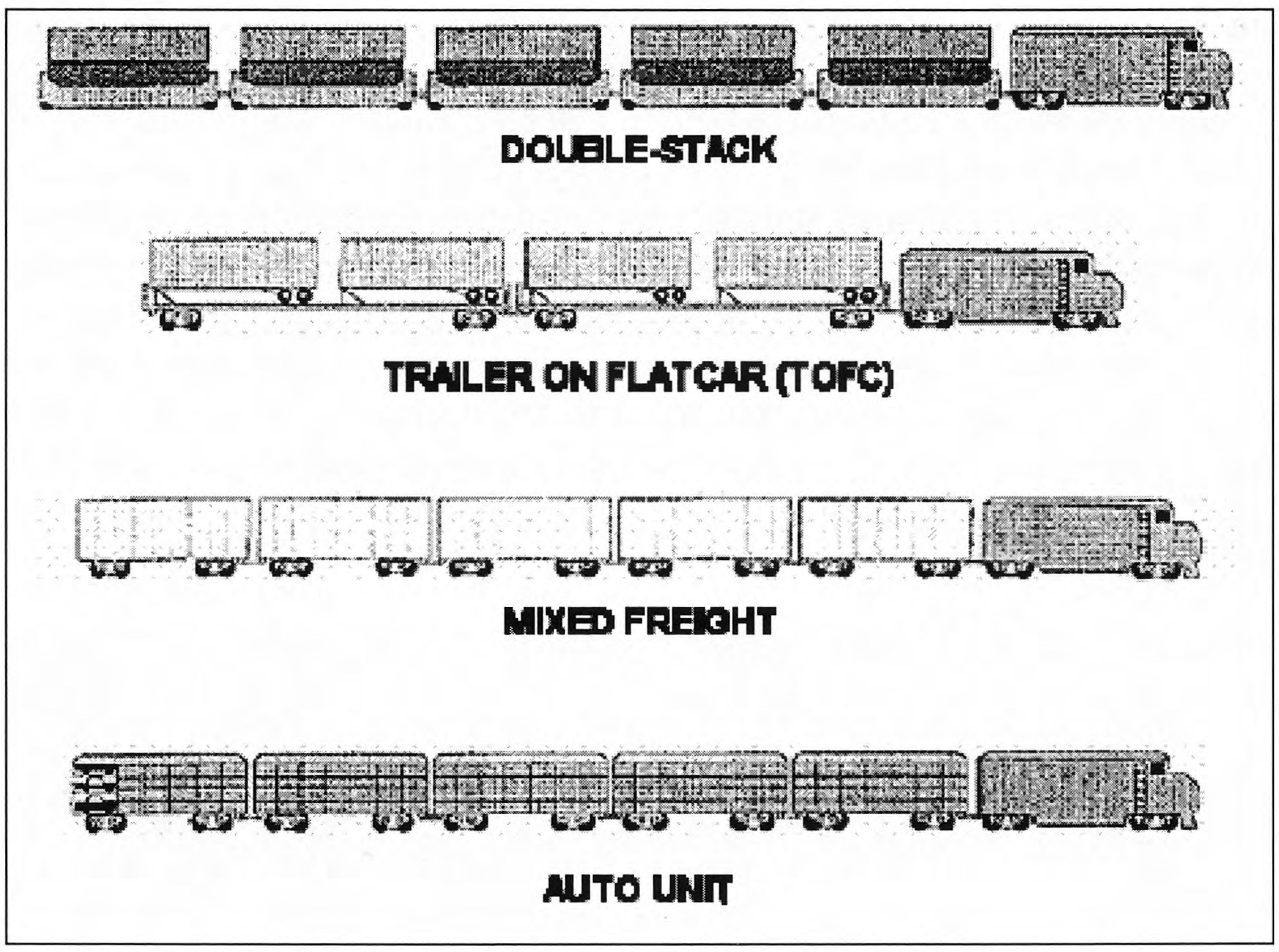

Figure 5: Typical Freight Train Classifications[127]

Table 2: Typical Truck Tractor Trailer Characteristics[128]

Truck Trailer Type	Number of Movements	Truck Loaded Weight (tons)
Dry Van	12	29 - 31
Container	3	23 – 31
Auto Hauler	3	30
Dump	2	37
Flatbed with sides	1	37
Tank	2	23 - 37
Total	23	23 - 37

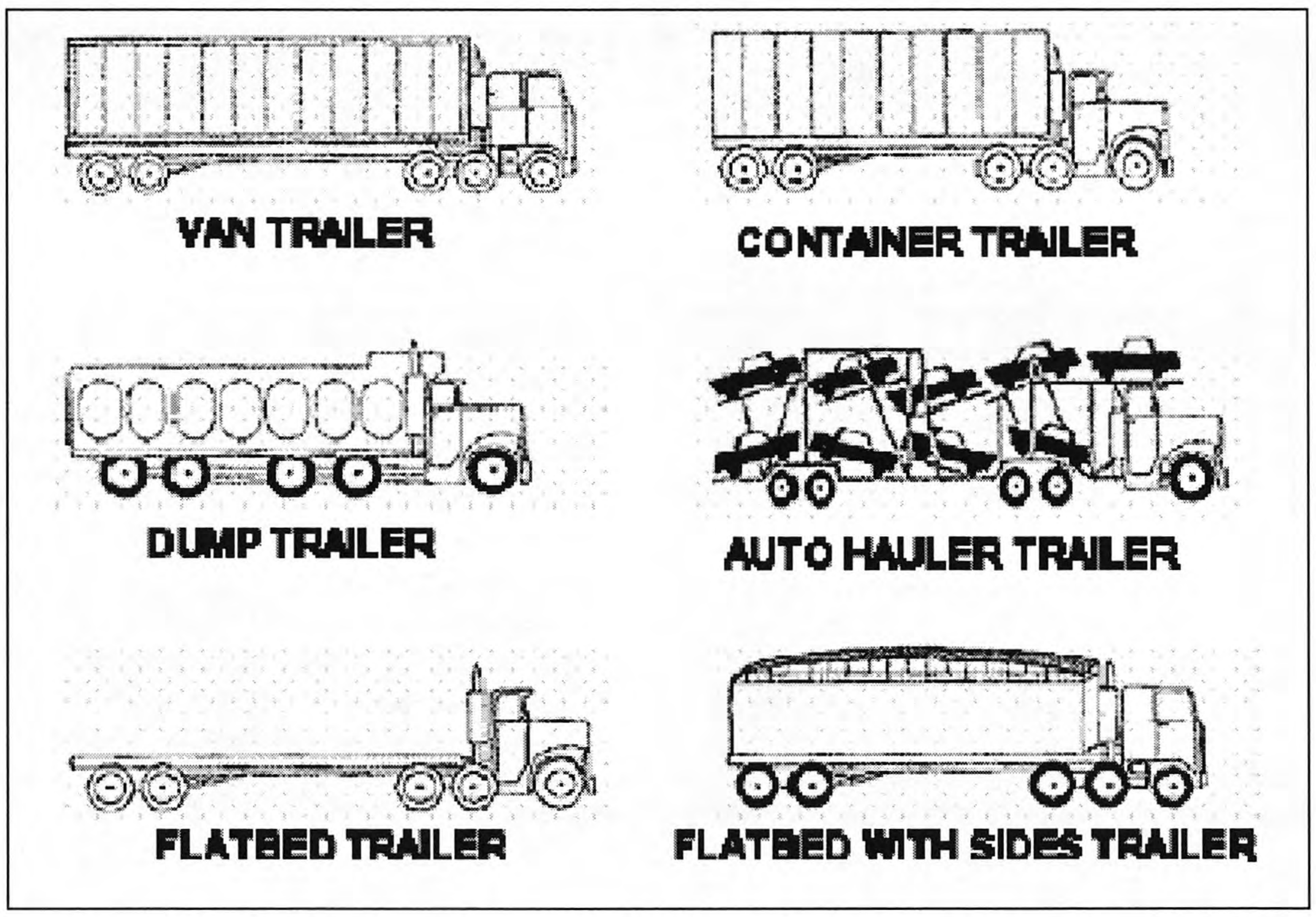

Figure 6: Typical Truck Tractor Trailer Classifications[129]

The BNSF and other rail carriers are cognizant of pending Congressional climate change legislation. Stevan Bobb, Vice President for BNSF Coal Marketing, maintains that, if a carbon tax were levied raising the price of fuel, three potential outcomes could occur, each impacting the railroad industry differently. Ton-miles-per-gallon greater fuel efficiency for railroads could result in some additional market share captured by railroads of trips previously reserved for trucking. Likely, trains would become more competitive for freight hauls of 400 to 500 miles in length. This would be a positive outcome for railroad firms. In contrast, a carbon tax may negatively affect intermodal transport activities. If trucking suffers, railroads will also suffer in sectors where trains and trucks cooperate to bring goods to market.

Another, perhaps more significant, drawback for railroads would be in the haulage of bulk commodities, namely coal transport.[130] Railroads currently account for more than 75 percent of domestic coal shipments. The vast majority of this coal is used for electricity generation by utilities. From a revenue standpoint, Table 3 indicates coal transport generally accounted for between a quarter and a third of 2009 revenue for the Union Pacific, BNSF, Norfolk Southern, and CSX. Coal revenue shares were decidedly lower, in the six- to ten-percent range, for the Canadian National Railway (CNI) and the Canadian Pacific Railway (CP). However, less emphasis should be placed on these smaller share magnitudes since Canadian railway transport *excludes* coal movements across the American-Canadian border.[131] Figure 7 illustrates that BNSF's Texas operations reflect the carrier's national coal exposure with shipments of Wyoming's Powder River Basin sub-bituminous variety constituting 381,626 carloads or approximately 28 percent of the bulk volume the rail carrier shipped to the Lone Star State in 2008.[132]

Table 3: Relative Coal Exposure and Mix Characteristics by Rail[133]

	% of 2009		Tonnage Mix		
Rail	Revenue	Carloads	Domestic	Export	Notes
UNP	22%	26%	vast majority	negligible	Over 75% mined in PRB, Some minimal exports from UT/CO mines, Persistent production/quality issues have hampered UT/CO volumes
BNI	26%	28%	vast majority	negligible	Over 90% mined in PRB, Virtually all utility coal
NSC	28%	24%	89%	11%	76% Utility, 8% Metallurgical, 5% Industrial; Export up 31% in 4Q after down 37% 1Q-3Q
CSX	29%	26%	86%	14%	78% Utility, 8% Other Domestic; Exports fell 25% in 2009, but lesser 14% in 4Q
CNI*	6%	11%	60%	40%	Coal segment is 85% coal, 15% pet coke, growing met volumes with win of portions of CP's TeckCoal business in mid-2009
CP*	10%	7%	25%	75%	All Canadian coal is met from Teck Coal in BC, exported via Vancouver, FOA decision in July '09 cut rates and lost some RTMs to CN. CP reached a 1 year agreement with Teck in April '10.

** Canadian export excludes moves between US and Canada*

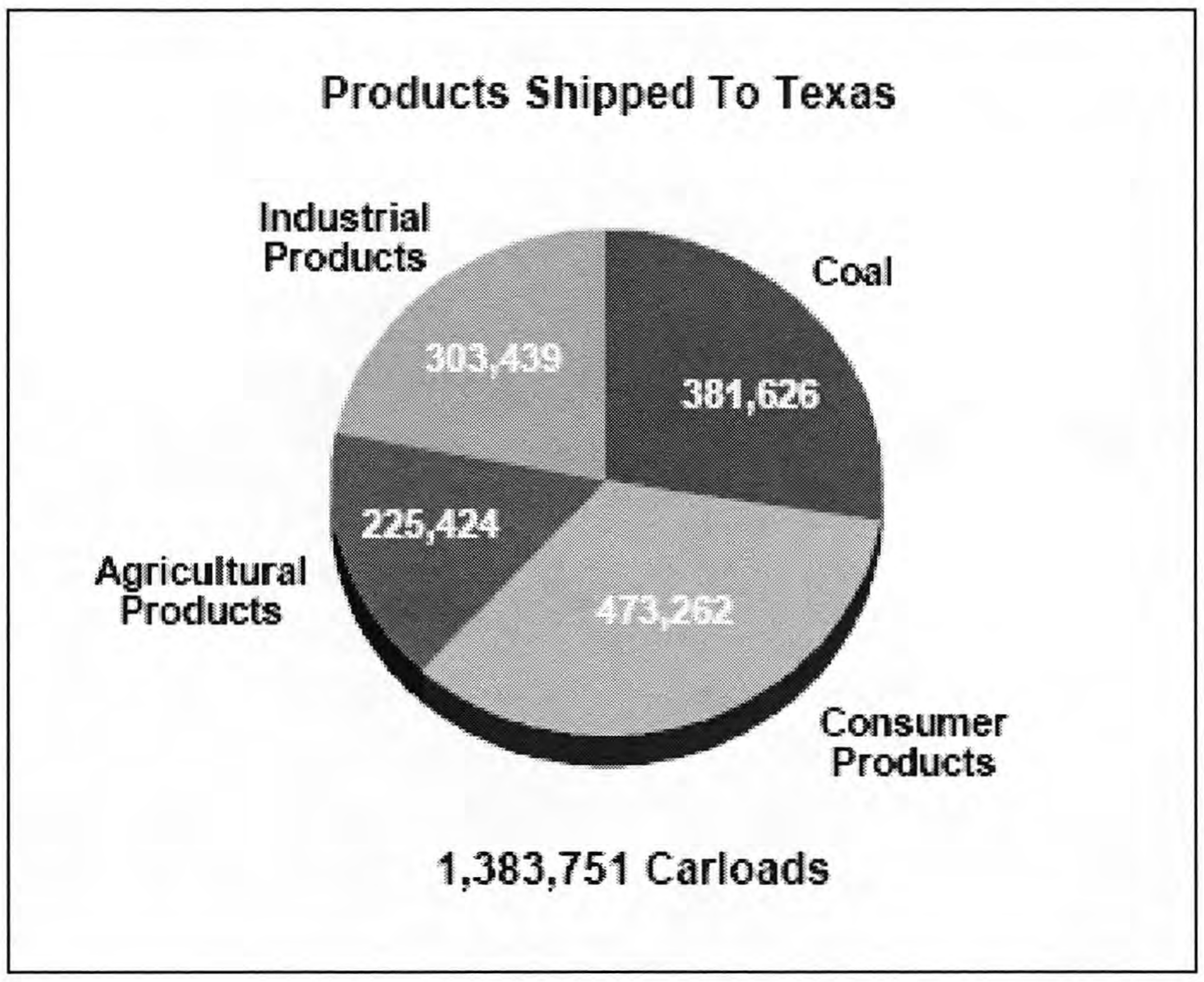

Figure 7: Products BNSF Shipped to Texas by Carload Volume in 2008[134]

The BNSF maintains a broad switch from coal power to less GHG-intensive electricity generation would hurt both the coal industry and freight railroads.[135] Indeed, economic modeling by the U.S. Environmental Protection Agency suggests just such a scenario, if the Waxman-Markey American Clean Energy and Security Act were to become law. Without climate change legislation constraining emissions in the electricity sector, power generation from coal would account for approximately 24 quadrillion Btu's in both 2015 and 2020. In contrast, the ACES Act would reduce power generation from traditional coal-fired power plants to approximately 20 quadrillion Btu's and 16 quadrillion Btu's in 2015 and 2020, respectively.[136] These legislative constraints on GHG emissions could result in a 33-percent reduction in coal demand by 2020 compared to business-as-usual (BAU) trends. In the first decade of a Waxman-Markey type carbon reduction regime, fuel switching from coal to natural gas would most likely make up for the largest portion of power generation no longer accounted for by coal. Most economists and energy policymakers see natural gas as the most likely "bridge fuel" for electricity generation before increased nuclear or renewables could come online after 2020. Increased reliance on natural gas, which is transported via pipeline, would not provide a viable commodity substitute for railroads. Conservatively, assuming coal transport for power generation accounts for 25 percent of annual revenue for Class I railroads, such demand destruction for coal could lead to more than an eight-percent drop in freight railroad operating revenues by the end of the current decade.

BNSF's Stevan Bobb emphasizes policymakers and legislators crafting climate change regulation have an important choice before them, "they can be either anti-global warming or anti-coal."[137] The BNSF and other railroads contend any Congressional climate change bill that fails to shield fossil-fuel intensive industries, including transportation, from the detrimental financial consequences of demand destruction will only succeed in reducing GHG emissions by jeopardizing the health of the American economy.

Proponents of the ACES Act argue the legislation considers the wellbeing of domestic, carbon-intensive industries in two ways. Provisions within the bill promote the development of carbon capture and sequestration technologies (CCS), which conceivably would enable continued use of coal power without the environmentally damaging GHG emissions. EPA economists estimate coal power plants with CCS capability will account for approximately two quadrillion Btu's of energy, or roughly 11 percent of total coal electricity production, by 2020.[138] However, these forecasts appear overly optimistic given the hurdles to date that face CCS. While various academic-and-industrial partnerships have undertaken pilot studies, CCS is not currently commercially available. Furthermore, federal government attempts to spearhead "clean coal" technologies have consistently come in over budget and produced mixed results. The most notorious of these is the FutureGen Project, a public-private partnership inaugurated by the Bush Administration in 2003 to build the world's first near-zero emissions coal power plant by injecting the anthropogenic carbon dioxide deep into the ground. After more than four years, Mattoon, Illinois was chosen as the site for the future plant in December 2007 only to have cost overruns halt the project in early 2008. The Obama Administration's Secretary of Energy, Steven Chu, expressed conditional support for continuing FutureGen in early 2009 but the U.S. Department of Energy decided to postpone its official decision of FutureGen's fate until early 2010.[139]

Climate change regulation proponents also contend free allocation of GHG allowances will help to mitigate the cost of carbon reduction early in the compliance period. However, while the power generation sector is explicitly included as a fossil-fuel exposed industry, rail, trucking, and other transport firms receive no specific mention within the ACES Act. The bill approved by the U.S. House of Representatives in June 2009 includes a 14-percent free credit allocation to "energy-intensive, trade-exposed industries" through 2020.[140] It remains unclear whether BNSF and related firms would qualify under such guidelines. Until such regulatory ambiguities are clarified, railroad and trucking companies will likely lobby against any climate change legislation that lacks safeguards to protect transportation firms from the cost increases constraining carbon may induce.

Chapter Six: Building Carbon Partnerships within the Lone Star State

Consideration of both residential and commercial transportation activities suggests policymakers need to devote greater attention to educating private motorists and freight haulers on why climate change regulation is so important. Otherwise, drivers will simply view any market-based, greenhouse gas reduction mechanism, such as a carbon tax, as an added cost burden that should be vehemently opposed. The State of Texas, which is comparatively fossil-fuel intensive from a transportation standpoint, presents both a challenge and opportunity to advocates of a comprehensive, national climate change policy.

Inclusion of transportation stakeholders in the regulation discussion may generate GHG reduction alternatives that the ACES Act and other previous climate change bills failed to consider. According to the American Trucking Associations (ATA), trucking firms would like to do their part to support climate change efforts, if legislators asked their opinion rather than only giving them mandates to comply with. Previous discussion has concerned the importance of increasing fuel economy. However, the ATA maintains that solely focusing on the miles-per-gallon metric misses an important opportunity to increase trucking emissions efficiency.[141] Chapter Five indicated freight railroads have greater fuel efficiencies compared to trucks, according to the U.S. Department of Transportation, because both modes are judged on the basis of ton-miles-per-gallon. Noel Perry of Freight Transportation Research Associates explains,

> Modifying existing truck size and weight standards, which have been frozen in the U.S. for over 20 years, would also improve transport's environmental footprint substantially. Both energy efficiency and safety would be improved by the operation of larger, but fewer trucks.[142]

According to this argument, by allowing nationwide access to dual, 33-foot-long tractor trailers, linked in series and pulled by one cab--sometimes referred to as western longer combination vehicles (LCVs)--regulators would enable the trucking industry to achieve a reduction of approximately 295 million tCO_2e over ten years. The attention given the importance of improving mpg CAFÉ standards over the past decade has been a positive development. However, equal awareness should be afforded the "ton" component in the ton-miles-per-gallon efficiency metric.[143]

In addition to greater knowledge transfer between transportation firms and regulators regarding how best to address the carbon externality, climate change advocates could win Lone Star allies by increasing Texan awareness of how the state could benefit in a carbon-constrained economy. Namely, if a carbon tax were to increase the cost of traditional transportation fossil fuels like gasoline and diesel, Texas could capitalize on its local renewable energy production, namely wind, and potential for advanced biofuel generation.

The Southwest, particularly Texas, has well documented advantages in terms of renewable power generation. Figures 8 and 9 show Texas' solar and wind energy characteristics, respectively. Generally speaking, prevailing weather patterns cause both solar and wind potential to increase going east to west across the Southwest region with the desert areas near El Paso, the high plains of eastern New Mexico and the Texas Panhandle featuring some of the windiest and sunniest locations in the nation.[144] Legislative mandates, including the Texas Renewable Portfolio Standard (RPS) passed in 1999, have incentivized utilities in the Lone Star State to harness these clean resources, particularly wind. In 2006, Texas surpassed California as the state with the largest amount of electricity derived from wind energy.[145] From a transportation fuel perspective, Texas' and New Mexico's wealth of wind and sunshine could promote development of a plug-in hybrid electric vehicle (PHEV) industry in the Southwest.

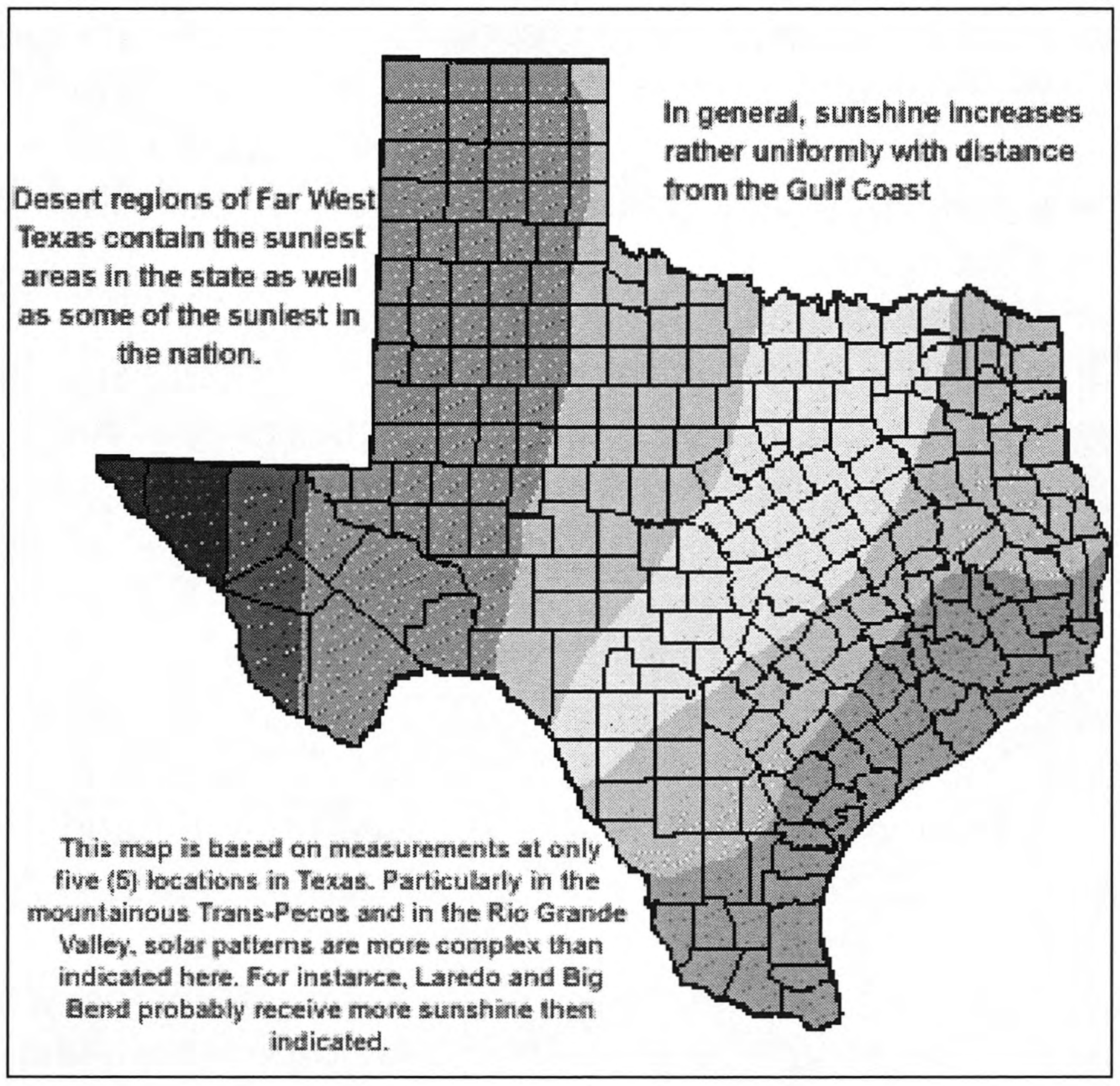

Figure 8: Texas Solar Energy Potential[146]

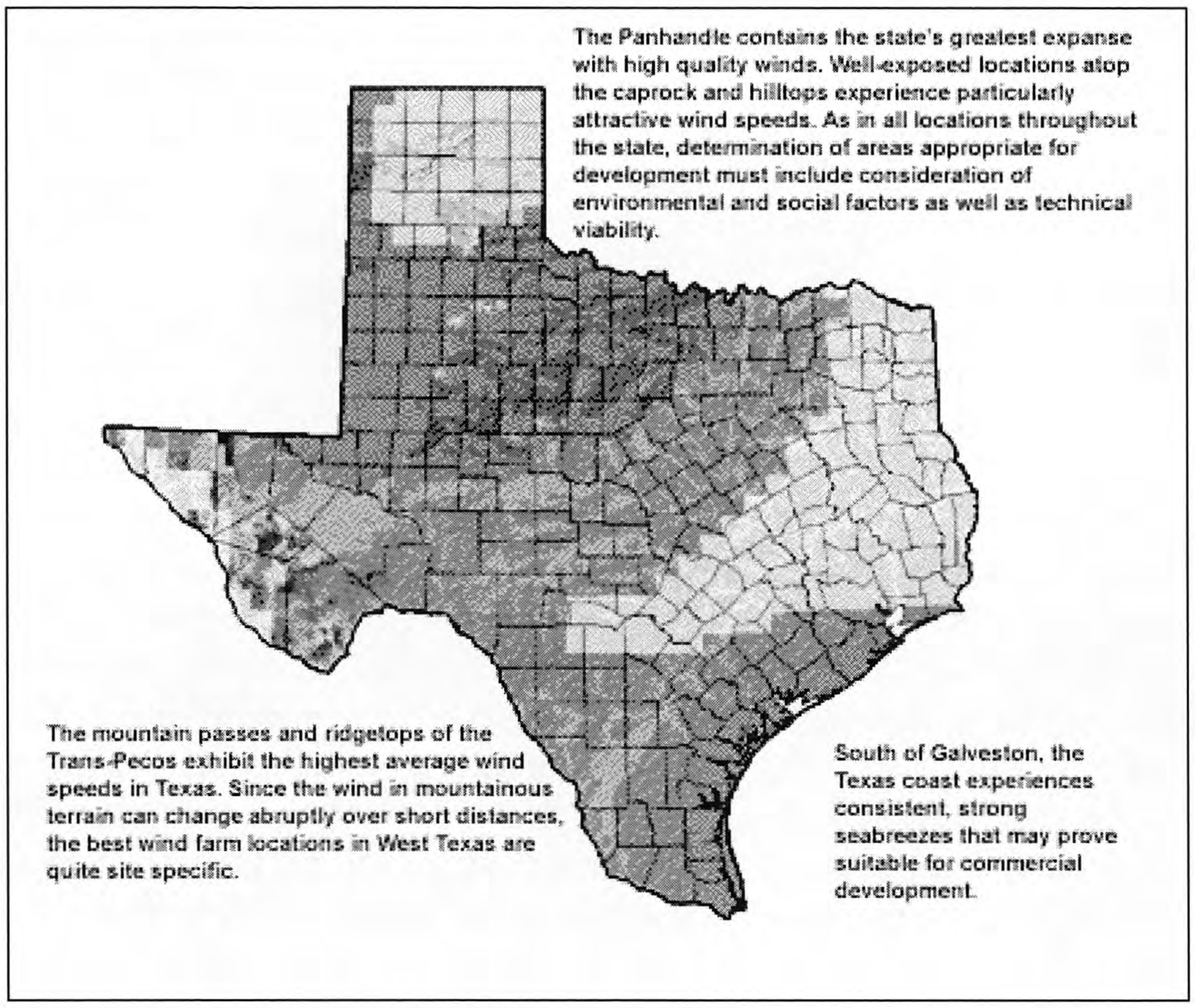

Figure 9: Texas Wind Energy Potential[147]

During the first decade of the twenty-first century, PHEVs represent the most viable application of electricity to the transportation sector. PHEVs combine a small internal combustion engine with an electric motor similar to hybrid vehicles currently commercially available, like the Toyota Prius. However, unlike conventional hybrid cars that charge their batteries with kinetic energy and power generated by their own internal combustion engines, plug-in hybrids utilize extension cords that can connect to conventional, 120-volt electrical outlets. By connecting directly to the power grid, PHEVs can realize significant reductions in gasoline consumption with peer-reviewed studies suggesting mileages of 80 to 160 miles per gallon (mpg), depending on city versus highway driving, are entirely feasible. Equipped with more powerful lithium batteries than conventional hybrid cars, PHEVs can rely on battery power alone to travel the first twenty miles. On longer trips, PHEVs would switch between their battery and internal combustion engines in a similar manner as conventional hybrids but utilize battery power a greater percentage of the time.[148] The abundance of wind and solar power generation in New Mexico and West Texas has the potential to fuel plug-in hybrid-electric vehicle re-charge stations. Wind energy is most reliable at night, which coincides with the time motor vehicles are least in demand. Plug-in hybrids could recharge at night drawing their energy from predominantly wind power. A common criticism of PHEVs is electric vehicles will not significantly "green" the transportation sector if the electricity plug-in hybrids utilize continues to come from mostly fossil fuel sources. This connection between the Southwest's renewable energy potential and the transportation sector would largely resolve this matter.

Austin Energy, the power provider for the city of Austin, is currently leading the way developing electric vehicle infrastructure. However, technological obstacles remain including more efficient methods for efficiently transporting the clean energy hundreds of miles from generation facilities in the west to population centers in the east. More importantly, battery capacity needs refinement in order to increase the distance range of PHEVs.[149]

Previous Southwest Region University Transportation Center reports have called into question the environmental benefits afforded by first-generation biofuels, like corn ethanol.[150] Moreover, Texas is not particularly well-suited for the corn ethanol industry for various reasons including the Lone Star State's semiarid climate.[151] While prospects for a first-generation biofuel renaissance in the Southwest region may look mediocre, Texas and neighboring states hold significantly more promise for transportation fuel technologies several years away from commercialization. Second-generation, cellulosic ethanol may play a significant role in developing the Southwest region's alternative transport energy economy. Cellulosic ethanol, also called lignocellulosic ethanol, is a type of biofuel produced from the structural material comprising much of a plant's mass. Corn stover, switchgrass, miscanthus and woodchips are some of the more popular cellulosic materials for ethanol production. Once synthesized, cellulosic ethanol is chemically identical to traditional forms of ethanol, including corn starch and sugar. However, cellulosic fuel production does not have some of the detrimental characteristics of first-generation ethanol. Most importantly, cellulosic ethanol synthesis would not compete with human or animal feedstock production. Although commercial production of cellulosic ethanol remains three to eight years away, preliminary research suggests various grass species including switch grass, miscanthus, and mustard seed, which can all grow under meager water and fertilizer conditions throughout the Texas prairie, would be worthwhile cellulosic energy crops. Cellulosic ethanol commercialization has the potential to open up vast tracts of fallow land in West Texas, which would fuel regional economic growth and help solve the United States' transportation energy crisis.[152]

Increasing awareness of the detrimental effects of climate change, forging public-private partnerships, and promoting ways both individuals and businesses could benefit from a decarbonized transportation sector are just a few opportunities to increase Texans' support for reductions in greenhouse gas emissions. Although the challenge is daunting, if Texas, the center of the U.S. energy industry, were to support carbon reductions, prospects for passage of a national legislative solution to combat global warming would increase dramatically. Furthermore, the Lone Star State's traditional adherence to pro-business principles would suggest a market-based mechanism, such as a carbon tax, would have a greater chance than command-and-control alternatives of garnering approval within the second-most populous state in the Union. Only time will tell if such education efforts succeed in modifying Texans' vehicle-centric transportation norms.

Endnotes

[1] U.S. Energy Information Administration, U.S. Department of Energy, Emissions of Greenhouse Gases within the United States 2008 (Washington, D.C., December 2009), p. 2. Online. Available: ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057308.pdf. Accessed: December 6, 2009.

[2] Anthony Paul, Dallas Burtraw, and Karen Palmer, Compensation for Electricity Consumers Under a CO2 Emissions Cap (Washington, D.C.: Resources for the Future, July 2008), 3.

[3] U.S. Department of Transportation, National Transportation Statistics 2007, U.S. Carbon Dioxide Emissions from Energy Use by Sector (Washington, D.C., December 2006), p. 4-49.

[4] "Table R2: Energy Consumption by Source and Total Consumption per Capita, Ranked by State, 2007," *State Energy Data 2007: Consumption* (2008). Online. Available: http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/rank_use_per_cap.pdf. Accessed: February 17, 2010.

[5] Intergovernmental Panel on Climate Change, "Summary for Policymakers," Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007). Online. Available: http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf. Accessed: November 6, 2009.

[6] The United Nations Framework Convention on Climate Change, Full Text of the Convention, Article 2: Objective (June 1992). Online. Available: http://unfccc.int/essential_background/convention/background/items/1353.php. Accessed: November 5, 2009.

[7] The United Nations Framework Convention on Climate Change, Kyoto Protocol Reference Manual (November 2008), pp. 13-14. Online. Available: http://unfccc.int/resource/docs/publications/08_unfccc_kp_ref_manual.pdf. Accessed: December 13, 2009.

[8] The United Nations Framework Convention on Climate Change, Kyoto Protocol to the United Nations Framework Convention on Climate Change, Article 10 (December 1997). Online. Available: http://unfccc.int/essential_background/kyoto_protocol/items/1678.php. Accessed: December 13, 2009.

[9] Ibid.

[10] "The Kyoto Protocol and Global Warming," Climate Change and Global Warming Fact Sheet. Online. Available: http://climatechange.110mb.com/nations-kyoto-protocol.htm. Accessed: December 13, 2009.

[11] The United Nations Framework Convention on Climate Change, Window on Kyoto Protocol (2008). Online. Available: http://unfccc.int/kyoto_protocol/items/2830.php. Accessed: November 5, 2009.

[12] The United Nations Framework Convention on Climate Change, Registry Systems Under the Kyoto Protocol (2008). Online. Available: http://unfccc.int/kyoto_protocol/registry_systems/items/2723.php. Accessed: November 5, 2009.

[13] Michael Szabo, "Emissions Traders Bullish over EU Climate Proposal," Reuters (January 23, 2008). Online. Available: http://www.reuters.com/article/environmentNews/idUSL23799320080123. Accessed: November 6, 2009.

[14] Linkages: Earth Negotiations Bulletin, Summary of the Copenhagen Climate Change Conference: December 7-19, 2009. Online. Available: http://www.iisd.ca/vol12/enb12459e.html. Accessed: February 17, 2010.

[15] "China Passes U.S., Leads World in Power Sector Carbon Emissions," Center for Global Development (August 27, 2008). Online. Available: http://www.cgdev.org/content/article/detail/16578/. Accessed: November 14, 2009.

[16] David Adam, "Recession 'Threatens UK Effort to Tackle Global Warming'," The Guardian (October 12, 2009). Online. Available: http://www.guardian.co.uk/environment/2009/oct/12/recession-threatens-global-warming-measures. Accessed: November 18, 2009.

[17] California Air Resources Board, Climate Change Scoping Plan (December 2008), p. 1. Online. Available: http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf. Accessed: December 13, 2009.

[18] California Air Resources Board, A Brief History of the Air Resources Board. Online. Available: http://www.arb.ca.gov/knowzone/history.htm. Accessed: December 13, 2009.

[19] California Air Resources Board, AB 32Fact Sheet – California Global Warming Solutions Act of 2006 (September 25, 2006). Online. Available: http://www.arb.ca.gov/cc/factsheets/ab32factsheet.pdf. Accessed: November 11, 2009.

[20] California Air Resources Board, Climate Change Scoping Plan, p. 38.

[21] Patricia Weisselberg, Shaping the Energy Future in the American West: Can California Curb Greenhouse Gas Emissions from Out-of-State, Coal-Fired Power Plants Without Violating the Dormant Commerce Clause?, in the LexisAcademic Online Database, http://www.lexisnexis.com/us/lnacademic/search/homesubmitForm.do. Accessed: February 19, 2009.

[22] California Air Resources Board, Climate Change Scoping Plan, p. 39.

[23] California Air Resources Board, Climate Change Scoping Plan, pp. 46-47.

[24] California Air Resources Board, Climate Change Scoping Plan, pp. 47-49.

[25] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, (Sacramento, California, October 2008), p. 2. Online. Available: http://www.energy.ca.gov/2008publications/CEC-100-2008-007/CEC-100-2008-007-F.PDF. Accessed: December 13, 2009.

[26] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, p. 14.

[27] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, p. 8.

[28] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, p. 14.

[29] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, pp. 12-13.

[30] The Regional Greenhouse Gas Initiative, History of RGGI (2008). Online. Available: http://www.rggi.org/about/history. Accessed: November 11, 2009.

[31] Ibid.

[32] Michael McCord, "RGGI: Quietly Setting the Standard," SeacoastOnline (September 20, 2009). Online. Available: http://www.seacoastonline.com/apps/pbcs.dll/article?AID=/20090920/NEWS/909200341/-1/NEWSMAP. Accessed: November 13, 2009.

[33] The Regional Greenhouse Gas Initiative, Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (March 2008), p. 1. Online. Available: http://rggi.org/docs/20080331leakage.pdf. Accessed: December 13, 2009.

[34] California Energy Commission and California Public Utilities Commission, Final Opinion and Recommendations on Greenhouse Gas Regulatory Strategies, p. 242.

[35] The Regional Greenhouse Gas Initiative, Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (March 2008), p. 3.

[36] The Regional Greenhouse Gas Initiative, Program Contacts by State (2008). Online. Available: http://www.rggi.org/Program_Contacts_By_State. Accessed: December 13, 2009.

[37] Patricia Weisselberg, Shaping the Energy Future in the American West. Accessed: October 17, 2009.

[38] Pew Center on Global Climate Change, *State Climate Action Plans*. Online. Available: http://www.pewclimate.org/what_s_being_done/in_the_states/action_plan_map.cfm. Accessed: April 28, 2010.

[39] The White House - President George W. Bush, President Bush Discusses Global Climate Change. Online. Available: http://georgewbush-whitehouse.archives.gov/news/releases/2001/06/20010611-2.html. Accessed: December 13, 2009.

[40] United Nations Framework Convention on Climate Change, "Projected Greenhouse Gas Emissions," in U.S. Climate Action Report 2006: Fourth National Communication of the United States of America under the United Nations Framework Convention on Climate Change (Washington, D.C. 2006), 60.

[41] United Nations Framework Convention on Climate Change, "Projected Greenhouse Gas Emissions," 61.

[42] New Energy for America, Organizing for America. Online. Available: http://www.barackobama.com/issues/newenergy/index.php. Accessed: November 13, 2009.

[43] Massachusetts et al. v. Environmental Protection Agency, 42 U.S. 7401-7671q (2007) 3, Supreme Court syllabus available at http://www.supremecourtus.gov/opinions/06pdf/05-1120.pdf.

[44] U.S. Congress, Section 109, Clean Air Act Amendments, 1990, 101st Congress, 2nd session (2008). Online. Available:

http://www.law.cornell.edu/uscode/html/uscode42/usc_sec_42_00007409----000-.html. Accessed: December 13, 2009.

[45] Massachusetts et al. v. Environmental Protection Agency, 42 U.S. 7401-7671q (2007) 3.

[46] CleanMPG, Massachusetts v EPA – Court Rules 5-4 for Mass. Online. Available: http://www.cleanmpg.com/forums/showthread.php?t=4029. Accessed: December 13, 2009.

[47] Massachusetts et al. v. Environmental Protection Agency, 42 U.S. 7401-7671q (2007) 4-5, Supreme Court syllabus available at http://www.supremecourtus.gov/opinions/06pdf/05-1120.pdf.

[48] Interview with Heidi King, Desk Officer, Natural Resources and Environment Branch, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C., August 7, 2009.

[49] Ibid.

[50] GovTrack.US – A Civic Project to Track Congress, H.R. 2454: American Clean Energy and Security Act of 2009. Online. Available: http://www.govtrack.us/congress/bill.xpd?bill=h111-2454. Accessed: November 14, 2009.

[51] U.S. Congress, Senate, Lieberman-Warner Climate Security Act of 2008, Senate Bill 3036, 110th Congress, 2nd session (2008). Online. Available: http://www.govtrack.us/congress/billtext.xpd?bill=s110-3036. Accessed: December 13, 2009.

[52] U.S. Congress, House, American Clean Energy and Security Act of 2009, House Bill 2454, Title III, Subtitle A, 111th Congress, 1st session (2009).

[53] U.S. Congress, House, American Clean Energy and Security Act of 2009, Part H, Sec. 782.

[54] Summary of the American Clean Energy and Security Act of 2009, Title III, Subtitle B. Accessed: November 14, 2009.

[55] U.S. Congress, Senate, Clean Energy Jobs and American Power Act of 2009, Senate Bill 1733, 111th Congress, 1st session (2009). Online. Available: http://kerry.senate.gov/cleanenergyjobsandamericanpower/pdf/bill.pdf. Accessed: December 13, 2009.

[56] "Senator Baucus Says Opposes Kerry-Boxer Climate Bill," Reuters (November 5, 2009). Online. Available: http://www.reuters.com/article/environmentNews/idUSTRE5A42V220091105. Accessed: November 14, 2009.

[57] Interview with Charles Groat, PhD, Director, Energy and Earth Resources Program, Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, November 14, 2009.

[58] U.S. Congress, Best Available Technology (BAT), Section 169, Clean Air Act Amendments, 1977, 95th Congress, 1st session (2008). Online. Available: http://www.law.cornell.edu/uscode/html/uscode42/usc_sec_42_00007479----000-.html. Accessed: December 13, 2009.

[59] Richard A. Kerr, "Acid Rain Control: Success on the Cheap," Science, vol. 282, no. 5391 (November 6, 1998): 1024. Online. Available:

http://www.sciencemag.org/cgi/content/full/282/5391/1024?ck=ck. Accessed: November 6, 2009.

[60] CleanMPG, Massachusetts v EPA – Court Rules 5-4 for Mass. Accessed: April 28, 2010.

[61] Ole Fauchald, Environmental Taxes and Trade Discrimination (London: Kluwer Law International, 1998), 30-1.

[62] Marla Cone, "California Cars to Switch to Cleaner Gas; Blend is Part of Broad Effort to Fight Smog," *The Washington Post*, January 14, 1996.

[63] C. Hepburn, "Regulating by Prices, Quantities, or Both: An Update and an Overview," Oxford Review of Economic Policy, vol. 22, no. 2 (2006), pp. 226-227. Online. Available: http://www.economics.ox.ac.uk/members/cameron.hepburn/Hepburn%20(2006,%20Oxrep)%20Regulation%20by%20P%20or%20Q.pdf. Accessed: December 13, 2009.

[64] Christina Harper, Climate Change and Tax Policy, in the LexisAcademic Online Database, http://www.lexisnexis.com/us/lnacademic/search/homesubmitForm.do. Accessed: October 17, 2009.

[65] Interview with Carey King, Center for International Energy and Environmental Policy (CIEEP), The University of Texas at Austin, Austin, Texas, November 5, 2009.

[66] Ibid.

[67] David Morris, "Green Taxes," Institute for Local Self-Reliance (1994). Online. Available: http://www.ilsr.org/ecotax/greentax.html. Accessed: October 17, 2009.

[68] Gareth Osborn and Tom Tietenberg, "Can Eco-taxation be Effective in Reducing Carbon Emissions?," Colby Economics Department. Online. Available: http://www.colby.edu/personal/t/thtieten/eco-taxation.htm. Accessed: November 9, 2009.

[69] Ibid.

[70] Ibid.

[71] Ibid.

[72] Christina Harper, Climate Change and Tax Policy.

[73] A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases (Arlington, VA: Pew Center on Global Climate Change, May 2003), iii.

[74] A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases, vi.

[75] A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases, vii.

[76] A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases, iii.

[77] Richard Kerr, "Acid Rain Control: Success on the Cheap."

[78] Ibid.

[79] Ibid.

[80] A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases, 12.

[81] Richard Kerr, "Acid Rain Control: Success on the Cheap."

[82] Ellerman et al., Markets for Clean Air: The U.S. Acid Rain Program (Cambridge, UK: Cambridge University Press, 2000).

[83] Joseph Wholey, Harry Hatry, and Kathryn Newcomer, ed., Handbook of Practical Program Evaluation (San Francisco: Jossey-Bass, 1994), 478.

[84] The Tax Foundation, *Tax Data: State Sales, Gasoline, Cigarette, and Alcohol Tax Rates by State, 2000-2009*. Online. Available: http://www.taxfoundation.org/taxdata/show/245.html. Accessed: February 21, 2010.

[85] Commission on the 21st Century Economy, *Proposed Carbon Tax for the State of California*, p. 1. Online. Available: http://www.cotce.ca.gov/documents/correspondence/staff_and_commissioners/documents/Carbon%20tax.pdf. Accessed: February 21, 2010.

[86] Ole Fauchald, Environmental Taxes and Trade Discrimination.

[87] Commission on the 21st Century Economy, *Proposed Carbon Tax for the State of California*, p. 3.

[88] U.S. Census Bureau, *Texas Fact Sheet*. Online. Available: http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=04000US48&_geoContext=01000US%7C04000US48&_street=&_county=&_cityTown=&_state=04000US48&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=040&_submenuld=factsheet_1&ds_name=null&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=. Accessed: March 15, 2010.

[89] Energy Information Administration, U.S. Department of Energy, *Texas State Energy Profile*. Online. Available: http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=TX. Accessed: March 15, 2010.

[90] Ibid.

[91] Ibid.

[92] Adapted from Energy Information Administration, U.S. Department of Energy, *Texas State Energy Profile.*

[93] U.S. Census Bureau, *Texas State Profile*. Online. Available: http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=&_state=04000US48&_county=&_cityTown=&_zip=&_sse=on&_lang=en&pctxt=fph. Accessed : March 16, 2010.

[94] U.S. Department of Transportation, Bureau of Transportation Statistics, *Texas Transportation Profile* (Washington, D.C.: Bureau of Transportation Statistics, 2002), A1.

[95] Texas Department of State Health Services, *Projected Texas Population by Area, 2010.* Online. Available: http://www.dshs.state.tx.us/chs/popdat/ST2010.shtm. Accessed: March 24, 2010.

[96] *Texas Transportation Profile*, A9.

[97] *Texas Transportation Profile*, A12.

[98] *Texas Transportation Profile*, A13.

[99] *Texas Transportation Profile*, D1.

[100] *Texas Transportation Profile*, E1.

[101] *Texas Transportation Profile*, E3.

[102] *Texas Transportation Profile*, G1.

[103] *Texas Transportation Profile*, G5.

[104] Office of Management and Budget, Executive Office of the President of the United States, *Environmental Protection Agency 2011 Budget Summary*. Online. Available: http://www.gpoaccess.gov/usbudget/fy11/pdf/budget/environmental.pdf. Accessed: April 7, 2010.

[105] Todd Litman, "Evaluating Carbon Taxes as an Energy Conservation and Emission Reduction Strategy," *Transportation Research Record: Journal of the Transportation Research Board* 2139 (2009): 125-126.

[106] Todd Litman, "Evaluating Carbon Taxes as an Energy Conservation and Emission Reduction Strategy," 125.

[107] Todd Litman, "Evaluating Carbon Taxes as an Energy Conservation and Emission Reduction Strategy," 126.

[108] Ibid.

[109] Jonathan E. Hughes, Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," *The Energy Journal*, vol. 29, no. 1 (IAEE 2008), p. 131.

[110] Ibid.

[111] S.E. Polzin and X. Chu, "A Closer Look at Public Transportation Mode Share Trends," *Journal of Transportation and Statistics*, vol. 8, no. 3 (2005), pp. 41-53.

[112] Jonathan E. Hughes, Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," p. 132.

[113] Arliadi Mahadi and Kelly Sims Gallagher, "Fuel Prices and Consumer Preferences for Vehicles," *Transportation Research Record: Journal of the Transportation Research Board* 2139 (2009): 33.

[114] Arliadi Mahadi and Kelly Sims Gallagher, "Fuel Prices and Consumer Preferences for Vehicles," 35.

[115] T.S. Turrentine and K.S. Kurani, "Car Buyers and Fuel Economy?," *Energy Policy*, vol. 35 (2007), pp. 1213-1223.

[116] Jonathan E. Hughes, Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," p. 133.

[117] Ibid.

[118] Burlington Northern Santa-Fe Railway, *Texas: Home to a Transportation Leader*, 2008.

[119] Access Maps, *Texas Highway Map*. Online. Available: http://www.aaccessmaps.com/show/map/us/tx/texas_all. Accessed: April 12, 2010.

[120] Phone interview with Stevan Bobb, Vice President for Coal Marketing, Burlington Northern Santa-Fe Railway, March 30, 2010.

[121] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors* (Washington, D.C., 2009), p. 55.

[122] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 58.

[123] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 64.

[124] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 70.

[125] Interview with Clayton Boyce, Vice President for Public Affairs, American Trucking Associations, January 4, 2010.

[126]Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 58.

[127] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 59.

[128] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 64.

[129] Federal Railroad Administration, *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*, p. 65.

[130] Phone interview with Stevan Bobb.

[131] Association of American Railroads, Citi Investment Research and Analysis, "Coal in Context," (April 11, 2010).

[132] Burlington Northern Santa-Fe Railway, *Texas: Home to a Transportation Leader*, 2008.

[133] Association of American Railroads, Citi Investment Research and Analysis.

[134] Burlington Northern Santa-Fe Railway, *Texas: Home to a Transportation Leader*, 2008.

[135] Phone interview with Stevan Bobb.

[136] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress* (Washington, D.C., June 23, 2009), p. 10. Online. Available: http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis.pdf. Accessed: April 24, 2010.

[137] Phone interview with Stevan Bobb.

[138] U.S. Environmental Protection Agency, *EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress*, p. 10.

[139] "Department of Energy Takes Another Step Forward on FutureGen Project in Mattoon, IL," U.S. Department of Energy, July 14, 2009 (press release). Online. Available: http://www.futuregenalliance.org/news/doe_pr_07_14_09.pdf. Accessed: April 24, 2010.

[140] White House Office of Energy and Climate Change Policy, *Summary of Cap-and-Trade Provisions of the Waxman-Markey Bill (H.R. 2454)* (Washington, D.C., May 2009), p. 4.

[141] American Trucking Associations, *Trucks Deliver a Cleaner Tomorrow, Recommendation 5: More Productive Truck Combinations*. Online. Available: http://www.trucksdeliver.org/recommendations/truck-size.html. Accessed: April 26, 2010.

[142] Interview with Clayton Boyce, Vice President for Public Affairs, American Trucking Associations.

[143] American Trucking Associations, *Strategies for Reducing the Trucking Industry's Carbon Footprint*, p. 12. Online. Available: http://www.trucksdeliver.org/pdfs/Campaign_Executive_Summary.pdf. Accessed: April 26, 2010.

[144] Class presentation by Richard Kyle, PhD, Professor at the Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, October 4, 2007.

[145] "Texas Renewable Portfolio Standard." *Texas State Energy Conservation Office (SECO)*. 2007. Online. Available: http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm. Accessed April 26, 2010.

[146] Class presentation by Richard Kyle, PhD, Professor at the Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, October 4, 2007.

[147] Class presentation by Richard Kyle, PhD, Professor at the Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, October 4, 2007.

[148] Joseph Romm and Peter Fox-Penner, *Plugging into the Grid* (Washington, D.C.: Progressive Policy Institute, March 2007), p. 1.

[149] Interview with Fred Blood, Alternative Energy Coordinator, Austin Energy, Austin, Texas, December 10, 2007.

[150] Southwest Region University Transportation Center, *A Scoping Study of the Impacts of Bioenergy and Alternative Fuels on the Southwest Region's Economy and Transportation Infrastructure* (Austin, TX: Center for Transportation Research, 2008), p. vii.

[151] Southwest Region University Transportation Center, pp. 64-65.

[152] "Cellulosic Ethanol." Texas State Energy Conservation Office (SECO). 2007. Online. Available: http://www.seco.cpa.state.tx.us/re_ethanol_cellulosic.htm. Accessed April 29, 2010.