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Controlling Carbon: A Study of National and Regional Emissions Trading Systems

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Abstract:

The release of carbon and other chemicals into the atmosphere is a growing environmental problem. The use of carbon-based processes is at an all-time high with the continued growth in carbon-fueled transportation, electric power generation and other carbon-intensive industrial processes. With climate change increasingly threatening the daily lives of Earth's population, many countries are beginning to take steps to reduce their impact on the Earth and its climate. Over the last decade, carbon markets have been established in 18 countries worldwide. While all of these emissions trading systems have similarities, each also has some unique traits, including differences in allowance prices, strategies for allowance allocation, size, and linkages to other regional systems. This research compares four specific emissions trading systems: New Zealand, the European Union, and two in the United States, weighing the successes and failures within each system and assessing the characteristics of an "ideal" system that could serve as a global emissions trading system.

Advisor: J. Douglass Klein

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1. Introduction

The release of carbon and other chemicals into the atmosphere is increasingly becoming an issue in today's environment. While the natural greenhouse gas effect of the Earth's atmosphere aids in making this planet habitable, the release of man-made greenhouse gases into the atmosphere intensify this natural phenomenon resulting in a rise in global temperatures and other adverse environmental effects. The use of carbon-based processes is at an all-time high with the use of and reliance on automobiles and the industries that release carbon as a byproduct of production. With climate change becoming more and more prevalent in the daily lives of Earth's population, many countries are beginning to take steps to reduce their impact on the Earth and its climate. Climate change has become a mainstream political issue with variable political framework addressing the protocol of national governments for coping with this issue (Giddens 2009). The introduction of carbon-markets to address the issue of climate change is creating a connection between the natural world and the current government and policy to help find a common solution.

Four of the most interesting and somewhat successful emissions trading markets in the world are in the European Union, New Zealand, the RGGI system in the Northeastern United States of America, and the sulfur dioxide trading system in the United States. While all four systems operate with many similar tactics, each carries its own unique traits to the realm of carbon markets, including; differences in allowance prices, strategies for allowance allocation, and size. This paper will compare four case studies of the emissions trading systems in New Zealand, the European Union, and two in the United States. This will include a comparison and analysis of the successes and failures within each system to determine the characteristics of an ideal system that would succeed on a global level to work to reduce the total amount of carbon emitted into Earth's atmosphere.

The remainder of this thesis is organized as follows: the second chapter will inform the reader of mechanisms used to reduce and control carbon. While the study of a market based system is the main focus of this thesis, there exist other physical and

economic mechanisms to control carbon at the source. This section will include information on taxes and fines imposed on carbon emitters, responses to carbon production to control carbon emissions as well as other harmful emissions, while also including some market-based systems. The following chapter will be a review of the literature regarding carbon markets. This chapter will define what a carbon market is and the purposes one serves, specifically related to the improvement of the environment in regards to carbon emissions as well as accomplishing economic goals in the process. This chapter will also include information on where carbon is traded in the world. As this thesis will describe, carbon is traded through markets based on allocation allowances, and this chapter will describe different carbon markets across the globe and the methods to trade these allowances.

The following four chapters will cover four case studies of emissions markets across the globe. The first of these chapters, chapter four, will focus on the sulfur dioxide cap-and-trade program in the United States. A history of this program will be given including environmental and human health effects that sparked its creation, its emissions reduction goals, and current successes of the program as a whole.

Chapter five is a case study of the European Union Emissions Trading System. This chapter will describe in detail how the system was established, the history of carbon emissions within the country to show the country's recognition of the need for a carbon cap-and-trade system. This section will also include a review of the system to-date, its current successes, challenges faced since the inception of the program, and future plans and projections for the duration of the system.

The third of these four chapters, chapter six, will be a case study of the New Zealand emissions trading system, including an overview of the policies regarding greenhouse gas emissions throughout the country of New Zealand, how allowances are allocated to participating facilities, and the pricing of allowances. This chapter will also summarize the success of the program and any future projections intended for the length of the program.

The last case study, chapter seven, examines the United States carbon emissions trading scheme. This chapter will be an in-depth study of the United State's greenhouse gas cap-and-trade program: the Regional Greenhouse Gas Initiative. This chapter will

include information on the inception of the program and initial goals and projections for this system. A summary will also be provided of current successes, allocations to participating states, as well as an overview of the program design.

The next chapter will compare different mechanisms within policy types in carbon-market systems across the globe. It will include a comparison of policy types, focusing on the allocation mechanisms within systems. It will also include a study of trading between systems and the benefits of exchange pathways between carbon markets.

The penultimate chapter of this thesis will be an analysis and potential creation of an ideal emissions trading system. This section will hypothetically design a system by first outlining the definition and criteria for an ideal emissions trading system and its goals. This section will also highlight successes of markets around the world and create a system that will yield the greatest results in reducing the carbon footprint of the world while also remaining in the boundaries of what is feasible in today's world economy. This chapter will be followed by a concluding section of the thesis, which includes a brief summary of the main points covered in this thesis and suggestions for further research in the subject area.

2. Mechanisms to Reduce and Control Emissions

This chapter will describe various mechanisms used to reduce and control the release of emissions into the atmosphere, including carbon emissions and sulfur dioxide emissions that are included in the case-study of emissions systems in the chapters to follow (chapters 4-7). The chapter will include sections on three major types of emissions-controlling mechanisms: taxes and fines, carbon capturing and sequestration, and markets.

2.1: Taxes, Fees, and Fines

Through the combustion of fossil fuels, humans are causing a rise in the global average temperature and changing the planet's climate system. This change has been largely attributed to an increase in the concentration of carbon dioxide (CO_2) in the atmosphere due to the use of coal, oil, and natural gas as our main energy sources. Many countries have considered implementing unilateral taxes to reduce human-caused CO_2 emissions, while only six countries have a tax explicitly on carbon (five Scandinavian countries and the United Kingdom) (Böhringer 1996, Gerlagh 2006, Jorgenson and Wilcoxen 1993, and Metcalf 2009). In 2007, President George W. Bush called for the United States as well as other major greenhouse gas emitting countries to "set a long-term goal for reducing greenhouse gases" (Hassett et al. 2009). Specifically, a carbon tax creates a cost to emissions by directly taxing the carbon content of fuels (Hassett et al. 2009). A carbon tax is a specific tax, such as a fixed amount per ton of coal or barrel of oil purchased, designed to internalize the externalities associated with the consumption of fossil fuels (Poterba 1991).

A tax imposed unilaterally in an open economy has the ability to have a significant impact on production and employment of energy- and export- intensive industries (Böhringer 1996). While this reduces the international competitiveness of certain industries, it also increases the cost of enforcing environmental policy and is often a point of conflict when implementing such a tax. Multiple international conferences throughout the years have called for sizeable reductions in the combustion of fossil fuels (Böhringer 1996 and Gerlagh 2006). It has proven difficult to construct a worldwide carbon dioxide-reduction schedule that works for all involved countries, resulting in the

lack of a concrete policy regarding the reduction of carbon dioxide emissions. The European Union mandated taxes on carbon emissions as an instrument to reducing global carbon dioxide emissions, under the condition that other developed countries would follow suit (Böhringer 1996). In order to remain internationally competitive in certain industries, some industries (i.e. power and energy) are exempted from the tax, resulting in a hindrance of success in reducing emissions.

In California, the issue of transportation emission reduction was addressed with the possibility of fuel taxes, vehicle miles of travel (VMT) fees, and emissions fees. With fuel taxes, an additional charge was proposed to pay for (among other things ranging from highway maintenance to the funding of transportation facilities) support programs for mitigating air pollution and greenhouse effects (Deakin 1996). Along with using the money collected from this tax to take action against negative effects of emissions, the fee would encourage some travelers to reduce or combine trips, use public transit, and even transition to a more fuel-efficient vehicle. The VMT fees would directly encourage a reduction in the amount of miles driven, but would not necessarily encourage a traveler to purchase a more fuel-efficient car, therefore having very little impact on the type of vehicles emitting. The emissions fee would likely be the most effective in inciting the use of fuel-efficient vehicles and a general reduction in the amount of harmful gasses emitted (Deakin 1996).

The taxing of carbon dioxide emissions is a nearly cost-efficient policy instrument to attain more strict climate change control goals, and using the resulting tax revenues (estimated to be significant) to support non-carbon energy resources reduces the costs associated with climate change mitigation while also promoting the use of renewable energy (Gerlagh 2006, Jorgenson and Wilcoxen 1993). A tax large enough to significantly slow carbon dioxide emissions would potentially collect revenues equal to several percent of the world GDP (Poterba 1991). Increasing energy prices through the implementation of a carbon tax will contribute to increase in efficiency investments, reducing the reliance on carbon-based fuels and ameliorating the problem (Metcalf 2009).

Jorgenson and Wilcoxen (1993) studied the effects of a carbon tax on emissions reductions in the United States and cost effectiveness in four different scenarios. Scenario 1 is if no carbon tax was implemented, and scenarios 2-4 focus on alterations of

a carbon tax. They stated that a carbon tax would raise the cost of coal-based energy, resulting in a decline in coal demand (Jorgenson and Wilcoxen 1993). In addition to potentially decreasing reliance on coal-based energy, a carbon tax would raise a significant amount of revenue each year that could be put back into the economy of the area. In scenario 4 of their model, Jorgenson and Wilcoxen designed the scenario to reflect a carbon tax on the content of primary fossil fuels just high enough to hold the United States CO_2 emissions at the 1990 level of 1576 million tons. The price of the carbon tax is designed to increase annually to eventually reach a price of USD $22.71 per ton of carbon (Figures 2.1.i and 2.1.ii below) (Jorgenson and Wilcoxen 1993).

Figure 2.1.i: Carbon Tax under Scenario 4

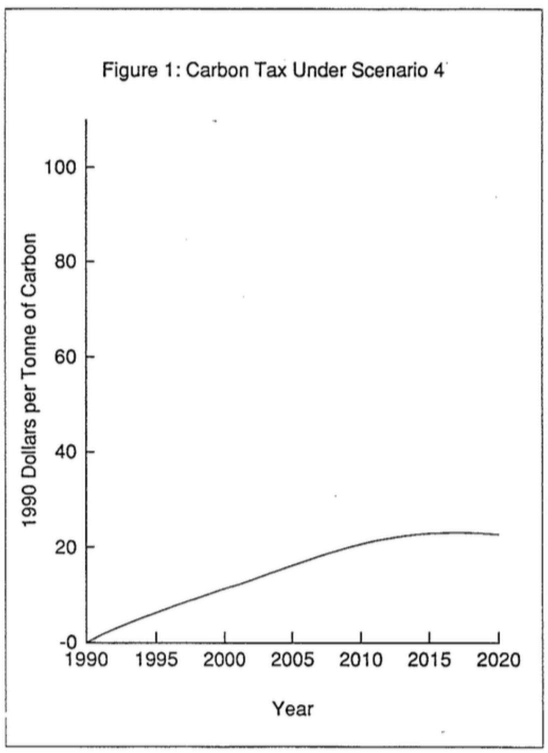
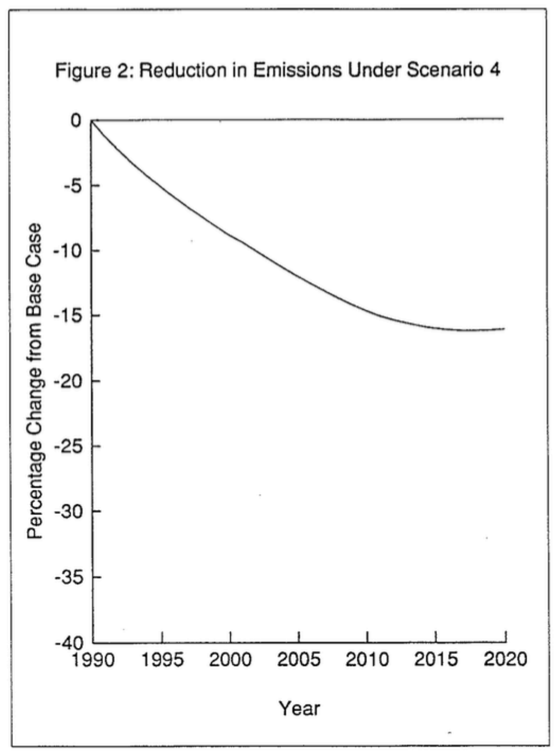


Figure 2.1.ii: Reduction in emissions under Scenario 4



Source: Jorgenson and Wilcoxen 1993

Scenarios 2-3 in the model represent more ambitious goals for the control of CO_2. In scenario 2, the tax is designed to result in a gradual decline in emissions through 2010, then ending up 20 percent below 1990 levels. Scenario 3 reflects a 20 percent fall by 2010 followed by a 50 percent reduction by 2050 (Figure 2.1.iii) (Jorgenson and Wilcoxen 1993). While scenario 3 seems to result in the highest reduction of emissions, Jorgenson and Wilcoxen concluded that as the stringency of the policy increased, the cost increased as well (Table 2.1.ii. and table 2.1.iv). When comparing scenario 4 with scenario 2, emissions dropped 32.9 percent in scenario 2 instead of just 16.12 percent in scenario 4, but the carbon tax was tripled in scenario 2 and the energy output under that tax declined significantly (Figure 2.1.iv below). When comparing scenario 3 against scenario 4, the carbon tax and loss of gross national product (GNP) increased by a factor of four in scenario 3 while the carbon reduction increased only by a factor of 2.4 (Jorgenson and Wilcoxen 1993). Due to this, the conservative approach of scenario 4 was determined to be the most effective in reducing emissions as well as remaining cost-effective for those affected by the tax (Table 2.1.v).

Figure 2.1.iii: Carbon Taxes Under Scenarios 2-4

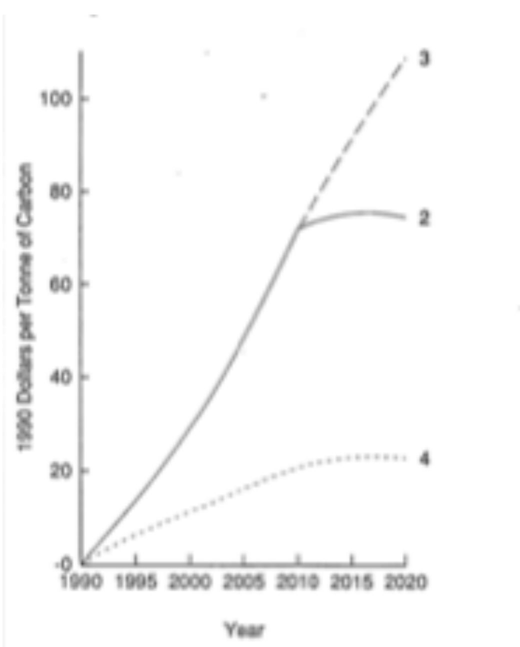
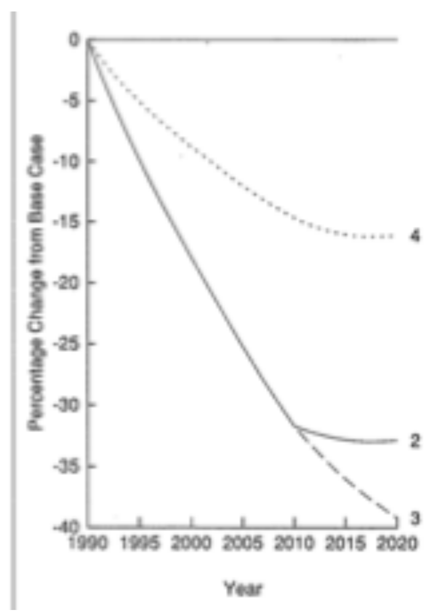


Figure 2.1.iv: Reduction in Emissions Under Scenario 4



Source: Jorgenson and Wilcoxen 1993

Table 2.1.v: Results for Scenarios 2-4 in 2020

Table 4: Selected Results for Scenarios 2-4 in 2020

Variable	Unit	Scenario		
		2	3	4
Carbon Emissions	%Δ	-32.90	-39.19	-16.12
Carbon Tax	$/t	74.49	108.78	22.71
Price of Capital	%Δ	1.10	1.40	0.40
Capital Stock	%Δ	-2.35	-2.95	-0.83
Tax Revenue	$B	82.52	109.16	31.41
Real GNP	%Δ	-1.71	-2.36	-0.55
Coal Price	%Δ	149.86	216.09	46.99
Coal Output	%Δ	-55.03	-62.47	-29.28
Electricity Price	%Δ	19.46	26.90	6.60
Electricity Output	%Δ	-16.43	-21.74	-6.17
Oil Price	%Δ	15.06	22.37	4.45
Oil Output	%Δ	-12.35	-17.63	-3.90

Source: Jorgenson and Wilcoxen 1993

2.2: Response to Emitted Carbon: Carbon Capture and Sequestration

This section will cover the method of carbon capture and sequestration used by carbon emitters to capture emissions and prevent their release into the atmosphere, contributing to the rise in atmospheric temperatures.

In 1992, over 250 scientists and engineers from around the world gathered in Amsterdam for the First International Conference on Carbon Dioxide Removal (ICCDR-1) (Herzog 2001). This meeting sparked the movement that led to carbon capture and

sequestration, along with the creation of an interconnected international community, including the creation of agencies such as the United States Department of Energy (DOE), establishing programs in carbon sequestration (Herzog 2001). The main device used to reduce emissions is the system of carbon capturing and sequestration (CCS). Generally, carbon is naturally sequestered through natural sinks such as forests, but the amount of carbon being released into atmosphere coupled with worldwide deforestation causes the natural process to work too slowly for the desired effect of mitigating climate change. The CCS system captures carbon dioxide before or after the combustion of fossil fuels, and subsequently stores it in either geological formations or the ocean, or re-uses it (Gerlagh 2006).

The enhancement of natural sinks is one approach to carbon sequestration, which includes increasing the uptake of carbon in soils and vegetation (by creating more forest space) or in the ocean (by iron fertilization), but carbon capture and sequestration from large sources is seen as emissions avoidance, reducing the need for greater natural sinks (Herzog 2001, Chen 2010). While carbon sequestration technology can similarly be applied to the reduction of nitrous oxides (NO_x) and sulfur dioxide (SO_2), the volume of CO_2 generated greatly exceeds that of other pollutants. Power plants account for more than one third of the CO_2 emissions worldwide, making them a prime candidate for carbon capture. After the carbon dioxide is captured, it can be used commercially, but most chemical processes that require CO_2 need it in the millions of tons, not the billions produced from the combustion of fossil fuels (Herzog 2001, Chu 2009).

Currently, CO_2 capture from power plant emissions is done using absorption-desorption cycling with either a solution or solid amine, transported by pipelines or ships, then pressurized and injected into a well (Chen 2010). Due to the excess amount of carbon dioxide that is available for potential capture, geological sinks (i.e. deep saline formations, depleted oil and gas reservoirs, and unminable coal seams) are ideal for carbon sequestration as they are able to hold thousands of tons of carbon, and the technology to inject carbon into these sinks is already well established. The United States has a storage capacity for CO_2 of 142.9 Gtons in oil and gas reservoirs, about 188.0-217.5 Gtons in unminable coal formations and 3619.5-13459.0 Gtons in saline aquifers (Chen 2010). In 1998, about 60 million m^3/day of CO_2 were injected into the

Earth at 67 enhanced oil recovery (EOR) sites in the United States (Herzog 2001). Abandoned coal seams are another potential storage site for the carbon, as the CO_2 is absorbed directly into the coal. Carbon dioxide can also be used to improve the recovery of coal bed methane, making the process nearly cost-free due to the additional methane removal offsetting the CO_2 storage operation costs.

An encouraging example of carbon sequestration is shown through the success of the Sleipner Project. Starting in 1996, the Sleipner Project is the first commercial application of emissions avoidance through the use of carbon capture and sequestration. The Sleipner gas and oil field is located off the coast of Norway in the North Sea. In order to meet commercial specifications, the CO_2 concentration must be reduced from about 9 percent to 2.5 percent. The common method of reduction at gas fields has been to release the gas into the atmosphere, but Sleipner took a different approach. At Sleipner, the CO_2 is compressed and pumped into a sandstone layer called the Utsira Formation located 100 m below the seabed (Herzog 2001). While the operation cost Sleipner about $80 million, the investment was paid pack in about a year and a half based solely on carbon tax savings. The Saline Aquifer CO_2 Storage (SACS) Project is monitoring the operation, and no negative effects of the project have been found, providing positive encouragement for the system as a whole. This process also carries risks, as CO_2 makes water acidic when dissolved, making it a danger if leaked to the surface or to ground water pools (Chen 2010).

Japan has a well-established carbon capture and sequestration technologies research program, having spent an estimated $50 million annually in direct research expenses, followed closely by the United States DOE carbon capture and sequestration research budget of $38 million (Herzog 2001). Prior to the US increasing their budget to the $38 million in 1998, the annual budget was only about $1-2 million. This research has the specific goal of seeking out sound carbon sequestration technologies to ensure environmentally acceptable sequestration to reduce anthropogenic CO_2 emissions and atmospheric concentrations. On a global scale, the International Energy Agency (IEA) has set up an agreement to establish the IEA Greenhouse Gas R&D (IEA GHG) Program, including 17 member countries and 7 industrial sponsors with the means to identify technologies for reducing emissions of greenhouse gases from fossil fuel use, with the

primary focus on carbon capture and sequestration (Herzog 2001, Chen 2010). While geologic and oceanic storage of CO_2 are not perfect methods, they are seen to be very effective. The ocean and atmosphere constantly exchange CO_2, meaning some (15-20%) of what is injected into the ocean will be released into the atmosphere over a period of hundreds of years, while the rest will remain indefinitely.

2.3: Markets

This section will act as a brief introduction to the world's carbon markets that will be covered in the following chapter (chapter 3) as well as in the four case-study chapters (chapter 4-7).

A carbon market is a market created from the trading of carbon emissions allowances meant to encourage and aid countries, states, and companies to limit their carbon dioxide (CO_2) emissions ("Definition", n.d.). Carbon trading is essentially the process of buying and selling of quotas or allowances that allow the holder to emit the equivalent of one ton of carbon dioxide. With this system, if a participating company, region, or country emits less than the quota it has been allowed, it can sell the excess allowances (Kill et al. 2010). On the other hand, if a participant exceeds its limits, it will have to purchase additional allowances on the market or reduce its production to meet the limit (Kill et al. 2010). Carbon markets also take into account the economic value of emissions trading, navigating the equilibrium between emissions reductions and cost-effectiveness (Gómez-Baggethun et al. 2009). The trade of carbon emissions is a way of reducing the release of greenhouse gas into the atmosphere by polluters.

The idea of carbon trading first came about in the 1960's when an economist at the University of Chicago, Ronald Coase, began promoting the idea of pollution trading, believing that pollution should be treated as a part of the cost of production (Kill et al. 2010). Coase believed that if pollution was priced as a part of the production process, market forces would eventually lead business away from polluting the environment simply because it would become less cost-effective, saying: "People don't pollute because they like polluting, they do it because it's a cheaper way of producing something else" (Kill et al. 2010). Economists at the Universities of Toronto and Wisconsin, J.H. Dales and Thomas Crocker, suggesting that while the market should control prices and

pollution levels, overall pollution limits will have to be handled by governments, developed Coase's theory further. The idea of pollution trading was seen as a way to make it cost-effective for polluters to comply with a state-set emissions target (Kill et al. 2010, Gómez-Baggethun et al. 2009).

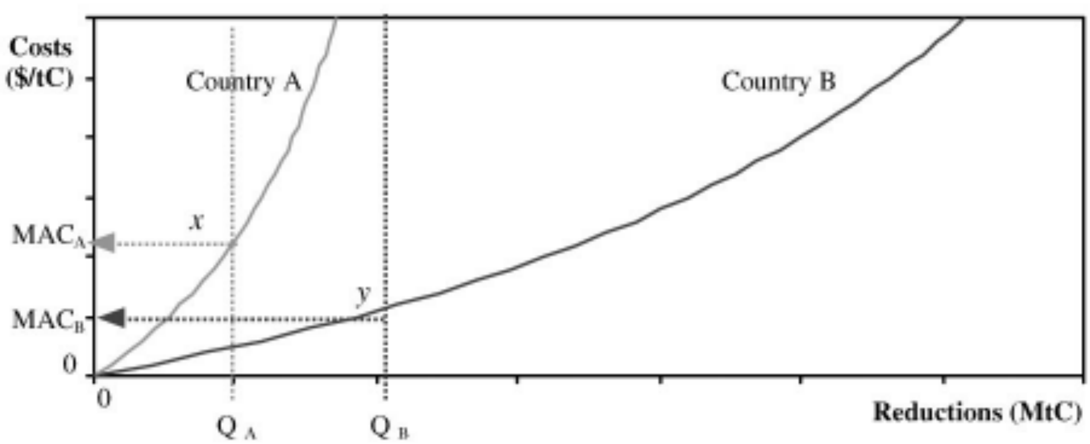
3: Carbon Markets

This chapter will discuss carbon markets in greater depth. It includes a section detailing the purpose and use of a carbon market, followed by a section summarizing all of the world's current carbon markets.

3.1: What is a carbon market?

This section will include information on what a carbon market is and how one works, as well as how carbon markets were first developed. Carbon markets were developed to control the emission of carbon into the atmosphere. The concept of emissions trading is a market-based approach to climate change abatement, factoring in the economic aspects of environmental issues. Figures 3.1.1 and 3.2.2. below show the marginal abatement costs associated with carbon reductions in two systems, and illustrate the economic factors that are associated with trading emissions permits on a market. This section will provide an in-depth description of the inner workings of a carbon market.

Figure 3.1.1 Marginal Abatement Costs of Carbon Reduction



Source: Criqui et al., 1999.

Figure 3.1.2 Marginal Abatement Costs Associated with Carbon Reduction and Tradable Permits

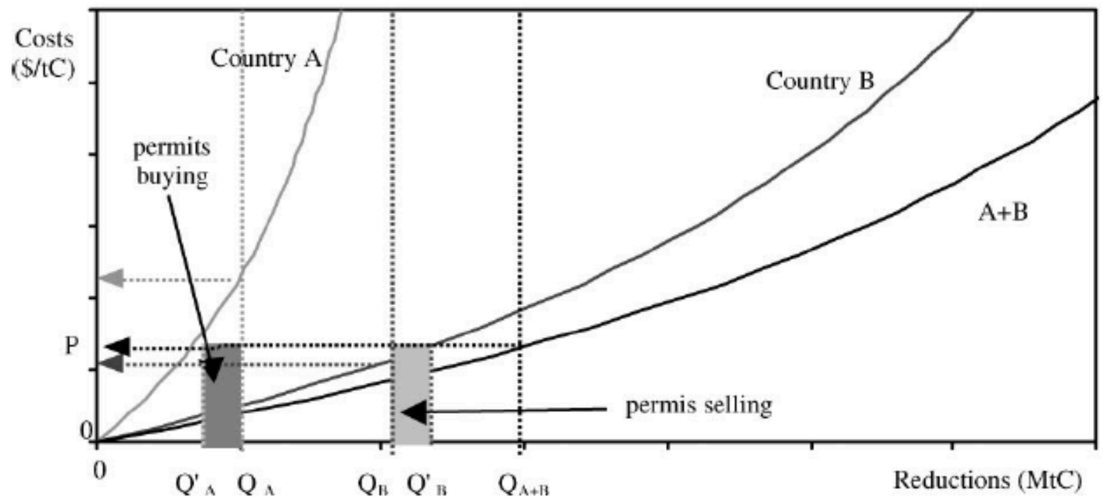


Fig. 4. Tradable permits between A and B.

Source: Criqui et al., 1999.

The idea of carbon trading is the backbone of the Kyoto Protocol. In 1992, member nations at the Earth Summit in Rio de Janeiro adopted the United Nations Framework Convention for Climate Change (UNFCCC). Under the UNFCCC, nations agreed to stabilize greenhouse gas concentrations in the atmosphere to prevent negative anthropogenic effects to the climate system in hopes of halting changes to the climate caused by human activities (Telesetsky 1999). In an effort to implement these goals, the UNFCCC introduced protocols, the first of which being the Kyoto Protocol, signed in 1997. The Kyoto Protocol puts forth binding greenhouse gas emissions targets to industrial countries and allows the use of market techniques (i.e. emissions trading) to achieve compliance (Telesetsky 1999). The United States insisted during the creation of the protocol that the trading of carbon allocations was a key element of the international climate treaty, with former Executive Secretary of the UNFCCC Michael Zammit Cutajar stating: “It is not an exaggeration to brand the mechanisms of the Kyoto Protocol as ‘Made in the USA’” (Kill et al. 2010).

In a cap and trade system, a government sets an overall limit on emissions (the cap) for a specific period of time, and grants a certain number of permits (or allowances), equivalent to one ton of carbon dioxide equivalent (CO_2e), to those releasing the emissions (Kill et al. 2010). In this case, the polluter must have enough allowances to cover the emissions it releases during the time period. If a polluter does not need all of its permits, it can trade them with another participating entity that needs to cover any excess emissions. While the cap sets the level of ambition for the system, the trading component allows compliance with the cap to be more cost-effective for the participants. To achieve the goal of the system, the distribution of allowances coupled with the monitoring of compliance ensure its success (Kill et al. 2010).

The Intergovernmental Panel on Climate Change (IPCC) recommends that the greenhouse gas concentrations in the atmosphere peak in 2015 then reduce by up to 85 percent by 2015 in order to stabilize at 445-490 ppm CO_2e. Even with this reduction, there is still a great chance that we will go over the 2 degrees of warming that has been set as the limit by the United Nations climate conferences (Kill et al. 2010). The lengths to which participating entities will go in order to comply with the cap depends on the severity of the consequences of non-compliance set by the system.

National and regional carbon trading schemes are operational across the globe, to be covered in the section to follow as well as in subsequent chapters containing case studies on four of the major systems in The European Union, the United States, and New Zealand.

3.2: Where is carbon traded?

This paper focuses mainly on four pollution markets in the world: the United States Sulfur Dioxide trading program, the United States Region Greenhouse Gas Initiative, the European Union ETS, and the New Zealand ETS. In addition to these markets, however, there also exist many other emissions trading and greenhouse gas programs throughout the world. This section will very briefly summarize existing carbon markets, including their history and implementation, and successes and failures to date.

Table 3.2: A Summary of Main Characteristics of Existing Systems

Location	Start Date	Total Emissions Level	CO2 Volume or Cap	Allowance Price (USD/tCO2)	Allocation Mechanism
UK	2001	12.5% below 1990 levels		\$3.05-18.29	
EU	2005	20% below 1990 levels (2020), 80-95% below (2050)		\$11.32 (ceiling set until 2022), about \$4.42	Free allocation (Phase I and II), freely allocated and auctioned (Phase III)
Norway	2005		15 MtCO2e/year (Phase II and III)		Free allocation (Phase I), Half allocated/half auction (Phase II), Total auction (Phase III)
Alberta, Canada	2007	12%below baseline annually (2003-2005)	32.3 million tons CO2	\$6.39-9.59 (2010)	
China	2008				
Japan	2008			~\$8-11	
New Zealand	2008	10-20% below 1990 levels (2020)	61.9 MtCO2/yr	\$1.47 (2013)	Free allocation and auctioning
Switzerland	2008	20% (10.5 MtCO2e) below 1990 levels (2020)	3.42 MtCO2 (2010)		Free allocation (2008-2012), free allocation and auctioning (2013-2020)
Brazil	2009	36.1-38.9% below BAU (2020)			Auctioned and exchanged on market
RGGI (USA)	2009	10% below 2009 levels (2020)	91 million short tons CO2 (2014)	\$2.55 (2013)	90% auctioned quarterly to each state, state then decides (free allocation/auction)
Tokyo	2010	25% below 2000 levels (2020), 50% below (2050)	1044 MtCO2 (projected for 2020)	\$100 (2012)	Free allocation
California, USA	2011	Meet 1990 levels (2020)	235 MMtCO2e (2015)	\$10 (floor), \$14.50 (2013)	Auctioned quarterly
India	2011			~\$38-43	Purchased and traded
Australia	2012	25% below 2000 levels (2020), 80% below (2050)		\$15.51-17.84 (2012-2013)	Free allocation and auctioning
Mexico	2012				Purchased/traded on the stock exchange
Kazakhstan	2013	50% below 1990 levels (2018)	147 MtCO2e		Free Allocation (Phase I) Auctioning (Phase II)
Québec	2013	20% of 1990 levels (2020)	54.74 MMTCO2e/year	\$11.99 rising 5% each year after 2012, cap at \$31.96-39.95	Free allocation (except for fuel distributors), excess allowances are auctioned
South Korea	2015	4% below 2005 levels (2020)	236 MtCO2e		Free allocation (Phase I), 97% free allocation (Phase II), 90% free allocation (Phase III)

3.2.a Alberta, Canada

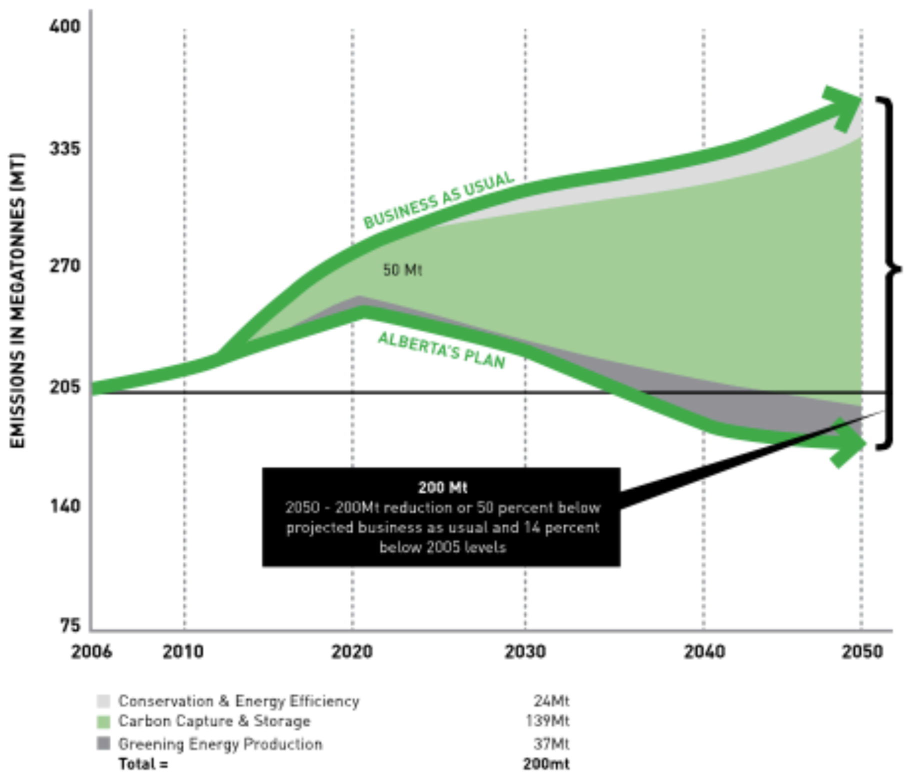
The Canadian province of Alberta committed to taking action against climate change in 2002 with the completion of a comprehensive climate change strategy. In 2003, Alberta passed the *Climate Change and Emissions Management Act*, reaffirming their commitment and leading to a mandatory reporting program for facilities emitting over 100,000 metric tons of carbon dioxide equivalent per year ($MtCO_2e/yr$). The Act required emitters to submit and annual report on their greenhouse gas emissions. In 2007, the *Specified Gas Emitters Regulation* (SGER), representing North America's first greenhouse gas regulation and compliance carbon pricing system (Sopher et al. 2014a, Talberg and Swoboda 2013). Alberta's greenhouse gas system runs on one-year compliance periods, except for the first period, which was only a half-year long and ended in December of 2007. 2014 marked the final year of SGER before any modifications take effect.

Alberta emits more greenhouse gases than any other Canadian provinces, accounting for about one-third (242 $MtCO_2e$) of Canada's overall emissions of 702 $MtCO_2e$ in 2011. The level of Alberta's emissions shows a reliance on coal-fired electricity as well as Alberta's role as a global energy supplier. Instead of placing an absolute cap on aggregate pollution, Alberta's greenhouse gas program sets a facility-level emission intensity goal (Sopher et al. 2014a, Talberg and Swoboda 2013). For facilities existing in 2000, the goal is to reduce annual emissions intensity by 12 percent below a baseline established using averages for emissions and productions during 2003-2005. For new facilities, the baseline is established during its first three years of operation. The obligation for new facilities begins at 2 percent per year, beginning in the fourth year of operation, and increases 2 percent each year until a 12 percent target is reached. Alberta's SGER does not have a decreasing target for facilities for a set amount of time, but instead requires facilities to meet a constant emissions intensity target each year (Sopher et al. 2014a).

Currently, Alberta has no existing policy to steer it toward achieving its planned reductions, and is not on track to achieve its 2020 targets. Figure 3.2.a.i below shows Alberta's planned emissions path relative to BAU levels:

Figure 3.2.a.i: Alberta's Planned Emissions Reductions from 2006-2050

Figure 2: Alberta's Planned Emissions Reductions 2006-2050



Source: IETA Greenhouse Gas Market 2012

Source: Sopher et al. 2014a

The program covers any industrial facility that has emitted over 100,000 tons of carbon dioxide equivalent in 2003 or any subsequent year. The program covers direct emissions from six greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Alberta's industrial process emissions and CO_2 from biomass are exempt from compliance requirements but must be reported on (Sopher et al. 2014a). Since the program is intensity-based, there is no allowance distribution or auctioning in place, but instead facilities are obligated to meet their 12 percent reduction below the

baseline via one of four compliance pathways. The four compliance pathways are: 1. Reduce emissions through improving the efficiency of the facility, 2. Pay a fee of CA$15 per ton of CO_2e per year to Alberta's Climate Change and Emissions Management Fund (CCEMC) (Talberg and Swoboda 2013). This fund creates a pool of resources that enables additional investments in reducing emissions or adapting to climate change, 3. Purchase an emissions offset generated from non-covered facilities in Alberta, and 4. Purchase Emissions Performance Credits (EPCs) from covered facilities that have reduced their emissions intensity below their target (Sopher et al. 2014a). Net emissions intensity if calculated using the following equation:

Net Emissions Intensity = Emissions Intensity of Covered Facility's Operations – (Fee + Offsets + Credits Production)

Where fee is the number of credits received from paying to the CCEMC, offsets equal the number of credits received form purchasing qualified offsets, and credits equals the number of EPCs purchased (Sopher et al. 2014a).

To monitor compliance, on March 31st of each year, covered facilities are required to submit a report confirming if they met their net emissions limit or provide an explanation and proposal to address non-compliance. A qualified third party auditor must also verify each report submitted. If a facility is found to be non-compliant, the director of the program may issue an order to the facility to remedy the effects of noncompliance. This may require the facility to purchase offsets or performance credits, make contributions to the CCEMC, or take any other measure the director sees fit. A fine may also be set to no more than $200 per ton of CO_2e in excess of the limit. In the case of a facility hiring an unqualified auditor, it can be fined up to $500,000 (Talberg and Swoboda 2013).

In addition to the carbon pricing system, Alberta also has two complementary policies for the reduction of greenhouse gases: a renewable fuel standard, mandating a 5 percent blend of ethanol and 2 percent blend of biodiesel; and incentives for energy efficiency. From 2007-2011, Alberta's carbon system reached 32.3 million tons of

reduction in CO_2e and raised almost $312 million for the CCEMC, $167 million of which had already been focused into Alberta-based low –carbon projects (Sopher et al. 2014a, Hood 2010). In 2010, approximately 42% of compliance was met through CCEMC payments, while 14%, 16%, and 28% of compliance was met through improvements to operations, EPCs, and emissions offsets respectively, as shown in Table 3.2.a.ii below:

Table 3.2.a.ii: Results of SGER from 2007-2011

Table 1: Operational Results for SGER (2007-2011)

SPECIFIED GAS EMITTERS REGULATION (SGER) OPERATIONAL RESULTS (SELECTED)			
Compliance Cycle	Offset Credits (in megatonnes)	Fund Payments (Cdn $)	EPC Credits Retired (in megatonnes)
2007 (half year)	1	$43 Million	0.25
2008	2.7	$82 Million	0.57
2009	3.8	$63 Million	1.2
2010	3.9	$70 Million	1.9
2011*	5.3	$55 Million	1

** Unaudited*

Source: IETA Greenhouse Gas Market 2012

Source: Sopher et al. 2014a

Since its inception, Alberta's SGER program has faced some challenges. First, it is unclear how the program will interact with any future federal Canadian government oil and gas sector regulations that are expected in the coming years. Next, as of May 2013, Alberta has not defined core proposed amendments to the program, or clear steps and

timelines for stakeholder review and consults. The delay in the process and uncertainty about the future of the program is causing concern across industry, investors, and other involved stakeholders. Finally, Alberta is not on track to meet its targets, yet remains committed to them (Sopher et al. 2014a).

3.2.b Australia

After committing to the Kyoto Protocol in 2007, an Australian Government Green Paper was released in 2008, followed by an independent review recommending the implementation of a national emissions trading system with a target of 25 percent reduction from 2000 emissions level by 2020. Following the independent review, a Government White Paper was issued setting out government policy on emissions reductions and refining the design of the Carbon Pollution Reduction Scheme (CPRS), a policy measure to achieve emissions targets (Sopher et al. 2014b, Hood 2010). After multiple political disagreements through elections, the Clean Energy Future (CEF) legislation was announced in the Climate Change Plan in July 2011 and passed the following fall. The main feature of the legislation is a Carbon Pricing Mechanism (CPM), which began in July 2012 as a system that allowed permits to be purchased from the government. The CPM is scheduled to transition into an emissions trading system in July 2015.

The Australian government put forth an emissions reduction target of 5 percent below 2000 levels by 2020 in 2010 (Sopher et al. 2014b, Hood 2010, Jotzo and Betz 2009). Following negotiations with the Green Party, a long-term target of 80 percent reduction below 2000 levels by 2050 was set. The first cap was set in May 2014 and will remain for five years and remains flexible following annual reviews to determine the cap for the next undefined year. With this system, the caps are set five years in advance to ensure national emissions meet international obligations. The system will cover about 60% of Australia's emissions (Sopher et al. 2014b). The agriculture sector and most of the transport emissions are not covered under the system, and the system covers most power generation sources. Oil and gas manufacturing processes (instead of point-of-use emissions), industrial process, fugitive emissions processes (excluding decommissioned coal mines), and non-legacy waste are covered under the cap for sources with annual emissions totaling above 25,000 tCO_2e/yr.

To distribute the emissions allowances, the Australian government will auction off a proportion of the allowances. The Regulator of the program determines the amount of allowances auctioned once free units are allocated or returned from covered participating entities. Free allocation will depend upon the level of emissions-intensive trade-exposed industries (Sopher et al. 2014b) that request assistance through free allocation. Companies fall under the EITE category if the value of their imports and exports is greater than 10 percent of the value of their domestic production (Sopher et al. 2014b). Australia's CPM encourages the use of domestic and international credits. Within Australia, the Carbon Farming Initiative (CFI) allows offset credits to be produced from projects in agriculture and land-use management. Australian Carbon Credit Units (ACCUs) produced by the CFI program are limited to 5 percent of a company's compliance obligation while the carbon price is fixed.

As of 2015, international credits can be used up to 50 percent of an entity's compliance obligation, but specific criteria is yet to be finalized. UNFCCC Clean Development Mechanism (CDM) and Joint Implementation (JI) are approved so that 12.5 percent of an entity's compliance obligation can be met using Certified Emissions Reduction (CER) or Emission Reduction Units (ERU) credits (Sopher et al. 2014b, Jotzo and Betz 2009). The Australian government believes that internationally linking systems is the key to contain costs, saying that costs of abatement would nearly double if all reductions were domestically sourced. A linkage agreement between Australia and the EU ETS was released in 2012, allowing Australian firms to purchase European Union Allowances (EUA) beginning in July of 2015. There are also plans in progress for a linkage between the Australia ETS and the New Zealand ETS, potentially beginning sometime in 2015.

The Australian ETS has three phases of cost containment: fixed, flexible, and floating. The fixed price phase involves companies purchasing allowances directly from the Australian government or AUD $23 (to increase each subsequent year). During the flexible price phase (from 2015 to 2018) the Government will set a price ceiling for allowances at AUD $20 above the international price. During the floating prices phase (after July 2018), the price ceiling will disappear (Sopher et al. 2014b, Hood 2010, Jotzo and Betz 2009). Banking of allowances is not allowed during the first three years of the

ETS while allowance prices are fixed and compliance must be fulfilled annually, however, when prices enter the flexible phase (after 2015) unlimited banking between years will be permitted.

The Australian government and parliament make the major policy decisions, such as setting the annual national emissions caps and international linking. The new Clean Energy Regulator will manage the CPM, the CFI, the Renewable Energy Target, and the emissions reporting under the National Greenhouse and Energy Reporting Scheme (NGERS) (Sopher et al. 2014b). The Climate Change Authority will offer independent advice to the Government on national emissions targets as well as mandate to the UK's Climate Change Committee. If a company's emissions exceed their allowances, it must pay 1.3 times the fixed allowance price for that year. Once in the flexible phase, the penalty for non-compliance will be double the average auction charge for that year (Sopher et al. 2014b).

The Australian ETS has faced challenges already since it has been implemented. First, the Government replaced the CPM in 2014 with the Direct Action Policy. Next, the carbon policy has been set in place in the midst of major planned investments in emissions intensive sectors of the economy, such as mineral extraction and natural gas production (Sopher et al. 2014b). Reducing emissions will need to rely on internal and external opportunities to minimize the impact on the economy and increase the program's cost-effectiveness. Lastly, slow international progress in the field will hinder the success of the program and will make the defense of Australia's actions against accusations that it is moving ahead of the world difficult.

3.2.c Brazil

In 2009, Brazil established the National Climate Change Policy (NCCP**),** setting a voluntary national greenhouse gas reduction target of between 36.1 and 38.9 percent by 2020 relative to BAU. One of the law's main purposes is the implementation of measures "to prevent, avoid or minimize identified causes of climate change with anthropogenic origin within the natural territory" (Sopher et al. 2014c, Hood 2010). Brazil detailed its official emissions reduction commitment to include three main goals:

1. LULUCF**:** 668 $MtCO_2e$/year mitigation in 2020 from deforestation reductions in the Amazon Region and the Cerrado; 83 to 104 $MtCO_2e$/year mitigation in

2020 from recovery of degraded pastures; 22 $MtCO_2e$/year mitigation in 2020 from reduced livestock emissions; 20 $MtCO_2e$/year mitigation in 2020 from zero tillage; and 16-22 $MtCO_2e$/year mitigation in 2020 from biological fixing.

2. Energy**:** 12-15 $MtCO_2e$/year mitigation in 2020 from energy efficiency measures; 28-60 $MtCO_2e$/year mitigation in 2020 from the biofuels usage; 79-99 $MtCO_2e$/year mitigation in 2020 from increased hydropower generation.
3. Industry**:** 12-15 $MtCO_2e$/year mitigation in 2020 from the substitution of native forest-based charcoal by planted forest-based charcoal in the steel industry.

Source: Sopher et al. 2014c

Brazil also released a list of means for achieving the country's emissions target, which may make use of the CDM or other UN mechanisms:

1. 80% reduction of annual Amazonian deforestation relative to the 1996-2005 average by 2020;
2. 40% reduction of annual Bioma Cerrado deforestation relative to the 1999-2008 average by 2020;
3. Expansion of renewable energy supply from wind, small-scale hydro and bioelectricity, biofuels supply, and energy efficiency;
4. Recovery of 15 million hectares of degraded pastures;
5. Extension of livestock-crop-forest integration projects by four million hectares;
6. Expansion of direct planting by eight million hectares;
7. Expansion of nitrogen fixation by 5.5 million hectares, substituting the use of nitrogen-based fertilizers;
8. Expansion of forest planting by three million hectares; and
9. Extension of technologies used for the treatment of 4.4 million cubic meters of animal waste.
10. For steel, the increased usage of charcoal that originates from planted forests, as well as improvement of the efficiency of the carbonization process.

Source: Sopher et al. 2014c

In Brazil, 19 states have climate change laws, and at least seven include provisions for the creation of markets for carbon credits. Rio de Janeiro was planned to implement an ETS, but it was never signed into law. The suggested Rio ETS would have launched in

2013, and was meant to be divided into three phases. Sao Paulo announced plans to also launch an ETS (SP ETS) with the plan of linking to the Rio ETS, but the system has been delayed due to an inability to find ways to cap emissions (Sopher et al. 2014c, Talberg and Swoboda 2013). The majority of Brazilian carbon market activity has happened through the Clean Development Mechanism (CDM), hosting 269 CDM projects, or 4.1 percent of the world's total. Being China and India, Brazil hosts the third most CDM Projects (Sopher et al. 2014c).

Currently, Brazil's environmental assets are exchanged on the Bolsa Verde do Rio de Janeiro (BVRio) and the BMF/Bovespa exchange. The BMF/Bovespa exchange operates as a stock exchange for voluntary reduction permits, as well as holding auctions for CERs and for voluntary carbon units. The market was the first of its kind to be in a developing country, and was launched in Sao Paulo in December 2004. The exchange acts to create the foundation for a Brazilian domestic carbon market but developing a secure trading environment for carbon credits (Sopher et al. 2014c). BVRio was launched in 2011 with the initial use to be an electronic exchange for trading Rio ETS allowances. Currently, BVRio has to main activities: developing market mechanisms for environmental services and assets, and providing and operating a trading platform for said assets.

3.2.d California, USA

In 2011, California was the world's ninth largest economy and twelfth largest emitter of greenhouse gases. To reduce the state's emissions levels, Governor Arnold Schwarzenegger signed into law Assembly Bill 32 (AB 32), also known as the Global Warming Solutions Act of 2006. A Scoping Plan developed by California's Air Resources Board (ARB) followed in 2008 that outlined the measures California would take to reduce its emissions, including:

1. Strengthening energy efficiency initiatives and standards for buildings and appliances
2. Adopting a renewable portfolio standard (RPS) with a target of 33 percent renewable source generation by 2020
3. Forwarding unspecified forestry protections
4. Adopting transportation related emissions targets and vehicle standards

5. Improving goods movement efficiency
6. Reducing refrigerant leakage reductions
7. Implementing a Low Carbon Fuel Standard (LCFS)
8. Adopting a multi-sector cap-and-trade program with links to other Western Climate Initiative (WCI) partners. WCI is a group of independent jurisdictions in Canada and the United States working together to identify, evaluate, and implement emissions trading systems at a regional level.
   Source: Sopher and Mansell 2014d

After gaining approval from the California Office of Administrative Law (OAL), the "California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms" was added to the California Code of Regulations in 2011. In January 2014, California linked its system to Quebec's, so compliance units are valid in both jurisdictions and joint auctions of both Quebec and California allowances began shortly after.

California set an economy-wide emissions reduction target to achieve 1990 levels of emissions by 2020. The cap-and-trade program works with three compliance periods, the first being two years long (2013-2014), the second and third spanning three years each, 2015-2017 and 2018-2020, respectively (Sopher and Mansell 2014d, "Cap-and-Trade Program" 2015, Hood 2010). The program covers emissions from a various large industrial sources who meet the threshold of 25,000 metric tons of CO_2e. In 2015, California began also covering emissions from all imported electricity under the program. Including the imported electricity emissions, the program covers 85 percent of California's GHG emissions. California sets an annual allowance budget throughout the three compliance periods, decreasing by 2 percent annually during the first compliance period, increasing by 235 $MMTCO_2e$ in 2015 to account for the addition of imported electricity emissions, and then decreasing by 12 $MMTCO_2e$/year in subsequent years (Sopher and Mansell 2014d, "Cap-and-Trade Program" 2015). This is shown in the Table 3.2.d.i below:

Table 3.2.d.i: Annual Allowance Budgets from 2013-2020.

Compliance Period	Year	Allowances (MMTCO²e)
First	2013	162.8
	2014	159.7
Second	2015	394.5
	2016	382.4
	2017	370.4
	2018	358.3
Third	2019	346.3
	2020	334.2

Table 1: Annual Allowance Budgets 2013-2020. Source: §95841 Table 6-1, page 70

Source: Sopher and Mansell 2014d

Allowance auctions are held quarterly using an electronic internet-based auction platform, where bidders submit their bids in a single-round, sealed-bid format (Sopher and Mansell 2014d, Hood 2010). At each auction, one quarter of allowances are auctioned for that year, as well as any unsold allowances from previous years. A purchase limit is set in place to prevent any one participant from purchasing more than 15 percent of the allowances up for sale. The auctioned allowances have a floor price starting at USD $10, set to raise five percent annually plus the rate of inflation. In 2013, California freely allocated most allowances to electricity generators and vulnerable industries such as refiners. As the program continues, the amount of freely allocated allowances will decrease so that about 50 percent of the total allowances will be auctioned (Sopher and Mansell 2014d, "Cap-and-Trade Program" 2015). While offsets are a part of the program, there is an eight percent quantitative usage limit so that no more than eight percent of a company's total compliance obligation for each compliance period can be satisfied using offsets.

The California cap-and-trade system linked with Quebec's system in 2014, with the first joint auction to be held shortly after. Methods to compliance including allowances and offsets are recognized as mutually acceptable in both programs. The banking of allowances is permitted under the system, so allowances from any previous year may be used to meet compliance or sold, and they never expire. The borrowing of

allowances from a future period is only allowed to satisfy an excess emissions obligation (Sopher and Mansell 2014d). In order to monitor compliance, there exists the Mandatory Reporting Rule (MRR) that requires participating entities to report and verify their emissions to ARB. Many factors of the California cap-and-trade system make the program unique, including: the cap was set based on real emissions data rather than estimates, the eligibility and approach to the environmental integrity of offsets, and its linkage to Quebec's system (Sopher and Mansell 2014d, "Cap-and-Trade Program" 2015).

As all other emissions trading systems, California has faced some challenges. First, the program requires imported emissions to be covered under the program, resulting in the issue of resource shuffling, where clean energy is filtered to the state and dirtier energy is sent to states that do not yet have a cap-and-trade system in place (Sopher and Mansell 2014d, "Cap-and-Trade Program" 2015). Next, California struggles with the issue of finding equilibrium between the numbers of allowances industries should receive for free and how many should be auctioned. Additionally, California will have to continually collaborate with Quebec in order to keep the linked system functioning smoothly and efficiently. Lastly, the state must maintain effectiveness in the auctioning of revenues. Lessons have also been learned from the creation of California's cap-and-trade system as well. First, it has been brought to light that implementing cap-and-trade regulations requires significant political support from many environmental and business groups. Also, with the lack of national legislation on the issue, it is still possible to demonstrate the ability of markets to reduce emissions through the pricing of carbon, and California will act as a trial run for cap and trade throughout the United States (Sopher and Mansell 2014d).

3.2.e China

The current climate policy in China is based on *China's National Climate Change Program* and *The Outline of the Twelfth Five-Year Plan for National Economic and Social Development* and is run by multiple administrative entities including the National Development and Reform Commission (NDRC) and the National leading Group to Address Climate Change (Sopher and Mansell 2014e). China's current goals under the NDRC include reducing CO_2 per unit of GDP by 40-45 percent relative to 2005 levels by

2020, and increase the ratio of non-fossil fuel energy to the use of primary energy to 15 percent, also by 2020. China also has goals set to be accomplished by the end of 2015, or the end of the 12th Five-Year Plan:

- Reduce CO_2 per unit of GDP by 17 percent relative to the end of the 11th Five-Year Plan (FYP 11)
- Reduce national energy consumption per unit of GDP by 16 percent relative to the end of FYP 11. This will lead to energy-saving capacity of 300 million tons of coal equivalent (tce) according to the NDRC
- Increase the ratio of the consumption of non-fossil fuel energy to primary energy to 11.4 percent
- Increase the acreage of new forests by 12.5 million hectares relative to the end of FYP 11, increasing forest growing stock by 600 million cubic meters and raising forest coverage to 21.66 percent
- Reach 478 million tce in total renewable energy consumption, 9.5 percent of the country's projected energy mix.
  Source: Sopher and Mansell 2014e

From 1990-2009, China's emissions intensity fell 53 percent from 4.97 $kgCO_2$/US$ to 2.33 $kgCO_2$/US$, but in terms of absolute emissions, China's have increased over the past 30 years. This upward trend can be attributed to population growth and accelerating urbanization in the country, and economic development that China has seen over this period.

Currently China does not have a mandatory national ETS, but voluntary emissions trading exists within the country as well as the development of an ETS at state and city levels. The NDRC states that China has plans to establish a national ETS during the Thirteenth Five-Year Plan (FYP 13, 2016-2020) (Sopher and Mansell 2014e, Hood 2010, Talberg and Swoboda 2013). The cities of Beijing, Shanghai, and Tianjin set up voluntary emissions trading exchanges in 2008, sparking the introduction of a carbon standard referred to as the "panda standard" in 2009 (Sopher and Mansell 2014e). In 2012, the NDRC released the *Interim Regulation for the Trading of China's Voluntary GHG Emission Reduction*, establishing a national framework for a voluntary carbon

market. The path to a nation-wide ETS in China is slow and steady, and the General Office of the NDRC selected five cities (Beijing, Tianjin, Chongqing, Shanghai, and Shenzhen) and two provinces (Hubei and Guangdong) in 2011 to put forth plans for a pilot ETS development (Sopher and Mansell 2014e). These pilot programs are designed to help guide China as a whole to an emissions trading market.

Shenzhen was the first Chinese jurisdiction to launch its pilot ETS in June of 2013, followed by Shanghai (October), Beijing (November), Guangdong (December), Tianjin (December), and Hubei (April 2014). The success and development of these pilot systems is set to be evaluated at the end of 2015 to prepare the country for a potential nation-wide ETS during FYP 13 (2016-2020). While China's ETS is not fully developed, even in its beginning stages it presents many unique aspects. First, it is the only ETS to attempt to build itself from the bottom up using provincial-and city-scale pilot schemes. Next, China is the largest developing country in the world, and the rate and scale at which the country struggles with environmental sustainability as its economy develops is unparalleled. Finally, China is the first single party government to take strides toward establishing a nation-wide ETS (Sopher and Mansell 2014e).

3.2.f India

India is projected to contribute approximately six percent of global emissions by 2020. Even as India is the world's third largest emitter of carbon dioxide, India is reluctant to create a functioning ETS in fear of hindering its own economic development. To encourage sustainable development, India committed to the Copenhagen Accord voluntarily in 2011 with a target of a 20-25 percent emissions intensity reduction relative to 2005 levels by 2020 (Sopher et al. 2014g). India's progress toward an emissions trading system is based on its 2008 National Action Plan on Climate Change (NAPCC) and the 2010 National Mission on Enhanced Energy Efficiency (NMEEE), functioning under the Bureau of Energy Efficiency (BEE).

Beginning in 2012, India's closest program to an ETS is its "Perform Achieve and Trade" (PAT) initiative began its first test phase (to be completed at the close of 2015). The main difference between Pat and traditional cap-and-trade systems is that cap-and-trade systems usually have absolute caps set, while PAT sets energy targets based on intensity (Sopher et al. 2014g). Three pilot ETS programs focusing on the abatement of

particulates rather than CO_2 are in the process of being launched in three Indian states: Tamil Nadu, Gujarat, and Maharashtra. Despite what seems to be progress toward a national cap-and-trade system, the Indian government has been historically against setting mandatory, absolute emissions reduction targets, stating that climate change is an issue caused by developed countries and therefore not India's problem. As of 2010, this mindset is still in place, hindering the future of a cap-and-trade system in the country. The PAT system sets mandatory energy efficient targets for 478 facilities that are either energy-intensive or members of the electricity sector (Sopher et al. 2014g). The aim of the program is to reduce emissions by 26 million tons of CO_2e as well as save 6.6 million tons of oil equivalent during its first commitment period (2012-2015).

In 2010, India implemented the Renewable Energy Credit Trading System (REC) to promote renewable energy. The country's State Regulatory Commissions (SERCs) sets targets for power companies to purchase a certain percentage of their total power from renewable sources. The targets are referred to as Renewable Purchase Obligations Standards (RPOs) (Sopher et al. 2014g, Shailesh 2010). Participating entities may trade RECs, each one representing one MWh of a covered type of renewable energy such as solar, wind, small-scale hydro (defined as having a capacity below 25 MW), biomass-based power, biofuels, and municipal waste based power. The purchase of the RECs is equivalent to the consumption of the corresponding quantity of renewable power. In this system, facilities are able to meet their renewable energy targets even if the local are is not well suited for renewable energy systems (Sopher et al. 2014g). Participation is voluntary under the system and is implemented by the Central Electricity Regulatory Commission (CERC). There are two compliance options for participants: 1. Sell renewable energy at a tariff fixed by the CERC, or 2. Sell the electricity generation and environmental benefits associated with renewable energy in the form of RECs (Sopher et al. 2014g).

The RECs are traded at India's two major power exchanges, IEX (Indian Energy Exchange) and PXIL, once per month. The price for certificates varies based on type of renewable, and the fixed prices are as follows: solar, USD $264-375 per MW/h and for wind, USD $33-86 per MW/h (Sopher et al. 2014g, Shailesh 2010). On the IEX, the

average process was about USD $42.70. On the PXIL, the average was about USD $38.23 (Sopher et al. 2014g).

The pilot systems launched in 2011 in three states focus on particulates such as SO_2, NO_x, and SPM, and the systems act as a potential foundation for a future carbon dioxide trading program. The five objectives for the pilot ETS are:

1. Extend the existing framework to support ETS specifically
2. Establish continuous monitoring standards
3. Create emissions markets and establish permits
4. Document emissions cuts and reductions
5. Document cost savings

Source: Sopher et al. 2014g

While establishing a national cap-and-trade system in India is still only a future possibility, the establishment of emissions abatement systems has already faced challenges. First, India views climate change as an issue only caused by developed countries therefore it is reluctant to create a nation-wide ETS in fear of stalling economic development. Next, India will need to improve its data collection and build its capacity in order to implement an effective ETS. Finally, the penalties for non-compliance are relatively weak so they could fail to incentivize participants. Despite these challenges, India also brings unique aspects to the world of emissions trading systems: PAT is the first system of its kind (a market system focused on enhancing energy efficiency) in the developing world, and very few other countries (especially in developing countries) have three national market-based environmental programs as India does (PAT, REC, and CDM) that have potential to reduce GHG emissions (Sopher et al. 2014g).

3.2.g Japan

As part of a commitment to the Copenhagen Accord, in 2008 Japan pledged to reduce GHG emissions 25 percent below 1990 levels by 2020, and 30 percent by 2030. In 2010, the Japanese Central Environmental Council committed to reducing the country's GHG emissions to 80 percent below 1990 levels by 2050. Unfortunately, Japan suffered a major loss of nuclear power in 2013, causing the Japanese government to reduce its target to 3.8 percent below 2005 levels by 2020, a huge cutback (Sopher et al. 2014h, Hood 2010). In 2005, Japan took the first step to begin a cap-and-trade system, implementing

the Japanese Voluntary ETS (which became part of the Experimental ETS in 2008), the Tokyo ETS, and the Experimental ETS. A summary of Japanese emissions abatement strategies is shown in Table 3.2.g.i below:

Table 3.2.g.i: Current Climate Change Policies in Japan

Policy	Jurisdiction	Details
Emissions Trading System	Japan	On March 12, 2010, the government of Japan proposed the "Basic Act on Global Warming Countermeasures", an overall climate change policy framework that includes introducing an ETS
Feed-In Tariffs	Japan	Feed-in tariff for all renewable energy sources with the goal of increasing domestic energy generation from renewable sources by 10% of total primary energy supply by 2020
Anti-Global Warming Measure Tax	Japan	Anti-global warming tax is proposed as an add-on to existing taxes covering a wide range of fuels, of which rates are proportional to CO2 emissions
Voluntary Experimental Integrated ETS	715 organizations	715 organizations had applied to participate, of which 521 supplied targets (as of July 2009). The trial program aims to bring together several existing initiatives, such as the Keidanren Voluntary Action Plan, plans for a domestic offsets program, and the Japan-Voluntary Emissions Trading System (J-VETS), which targets smaller emitters
Tokyo Emissions Trading System (cap and trade)	Tokyo	The Tokyo metropolitan area launched its own mandatory cap-and-trade system on April 1, 2010, which targets office and commercial buildings (including universities) and factories. The system covers approximately 1,400 installations and 1% of the country's emissions
Saitama Prefecture Trading System (Cap-and-Trade)	Saitama Prefecture	Starting April 1, 2011, Saitama, the fifth largest prefecture in Japan, became the second Japanese prefecture to implement a mandatory emissions trading system. Saitama and Tokyo signed a pact to link their cap-and-trade programs in the future

Table 1: Current Climate Change Policies in Japan. Source: Peak Oil (2011)[18]

Source: Sopher et al. 2014h

Under the Japanese Voluntary ETS (JVETS), firms were given an absolute cap to abide by, working in one-year commitment periods; the JVETS results for 2006-2009 are summarized in Table 3.2.g.ii below:

Table 3.2.g.ii: JVETS Results for 2006-2009

Commitment Period	FY 2006	FY 2007	FY 2008	FY2009
Achieved Reduction (kt-CO2)	377 (29%)	280 (25%)	383 (23%)	950 (28%)
Committed Reduction (kt-CO2)	273 (21%)	217 (19%)	136 (8%)	335 (10%)
Number or Transactions	24	51	23	24
Average JPA Price (JPY/t-CO2)[31]	JPY$1,212 (US$10.15)	JPY$1,250 (US$11.30)	JPY$800 (US$8.81)	JPY$750 (US$8.14)

Table 2: JVETS results for fiscal 2006-fiscal 2009. Source: MoE Japan (2011)[32]

Source: Sopher et al. 2014h

Under the JVETS program, participants must surrender Japanese Emission Allowances (JPAs) for every ton of emissions produced. If an emitter was below their cap, they could sell their allowances to trades who had exceeded their cap. Usage of Clean Development Mechanism (CDM) credits was unlimited, and banking was allowed while borrowing was not. To aid in participation, the government subsidized one-third of the cost of the reduction measures, to be returned in the event of non-compliance (Sopher et al. 2014h).

In the Experimental Integrated ETS (EI ETS), the goal was to aid the country in reaching its Kyoto target and was meant to be used as a foundation for a nation-wide ETS, but the plan was dropped in 2012 after the EI ETS trial period, but firms are still encouraged to participate. Under the EI ETS, participants set their own emissions targets that are met with allowances. The Japanese government verifies the targets and monitors the emissions to ensure compliance (Sopher et al. 2014h). As all cap-and-trade programs, Japan has faced challenges. First, the deferral of a nation-wide ETS raised concerns over the cost of a system that greatly influence Japan. Also, the country's targets are extremely ambitious when compared with other industrialized countries, and Japan's refusal to renew its initial Kyoto commitment shows a possible decline in political interest in climate change (Sopher et al. 2014h, Talberg and Swoboda 2013). Unique aspects of the Japanese emissions trading systems include: the commitment of the Tokyo government, Japan's largest sub-national government, to create an ETS, showing promise but faced with the plateau of plans toward a nation-wide ETS in 2010, and the major loss of nuclear power in the aftermath of the Fukushima disaster requiring Japan to

rework its plans to meet its 2020 climate targets, potentially forcing the country to increase the use of international offsets (Sopher et al. 2014h).

3.2.h Kazakhstan

Kazakhstan first took a step toward an emissions trading system in 2012 to help meet its goal of reducing GHG emissions 7 percent below 1990 levels by 2020 (Sopher and Mansell 2014i, Talberg and Swoboda 2013). The pilot phase of the system began in 2013, making it the first Asian nation to establish an economy-wide cap. Kazakhstan ratified the Kyoto Protocol in 2009, inspiring the 2012 law that created the Kazakh ETS, a system designed to operate similarly to the EU ETS. The ETS covered 178 companies, setting a cap at 147 $MtCO_2e$, covering only CO_2. Participating companies are required to report data that is verified by an independent third-party. The long-term goal of the system is to reach 25 percent (65 $MtCO_2e$) below 1992 levels by 2050 (Sopher and Mansell 2014i, Talberg and Swoboda 2013). The threshold for participants is set at 20,000 tCO_2e/year, emitters above this level are considered ‘major emitters’ and are allowed to trade allowances domestically. Any emitter below the threshold is not allocated allowances for the program, but are obligated to pay an emissions tax (Sopher and Mansell 2014i).

Non-compliance results in fines and criminal prosecution, while also staying obligated to surrender sufficient allowances. The consequences for non-compliance are set to apply after the first phase ends. Kazakhstan hopes to strengthen its ETS by linking to larger markets such as the EU ETS and the Japanese ETS, the reason behind the Kazakh system running similarly to the EU ETS. As with most systems, the Kazakhstan ETS relies on the design of Monitoring, Reporting, and Verification (MRV) in order to succeed with their own system as well as link with other larger markets. The main challenge the Kazakhstan ETS has faced is the lack of non-compliance consequences during the pilot phase, making compliance less of a priority for participating companies. In addition to being the first Asian country to implement an economy-wide ETS, the Kazakhstan ETS has many unique aspects. First, the ETS applies to companies rather than installations. Next, Kazakhstan has a Kyoto status as an Annex 1 country that is not part of Annex B, of which many countries with an ETS are a part. Finally, the

implementation of the ETS has not been delayed by the enactment of laws and approval rules, making its implementation relatively easy (Sopher and Mansell 2014i).

3.2.i Mexico

Mexico first began legislation regarding climate change in 2007 with the launch of the National Strategy on Climate Change (ENACC), followed by the Special Program on Climate Change (PECC), setting a short-term emissions reduction target of 51 $MtCO_2e$/year for the years 2009-2012, with another target of a 20 percent emissions reduction below BAU levels by 2020. Mexico's long-term target was set at 50 percent below 2000 levels by 2050. In 2012, the General Climate Change Law was signed that called for the establishment of a domestic carbon market (Sopher et al. 2014j, Hood 2010). While the law does not mandate an ETS, it paves the way for the creation of one, creating the following voluntary emissions reduction targets:

1. Reduce GHG emissions 30 percent below BAU levels by 2020
2. Reduce emissions 50 percent below 2000 levels by 2050
3. Source 35 percent of electricity generation from clean energy by 2024

   Source: Sopher et al. 2014j

The country has faced challenges in its attempt to create en ETS. First, the current policy relies heavily on international funding to meet its commitments. Next, the implementation and enforcement of laws that have been passed to mitigate climate change will determine which of these laws is effective. Next, the GHG emissions reduction targets are completely voluntary, and setting strict caps would required additional legislation. Lastly, energy reform in Mexico is still under development (Sopher et al. 2014j). Along with these challenges, Mexico has unique aspects as well. First, the General Climate Change Law does not mandate a system but simply enables the country to implement one. Next, between today and Mexico's long-term goal date (2050), the country is predicted to jump from the world's 11^{th} largest economy to the 5^{th} largest, which could lead to the "lock-in" of carbon intensive infrastructure (Sopher et al. 2014j). Also, Mexico's federal oil and electricity monopolies have recently been dissolved, possibly encouraging the energy sector to become cleaner. Finally, the recent passage of a carbon tax along with a new offset trading platform on the Mexican stock

exchange where carbon allowances can be purchased voluntarily could incentivize participation in the system (Sopher et al. 2014j).

3.2.j Norway

Norway committed to a Kyoto Protocol ledge to reduce its greenhouse gas emissions to no more than one percent above its 1990 levels for the period of 2008-2012. To help offset its emissions, Norway purchases United Nations offsets and has implemented a carbon dioxide tax, the Pollution Control Act, the Petroleum Act, and the Greenhouse Gas Emissions Trading Act (GGETA) that outlines Norway's ETS that was implemented in 2005 (Sopher et al. 2014l, Hood 2010). Similarly to the Kazakh ETS, the Norwegian ETS was designed with the possibility of a future linkage to the EU ETS. Like the EU ETS, the Norwegian ETS is split into three phases (2005-2007, 2008-2012, and 2013-2020). The Norwegian ETS and the EU ETS officially linked at the beginning of Phase II and worked together fully for Phase III (Sopher et al. 2014l, Hood 2010).

While Norway's initial Kyoto Protocol commitment was to reduce emissions to one percent above 1990 levels for 2008-2012, they quickly surpassed that goal by pledging to reduce emissions to nine percent below 1990 levels for 2008-2012, which was not met. To remain committed to its Copenhagen Accord pledge, Norway aims to reduce its GHG emissions by 30 percent relative to 1990 levels, and to reduce GHG emissions by 100 percent relative to 1990 levels by 2050 (Sopher et al. 2014l). During Phase I of the system, carbon dioxide was the only gas covered, and nitrous oxide (N_2O) was added during Phase II. Each year, participating entities self-report their emissions to the Pollution Control Authorities to be verified. Corresponding allowances must be surrendered soon after the reports are in. Non-compliance can result in a fine as well public shaming as well as surrendering additional allowances the next year to cover the excess from the prior year (Sopher et al. 2014l). Norway was unique in that it is one of the few countries that operates with an ETS as well as a carbon tax that overlap, also in the sense that allowance allocation is more in auctions rather than freely allocated. A challenge that has arisen in the implementation of the Norwegian ETS has been difficulty in combining the carbon tax with the EU ETS without price signals for carbon emissions (Sopher et al. 2014l).

3.2.k Québec

Québec set an emissions reduction target of 20 percent below 1990 levels by 2020 in November of 2009. In 2008, the Canadian provide joined the Western Climate Initiative (WCI), a collaboration of independent jurisdiction in Canada and the United States to create regional-level emissions trading systems, where it linked with the state of California in 2014 (Sopher et al. 2014m, "The Carbon Market). This linkage allows the purchase and use of California allowances within the Québec system. The program operates with three compliance periods (2013-2014, 2015-2017, and 2018-2020). Allowances within the system are freely allocated, except to fuel distributors who are ineligible for free allocation. The allowances are freely allocated based on a participant's average historic emissions intensity between 2007 and 2011. Any excess allowances are auctioned to participants up to four times per year (Sopher et al. 2014m, "Québec").

The auction floor price started at CAD $10/ton, rising five percent each year after 2012, and was raised to CAD $15/ton. Proceeds collected from the auctioning of allowances are placed in Québec's Green Fund for the following purposes: finance GHG reduction, limitation or avoidance measures, mitigation of the economic or social impact of GHG reductions, public awareness, adaptation to climate change, or to finance the development of Québec's regional and international partnerships (Sopher et al. 2014m). The free allocation of allowances aids in competitiveness and prevents leakage for high-risk entities.

Québec's emissions trading system has multiple aspects that set it apart from previously developed systems. First, the province developed a cap-and-trade program where renewable generation from hydroelectric power is the largest power source on the grid. Next, the program is linked with California, bringing unique opportunities and challenges, specifically in joint allowance auctions and coordinating pricing and sales in different currencies. Finally, the program has been developed with consideration to the potential future linkage with other WCI partners. The main challenge for the Québec program has been that there are minimal reduction opportunities in the electricity and manufacturing sectors. Nearly all of Québec's electric power supply comes from renewable sources of energy, resulting in the prioritization of GHG reductions in the transport sector of the program (Sopher et al. 2014m).

3.2.l South Korea

In its commitment to the Copenhagen Accord, South Korea pledged to reduce its GHG emissions by 30 percent relative to BAU projection levels by 2020 (equivalent to a four percent reduction below 2005 levels) (Sopher et al. 2014o). The country's draft for an emissions trading system, modeled by the EU ETS, was submitted in 2011, and was set to begin in January of 2015. The system will run in three phases (2015-2017, 2018-2020, and 2021-2026) (Talberg and Swoboda 2013). Under the system, a national emissions cap is set, and allowance allocation will vary between phases, industries, and sectors. Participants must submit allocation application forms before each phase of the program to receive allowances. During the first phase, allowances are freely allocated, followed by 97 percent free allocation in Phase II, and 90 percent free allocation in Phase III (Sopher et al. 2014o). The remaining allowances will be auctioned. High-risk entities will always be covered under free allocation.

Participating facilities are required to have an annual emission inventory verified by a third party before submitting them to the government for certification. With this yearly information, the Korean government will compile a register to record allocation, trading, and transfer or permits. The Korea exchange has been promoting emissions trading will be set to manage future allowance trading under the program (Sopher et al. 2014o, Talberg and Swoboda 2013). Non-compliance consequences will entail a fine to be set at three times the prevailing market price, with a maximum penalty of about USD $94 (KRW 100,000) per ton. South Korea was the first Asian country to pass an economy-wide ETS into law, and is the second to implement one, following the Kazakh ETS that began in 2013. Other unique aspects of the Korean ETS are its ability to stabilize prices with early reserve auctions, and a company-level threshold (125,000 tCO_2e/year) for receiving the mandatory cap (Sopher et al. 2014o). Major challenges faced by the Korean ETS are the ability for the BAU projections to be revised under the Master Plan, and Korea's industrial sector has showed opposition to the system, which could potentially harm the system (Sopher et al. 2014o).

3.2.m Switzerland

In order for Switzerland to meet its commitment to the Kyoto Protocol, the country passed the Act on the Reduction of CO_2 Emissions (CO_2 Act) in 1999 as a supplement to

the existing Act on the Protection of the Environment (PE Act) (Sopher et al. 2014p, Hood 2010). Switzerland's pledge to the Kyoto Protocol was an eight percent reduction in GHG emissions relative to 1990 levels for the period of 2008-2012. The CO_2 Act was revised in 2011 to include the target of a 20 percent reduction below 1990 levels of CO_2 emissions by 2020. To aid in compliance with the country's Kyoto target, the Swiss ETS was launched in January of 2008 (Sopher et al. 2014p, Hood 2010). The system was voluntary, as emitters had the choice between paying a CO_2 levy and voluntarily setting an absolute emissions target and participate in the ETS.

During the first period of the system, 2008-2012, allowances were freely allocated to participating firms. The number of allowances allocated to each firm was determined with a "bottom-up" approach, based on projected production and CO_2 emissions as well as CO_2 reduction measures already in use (Sopher et al. 2014p, Talberg and Swoboda 2013). In the second phase of the system, 2013-2020, allowances will be freely allocated and sold at auctions. The Swiss ETS was designed to correspond with the EU ETS to keep open the possibility of future linkage, and international offsets are accepted in the system. Within the Swiss ETS, there are no limits on banking Swiss allowances or international permits, and both banking and borrowing were allowed throughout the first period. The Swiss credits are traded electronically on the National Emissions Trading Registry, and emitters are able to buy and sell allowances on the Registry in accordance to their compliance. Non-compliance consequence during the first compliance period was a retroactive payment of the carbon levy for each ton of CO_2 emitted, and in the second period it is a fine of CHF \$125/tCO_2e (Sopher et al. 2014p, Hood 2010). Table 3.2.m.i below outlines the results of the Swiss ETS:

Table 3.2.m.i: Overview of the Swiss ETS Performance 2008-2010

	2008	2009	2010
Emission Target (Allocated emission allowance)	3.3 $MtCO_2$	3.1 $MtCO_2$	3.42 $MtCO_2$
CO_2 Emissions (effective)	2.9 $MtCO_2$	2.6 $MtCO_2$	2.85 $MtCO_2$
Over-performance (surplus emission allowances)	0.4 $MtCO_2$	0.5 $MtCO_2$	0.57 $MtCO_2$

Table 2: Overview of ETS Performance 2008-2010. Source: Department of the Environment, Transport, Energy and Communications[51]

Source: Sopher et al. 2014p

The Swiss ETS has many characteristics that make it unique. First, during its first compliance period, the ETS worked as a voluntary program that offered an alternative way to comply with the carbon tax, which is different from the majority of emissions trading systems. Also, the Swiss ETS will transition to a more standardized (EU ETS style) system to aid with negotiations for a future linkage between the two systems. Next, individual entities face absolute caps, but the system as a whole does not have an absolute cap, as a result of the “bottom-up” allowances allocation method. Lastly, the Swiss ETS is relatively small, with a reduction of only 3.42 $MtCO_2$ in 2012 (Sopher et al. 2014p). Among these unique characteristics, the Swiss ETS has also faced challenges. First, the program will have to be modified in order to link with the EU ETS in the future. Also, the small size of the market reduces the cost-effective reduction potential, liquidity, price stability, and flexibility in achieving targets (Sopher et al. 2014p).

3.2.n Tokyo

As a city, Tokyo consumes as much or more energy than many countries. To reduce its emissions Tokyo began the Tokyo CO_2 Emissions Reduction Program in 2000. The program contained mandatory reporting programs as well as a voluntary emissions reduction plan (Sopher and Mansell 2014q, Talberg and Swoboda 2013, Hood 2010). An official ETS began development in 2002, creating two voluntary phases for reduction (2002-2004, and 2005-2009). The goal for the climate plan was a 25 percent CO_2 reduction relative to 2000 levels by 2020 and 50 percent reduction by 2050. CO_2 reduction obligations apply to large-scale facilities, defined as individual buildings or

facilities that emit above a 1,500 kL crude-oil equivalent threshold annually. Large-scale facilities are required to submit five-year reduction plans and annual reports (Sopher and Mansell 2014q). Medium- and small- scale emitters must submit annual energy efficiency reports, but reductions are not mandatory.

The Tokyo ETS was designed to have two fully functioning phases (2010-2014, and 2015-2019). During the first compliance period, allowances were freely allocated by a grandfathering method based on past emissions. Unlimited banking is permitted in the Tokyo ETS while borrowing is not allowed (Sopher and Mansell 2014q, Talberg and Swoboda 2013). Along with submitting annual reports, public disclosure is also mandatory along with independent verification of the annual reports. Tokyo's emissions trading record and credits are managed on a registry. Facilities may sell excess allowances after their own annual emissions are accounted for, and the permits are exchanged on the Japan Climate Exchange and the Tokyo Stock Exchange. Failure to comply within the first compliance period will result in a larger cut in emissions during Phase II, and the possibility of a fine. Similar to Norway's non-compliance consequences, Tokyo will publicly shame a participant that has failed to comply.

The main challenge faced by the Tokyo ETS is that a national ETS in Japan was postponed in 2010, and there is little momentum behind the policy to date. Aside from this, Tokyo's ETS presents many unique aspects. First, Tokyo was the first large city to implement its own ETS, and it is the first local GHG ETS to focus on commercial activities and the end-use of energy (Sopher and Mansell 2014q, Hood 2010). Next, the program covers large-scale office buildings, which the EU ETS and RGGI do not. Also, Tokyo runs on five-year compliance periods, longer than the majority of systems. Also, allowances are only distributed based on results, rather than projections. The market price for allowances in Tokyo is extremely high, being seven times higher than the EU ETS at the start of the system in 2010. Finally, the targets during the first phase are based on the categorization of the industry to which each facility belongs (Sopher and Mansell 2014q).

3.2.o United Kingdom

The United Kingdom ETS was the first national, multi-sector emissions trading program of the world. The UK ETS was formed in 2001 as part of the UK Climate Change Program legislative package (Sopher and Mansell 2014r, Hood 2010). In 2007, the mandatory EU ETS replaced the UK ETS after the mandatory nature of the larger system took precedence over the voluntary, smaller UK ETS. The UK's individual commitment to the Kyoto Protocol was to reduce emissions by 12.5 percent below 1990 levels. The program issued absolute targets for participating firms and covered emissions from six greenhouse gases: carbon dioxide (CO_2), methane (CH_4) nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) (Sopher and Mansell 2014r). Since there was no legal obligation to reduce emissions, allowances were allocated in a reverse-auction format, where the government offered payments to emitters to commit toward reducing GHG emissions. The allocation for each year was based on the baseline emissions minus the annual contracted emissions reductions of each individual firm.

The United Kingdom ETS was unique as it was developed without the help of example of similar programs and relied on stakeholder agreement. Also, the UK ETS played an important role in extending the ETS throughout the EU. Another unique aspect was that the UK ETS was a voluntary program, providing an alternative way to pay the Climate Change Levy, a tax targeting downstream energy consumption covering all sources of energy (Sopher and Mansell 2014r, Hood 2010, de Muizon and Glachant 2003). The descending clock auction format also resulted in cost efficient emissions reductions. The major challenge faced by the UK ETS was that the United Kingdom introduced the first national, economy-wide emissions trading system for GHG emissions. Many lessons were learned from the UK ETS. First, it proved that a national program holds the possibility of becoming a part of a wider regional market in the future. Also, it showed that many companies prefer the option of flexibility to reduce emissions rather than an arbitrary levy with no flexibility for compliance, such as the command and control approach, where a method of compliance is dictated rather than an emissions level (Driesen 1998). Finally, the banking of allowances over time allowed flexibility for

companies who were making emissions reduction investments to comply with their requirements (Sopher and Mansell 2014r).

4. The SO_2/Acid Rain Program in the United States

This chapter will provide review of the literature surrounding the efforts of United States to reduce the emissions of sulfur dioxide into the atmosphere and therefore reduce the effects of acid rain, including the background and origin of the system, designs, and its performance. It will also highlight specific features of the system and its potential to act as a model for addressing other pollution problems.

4.1 Background:

The emission of sulfur dioxide (SO_2) in the United States is a threat to the environment as well as public health. Sulfur dioxide from coal-fired power plants is a precursor to acidic particulate matter that contributes to the acidification of ecosystems in the form of acid rain, which damages the natural world. Acid rain (acid deposition) occurs when sulfur dioxide (SO_2) and nitrous oxides (NO_x) react in the atmosphere to form sulfuric and nitric acids (Burtraw and Palmer 2004, Joskow and Schmalensee 1998). States have been required under the Clean Air Act (1963) to develop implementation plans to show reasonable progress toward the national ambient air quality standards (NAAQS). Usually these plans include regulation of existing sources of the SO_2 pollution. A market-based instrument such as a cap-and-trade policy is an aspect of laws or regulations that encourage behavior through market signals, specifically a cost-saving incentive to reduce pollution, rather than through explicit directive regarding pollution control levels or methods (Stavins 2003).

To control the emissions throughout the 1970's, taller stacks were constructed on coal-fired boilers in the electricity industry, remedying the issue of SO_2 at the local level, but intensified the air quality issue at a regional level (Burtraw and Palmer 2004). The taller stacks allowed for the sulfur dioxide to be emitted high into the atmosphere, which was then carried for hundreds of miles across the country before it reached the ground in the form of acid rain, increasing the acidification in the soils and waterways. The acid rain problem is largely national, but is most severe in the Eastern United States (the Adirondacks and New England) due to the tendency of weather patterns to carry emissions from coal-fired power plants (the majority of which are located West of the Mississippi River) from west to east (Burtraw and Palmer 2004, Joskow and

Schmalensee 1998). The acid rain that falls to the ground in the affected areas damages aquatic life and harms trees and plant life in sensitive and often protected forest areas (Joskow and Schmalensee 1998).

Created by Title IV of the 1990 U.S. Clean Air Act Amendments (CAAA), the sulfur dioxide (SO_2) allowance market presented the first real test of economists' advice to use market-based approaches (such as cap-and-trade programs or emissions taxes) to control pollution (Burtraw and Palmer 2004, Joskow and Schmalensee 1998). Title IV of the 1990 U.S. CAAA regulates emissions of SO_2 from electricity generating facilities under an emission-trading program designed to encourage the electricity industry to minimize the costs of reducing emissions. A system such as this, if well designed and properly implemented, can encourage firms or individuals to undertake pollution control efforts that are in their own interests while also meet policy goals (Stavins 2003).

The industry is allocated a certain number of total emissions allowances, and participating firms are required to surrender one allowance for each ton of sulfur dioxide emitted. The allowances can be transferred between facilities or banked for use in subsequent years. Title IV works to reduce SO_2 emissions by setting the annual cap on average aggregate emissions at about one-half the amount emitted in 1980 (Burtraw and Palmer 2004).

The implementation of a cap-and-trade program rather than forcing firms to emit SO_2 at a uniform rate or install specific control technology allows for flexibility in the trading and banking of allowances, allowing power plants operating at high marginal pollution abatement costs to purchase allowances from plants with lower marginal abatement costs. The efficiency of sulfur dioxide trading programs requires marginal abatement costs to equal the marginal damage for each polluting firm, and rather than equalizing pollution levels among firms (as with uniform emission standards), market-based instruments equalize the amount that firms spend to reduce pollution, like their marginal abatement costs (Muller 2008, Stavins 2003). The trading within the system equalizes the marginal abatement costs among participating emitters, therefore achieving lower SO_2 emissions at a lower cost than traditional command-and-control approaches, where a specific method of controlling emissions is mandated rather than a total emissions cap that allows for flexibility (Burtraw and Palmer 2004).

Prior to the inception of the SO_2 emissions trading system, acid rain was an unregulated problem in the United States, and the program was the first step to reduce emissions to better the health of the population as well as improve environmental conditions directly caused by emissions (Stavins 2003). Amendments to the Clean Air Act implemented performance standards for new sources, as well those undergoing major modifications, based on emissions per unit of heat input. These new standards were named the New Source Performance Standards (NSPS, 1970). The first generation of NSPS was an emission rate standard of 1.2 pounds of SO_2 per million Btu of heat input at a facility (Burtraw and Palmer 2004).

The previous section has covered the background of the United States sulfur dioxide trading system, including problems associated with the emission of sulfur dioxide, the inception of the program and its goals, as well as plans and projections to meet these goals. The next section turns to the scope of the United States sulfur dioxide program, also referred to as the Grand Policy Experiment.

4.2 Scope of 'Grand Policy Experiment':

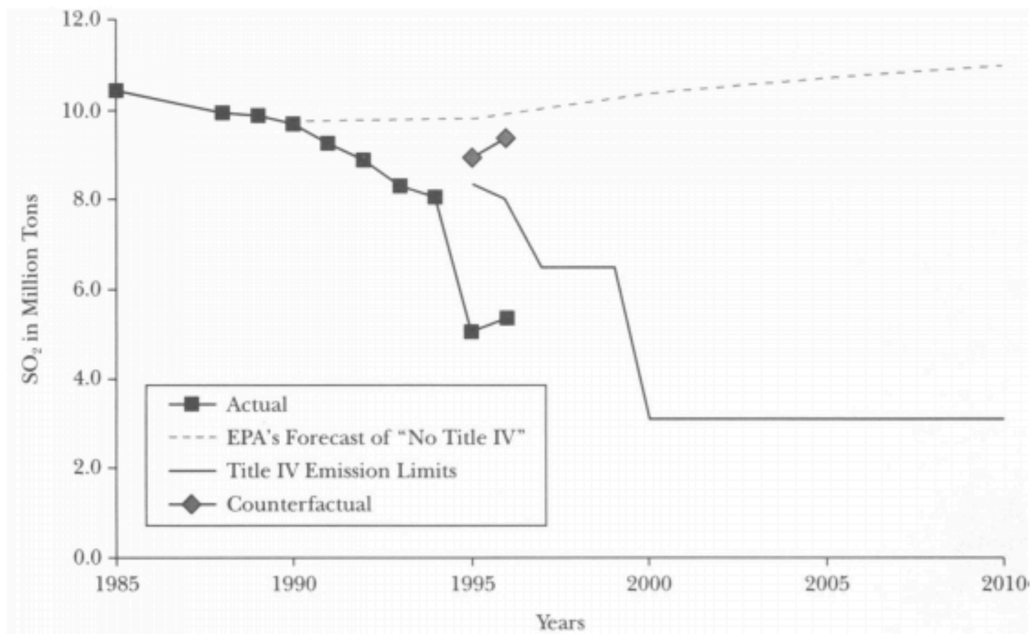
During the 1980's, many pieces of legislation were proposed to address the issue of SO_2 emissions and the environmental problems they cause. A 1983 proposal called for a reduction of 10 million tons of SO_2 from 1980 levels, through the installation of scrubbers (flue gas desulfurization equipment) on the dirtiest power plants that accounted for 89% of the nation's pre-New Source Performance Standard coal-fired capacity (Burtraw and Palmer 2004). Estimates of the cost of this proposal ranged from about $7.9 billion per year ($1995) to $11.5 billion per year ($1995), with an expectation of allowances valuing about $5 billion per year once the program was fully operational (Joskow and Schmalensee 1998). A debate over the cost of controlling acid rain sparked a search for an alternative to forced scrubbing, culminated in Title IV of the CAAA of 1990. The "cap with trading" design offered a compromise between environmental interests, which sought a 10 million or 12 million ton reduction in annual SO_2 emissions, and industry group, resulting in what has been called the 'grand experiment' – the United States SO_2 emissions trading system (Burtraw and Palmer 2004). Figure 4.2.1 below

shows the emissions, caps, and forecasts from the start of the program to just before 2000:

Figure 4.2.1: The Emissions, Caps, and Forecasts from the start of the US SO2 Program through 2000

Figure 1

SO_2 Emissions, Caps and Forecasts for Phase I Units



Source: Derived from Pechan (1995), EPA's EMS and ATS, and EPA (1996).

Source: Schmalensee et al. 1998.

4.3 Program Design:

Under Title IV, the annual allocation of allowances for SO_2 emissions from electric utility power plants are capped at 8.95 million tons, about 10 million tons less than the amount emitted by facilities in 1980 (Burtraw and Palmer 2004). The system operated in two phases, Phase I began in 1995, and Phase II began in 2000. Phase I covered the 110 dirtiest coal-fired electricity generating facilities, while Phase II covered all other facilities with a capacity of at least 25 megawatts, plus smaller facilities with sulfur content of fuel greater than 0.05% (Burtraw and Palmer 2004, Joskow and Schmalensee 1998).

The program assigned allowances to each power plant based on its heat input during the historical base period (1985-1987), multiplied by an emission rate calculated such that aggregated emissions equal the target emission cap. Each emission allowance is equivalent to one ton of SO_2. Affected facilities could trade emission allowances between their own facilities or with other firms. If a plant fails to reduce its emissions below its endowed level of emissions, through implementing abatement measures or simply reducing output, it must compensate another plant or firm to reduce emissions commensurately. While the initial allocation of units follows this formula, the EPA conducted small annual revenue-neutral allowance auctions, starting in 1993. The auctioned allowances were collected by the EPA retaining 2.8 percent of the allowances annually issued to each unit, and each unit in turn receives a pro rata share of the proceeds of each auction (Joskow and Schmalensee 1998). The retaining of allowances created a decrease in emissions each year, effectively reducing the cap on the system. The cost incentives to reducing a firm's emissions output also encourages firms to invest in research and development of abatement instruments in order to further lower costs (Muller 2008). This allows for cost savings by creating incentives for the plants with the lowest costs of SO_2 reductions to make more of the reductions, therefore minimizing overall compliance costs (Burtraw and Palmer 2004).

4.4 The Beginning of the Program:

This section will provide an overview of the first few years of the system, including its effect on the emissions, environmental effectiveness, effects of trading on the environment, and the economic performance of the system.

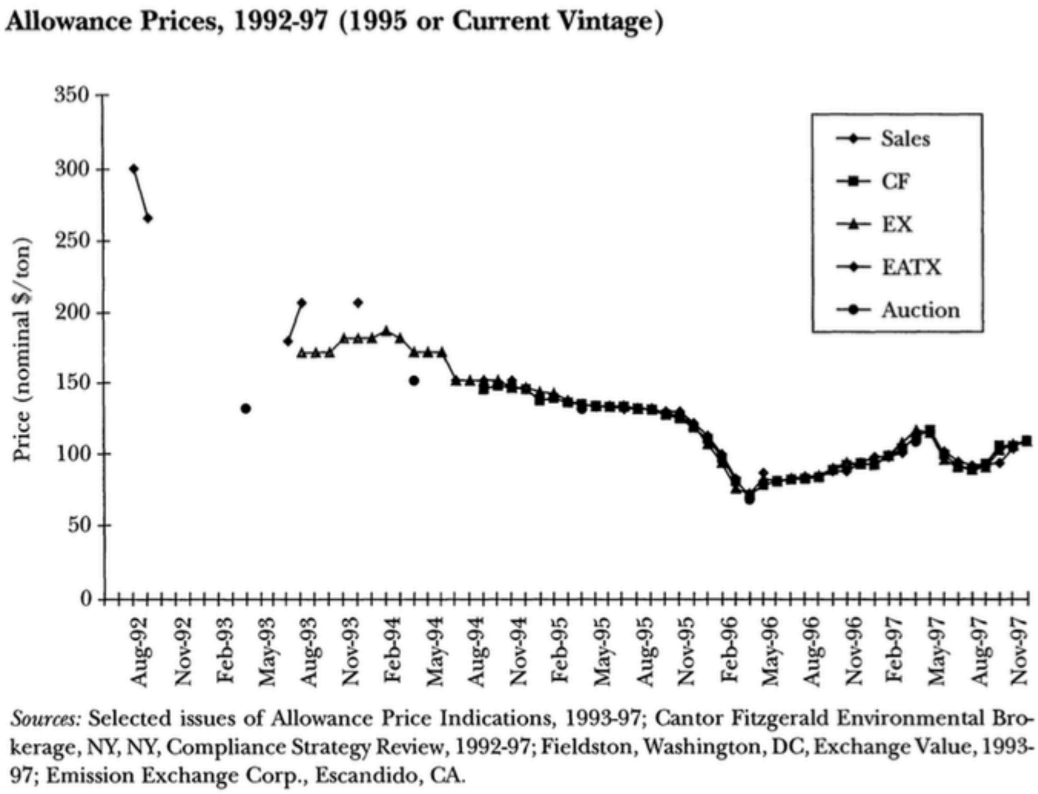
4.4.a Emissions:

The SO_2 emissions trading program had two main goals: to achieve the emissions reductions and influence related environmental and health benefits. During the first phase of the system, SO_2 emissions decreased drastically compared to 2003 levels. The Phase II facilities were required to reduce their collective emissions by 3.5 million tons per year (Joskow and Schmalensee 1998). In 1995, the first year of the program, the total emissions totaled 11.87 million tons, 25 percent below 1990 levels and more than 30

percent below 1980 levels (Burtraw and Palmer 2004). As seen in other systems, the first phase of the program resulted in total emissions falling well below capped levels throughout the period. Participants in the program were allowed to bank unused emission allowances for use in future years, totaling nearly 11.6 million allowances by the end of Phase I (Burtraw and Palmer 2004). Throughout the first phase (1995-1999), emissions from Phase I units remained relatively steady, while emissions from Phase II units rose, causing total emissions of the program to climb slightly. During the first year of Phase II, total SO_2 emissions declined, reaching a level of 10.63 million tons, almost 40% below 1980 levels.

The ability to bank allowances for future use was crucial to the success of the program, as firms with banked allowances committed themselves to maintain the value of those banked credits, in turn furthering the success of the program itself. While facilities were allowed to bank allowances for subsequent years, the failure to surrender the necessary allowances to cover a facility's emissions would result in substantial financial penalties and the need to make additional future emissions reductions (Joskow and Schmalensee 1998). During the first two years of Phase II, beginning in 2000, emissions exceeded the allowance allocations by about 1 million tons per year as emitters began to pull from the bank, and emissions were expected to continue to be above the annual cap through 2010, as the emissions number declines to roughly 9 million tons per year. While emissions were estimated to be the same with or without Title IV during Phase I, emissions throughout Phase II were thought to be significantly lower than predicted in the absence of Title IV (Burtraw and Palmer 2004). Figure 4.4.1 below shows the progression of prices of sulfur dioxide allowances throughout the program:

Figure 4.4.1: Progression of Prices of Sulfur Dioxide Allowances



Source: Schmalensee et al., 1998

The previous section has covered the emission goals of the system and the steps taken to achieve these goals through program regulations. The next section will summarize the environmental effectiveness of the system, as well as the effects of trading on the environment.

4.5 Effects on the Environment:

The SO_2 emissions trading program in the United States has proven to be successful in terms of environmental progress, with wet sulfate deposition (acid rain) in the eastern United States declining as much as 25% during Phase I, according to the EPA the main goal of the system was to reduce acid rain, most of the benefits have been

shown through improvements to human health. Air quality in areas where sulfate (SO_4) concentrations have been historically high has improved with a decline in ambient concentrations of sulfate particles. The EPA believes that the human health benefits to this decline are substantial, estimating that in 2010, the total annual health benefits associated with the SO_2 emissions under the program will be more than $50 billion per year (Burtraw and Palmer 2004). The allowance-trading program had positive welfare effects, with benefits of the program being an estimated six times greater than costs (Burtraw and Palmer 2004, Stavins 2003). The majority of the benefits of the program lie in the positive human health impacts due to the decreased local SO_2 and particulate concentrations rather than the ecological and environmental impacts. These effects were somewhat inconsistent with the original goals of the program at the time of enactment in 1990, but accomplished a positive goal nonetheless.

4.6 Lessons learned:

A market-based system must be somewhat flexible to allow for compliance alternatives, in terms of timing and technological options, to be successful. Allowing for flexible timing and trading of permits, such as banking allowances for future years, played a significant role in the success of the SO_2 allowance trading program (Stavins 2003). Transparency within the system's rules and guidelines avoided issues hindering success. The absence of requirements for prior approval reduced uncertainty for utilities and administrative costs for government, contributing to low transactions costs (Rico 1995, Stavins 2003). The use of market-based systems also calls for efficient monitoring and enforcement standards. In other systems where monitoring and enforcement have been lacking, policies have been ineffective. The U.S. SO_2 emissions trading system includes costly continuous emissions monitoring of all sources in order to provide sufficient assurance of the high degree of compliance that was achieved through the program (Stavins 2003).

The history of market-based approaches to environmental problems has led to an understanding of the conditions under which a market-based system would be most effective. In the case of the United States SO_2 emissions trading program, it became clear early on in the program that the abatement cost heterogeneity was great due to differences

in ages of plants and their proximity to sources of low-sulfur coal. A market-based approach worked well in this case as well as others where the cost of abating pollution differs widely among sources, and is likely to have greater success than a conventional, command-and-control regulation (Stavins 2003). On the other hand, where abatement costs are likely to be relatively constant across sources, political costs of forming an allowance trading system are likely to lack support and justification.

In the SO_2 emissions trading system, the initial allocation was done by distribution without charge, as opposed to auctions like in other emissions trading systems. While the auctioning of permits has been seen to be economically superior, factors in the system favor permits allocated without charge over other market-based instruments. Existing firms participating in the program prefer this method because permits allocated without charge raise entry barriers, since new entrants must purchase existing permits from existing permit holders (Stavins 2003). Therefore, the rents existing firms can convey to the private sector by tradable permits allocated without charge are sustainable. When given the choice between tradable permits and emissions taxes, environmental advocacy groups prefer the former. Tradable permits reduce the visibility of environmental protection costs to consumers and voters, while also quantifying the amount of pollution reduction that will be achieved (Stavins 2003).

The previous section has summarized the lessons learned from the United States sulfur dioxide cap-and-trade program and the challenge associated with this type of market-based system.

5. The European Union Emissions Trading System

This chapter is a description of the emissions trading system of the European Union. It will cover the background of the system, its scope and coverage, pricing of allowances and methods of allowance allocation, and future projections for the system.

5.1 Background:

The European Union Emissions Trading System was the first multi-national installation-level cap-and-trade program that limits carbon dioxide (CO_2) emissions as well as greenhouse gas emissions (Betz and Sato 2006, Sopher and Mansell 2014f). The system operates within eight sectors: electricity generation, oil refining, coke and steel, cement and lime, glass, bricks and ceramics, pulp and paper, and miscellaneous, with 31 participating countries within the European Union. The system accounts for 50 percent of CO_2 emission within the European Union (among countries involved in the emissions trading system) and 43 percent of total greenhouse gas emissions, and forms the centerpiece of European policy on climate change (Grubb 2006, Sopher and Mansell 2014f).

The EU trading system was based on many years of economic research into theories of emissions trading, combined with the experience of the sulfur dioxide and carbon trading systems in the United States, and it is estimated that the system includes over 12,000 installations (Grubb 2006, Kruger 2007). This system draws on the United States sulfur dioxide (SO_2) trading system for inspiration, but focuses more on decentralized decision-making for the allocation of allowances and managing of sources, setting itself apart from the emissions trading systems in the United States (Kruger 2007). The European Union ETS rests in between a totally decentralized and a centralized system, with the European Commission (EC) making basic decisions on the structure of the system and participation in the system, but the participating countries deciding their own national cap level, allocating their permits, creating monitoring, reporting, and verification institutions, and making choices about structural features such as auctions and banking (Kruger 2007).

While the system allows member states to set their own national cap level, it is all regulated based on the history of emissions to equal the commitment made by the European Union to the Kyoto Protocol. The goals of the European Union system are to

comply with their Kyoto Protocol Commitment to reduce greenhouse gas emissions to eight percent below 1990 levels by 2012 and 20 percent below 1990 levels by 2020, with a long term objective to reduce domestic emissions by 80-95% below 1990 levels by 2050 (throughout the entire European Union) (Sopher and Mansell 2014f).

5.2 Scope, Coverage, and Pricing of the EU Project:

The EU emissions trading system is scheduled to operate across four stages: 2005-2007, 2008-2012, 2013-2020, and 2021-2028. The first stage focused mainly on establishing a price for carbon allowances and creating the necessary infrastructure for monitoring, reporting, and verifying emissions that would allow success for the future of the system (Sopher and Mansell 2014f). During phase two, five countries were added to bring the number of participants to the current number (31): Bulgaria, Romania, Liechtenstein, Iceland, and Norway. Throughout the third stage (2013-2020), the cap on emissions will decrease 1.74% annually to reach the goal of 21% below 2005 emissions by 2020. To reach this goal, a few design changes were put in place during this phase. During this phase, a single EU-wide cap was put in place rather than separate caps for each participating country, along with harmonization of monitoring, reporting, and verification of emissions in order to create a more unified system throughout the European Union.

During the first two stages of the system, allowances were allocated freely, but a more allowances were auctioned during the third stage to help reduce the over allocation of allowances that was seen during the first phase (Betz and Sato 2006, Sopher and Mansell 2014f). Also throughout phase 3, the use of certified emissions reduction units (CERs) and emissions reduction units (ERUs) were used to allocate emission allowances. In phases two and three of the system, unlimited banking was permitted, allowing participating countries to bank allowances from previous or upcoming years in order to meet their emitting needs. The current plan for the fourth stage of the system (2021-2028) calls for a greenhouse gas reduction of 43% within the EU countries participating in the trading system, and a 40% reduction of emissions from the European Union as a whole by 2030. The linear reduction factor will increase from 1.74% to 2.2% annually, and there will be no acceptance of international credits within the trading system. There

is also a plan set in place to establish a market stability reserve (MSR) during this fourth and final stage of the European Union emissions trading system (Sopher and Mansell 2014f).

The price for European Union Allowances (EUAs) is set to stay below ten euro per ton of carbon dioxide emitted until 2022. With the current costs, the value of allowances issued every year is about 22-66 billion euros, dwarfing the value of allowances in both the United States emissions trading system and the New Zealand emissions trading system (Betz and Sato 2006, Grubb 2006).

The previous section has summarized the scope of the EU ETS, including its stages of operation, a brief summary on allocation and pricing, and a general plan for the system. The next section will outline the future plans for the European Union emissions trading system, including the future goals, projections, and any changes that are projected to occur between now and the final stages of the system.

5.3 Future of the EU system:

The European Union recognizes that linkage to other carbon markets is essential to building a global carbon market, and signed a linkage agreement with Australia in 2012. The linkage of emissions trading systems across multiple nations in the European Union emissions trading systems begs the question as to whether linking trading systems in different regions of the world to make a more global regime for the trading of carbon dioxide is feasible and desirable (Kruger 2007).

In theory, linking of systems will increase efficiency by taking advantage of the diversity of marginal abatement costs throughout the larger linked system; however, challenges arise when considering the implementation of a linked system. In order for a linked system to be efficient, there needs to be consistency in certain areas, specifically: monitoring and enforcement, allowance distribution, and target goals (Kruger 2007). Most studies conducted on a globally linked system have concluded that it is technically feasible, but reconciling differences in design elements may require procedures that will increase administrative costs and complexity (Kruger 2007).

The idea of a linked system also brings about issues of fairness, which may be more difficult to resolve between nations, due to the fact that in some instances a linked system

is a disadvantage when compared to an independent system for some regions. For example, when two programs with different emissions targets with different levels of stringency are linked, the prices in the combined system may be higher for one of the programs and lower for the other than they would have been in separate systems. Differences in greenhouse gas obligations also come into play with linked systems, with studies noting that there may be large capital flows associated with these differences, causing political controversy (Kruger 2007).

To continue moving forward toward the goal of a global carbon market and to reach their benchmark goals, the European Union permits emitters who are "at-risk" of carbon leakage to receive free allowance allocations to prevent carbon leakage. Also, until 2020, emissions-intensive trade exposed (EITE) firms will receive up to 100 percent of their benchmark allocations via free distribution. The European Union is firmly adhering to their goals to remain consistent with their Kyoto Protocol agreement, using the Kyoto National Registry System for market regulation, compliance, and oversight purposes, as well as implementing a 100 euro penalty for each ton of carbon dioxide emitted exceeding their allowance (Sopher and Mansell 2014f).

The previous section has included information on the future projections for the EU ETS, including the realization of the necessity of a global system, addressing monitoring issues and plans, and current system details that aid in the eventual creation of a global system.

5.4 Results and Challenges of the EU ETS:

While only in the second phase of the system, the first phase yielded a 2-5 percent decrease in emissions, and the second phase is on track with the Union's goals for success, after learning from and overcoming initial problems presented in the first phase. The European Union emissions trading system brings unique qualities to the world of trading schemes, being the largest emissions trading system in the world and the first multi-national installation-level cap-and-trade system that set up a market for both carbon dioxide and greenhouse gas emissions.

Being only in the second phase of the system, challenges have presented since the implementation of the system. First, there is a lack of clarity for what will happen post

2020, even with a loose plan set in place. Second, the low allowance prices and excessive supply of allowances hinders success of an overall emissions reduction, which can be remedied by allowing flexibility between phases through banking and borrowing to reduce potential problems that may arise from over-allocating. Finally, overlapping policies exist within the system, which complicate the uniformity of monitoring, reporting, and verification.

The system is also at risk of being undermined by three main problems: the approach to allocation and the allocation methods, the absence of a strong commitment to post-2012 continuation of the system, and concerns about its impact on the international competitiveness of key sectors (Grubb 2006, Sopher and Mansell 2014f).

The previous system included the results to-date of the EU ETS, challenges faced in the program, and potential risks to face the system in the future.

5.5 Lessons learned/conclusions:

This section will discuss the lessons learned from the system's progress and any conclusions about the European Union emissions trading system.

The European Union emissions trading system learned valuable lessons, including: the importance verified emissions information as well as harmonized measuring, reporting, verification, and allowance distribution mechanisms. The realization that long-term policy certainty is fundamental has also come upon the EU emissions trading system, and continued monitoring throughout subsequent phases will aid in creating an ideal system (Betz and Sato 2006, Sopher and Mansell 2014f).

6. The New Zealand Emissions Trading System

As with each of the in-depth case studies, this chapter is covers including the background and scope of the emissions trading system in New Zealand, information about the allocation of allowances, pricing of the allowances, and challenges faced by the system.

6.1 Background:

New Zealand is a Pacific Island nation with a population of approximately 4.1 million people and a modern, industrialized economy. The country is already experiences negative environmental consequences due to climate change, including changes in temperature, rainfall levels and distribution, and sea level rise. The country's greenhouse gas emissions are increasing and its per capita emissions are the world's twelfth highest, while only contributing to 0.1% of total global greenhouse gas emissions. Due to this, the New Zealand emissions trading scheme was developed in 2008 to fulfill the requirements of the Climate Change Response Act of 2002, in hopes that its emissions reductions will be a part of an international effort to combat climate change (Moyes 2008).

Along with this, NZ wants to preserve its reputation as a leader in environmental issues and awareness, which is valuable to its biggest economic sectors: tourism and primary production (Moyes 2008). The New Zealand ETS is the only trading scheme in the world that includes emissions liabilities for land-use sectors: deforestation of pre-1990 forestland (as of 2008) and biological emissions from agriculture (Jiang et al. 2009, Sopher and Mansell 2014k). Like the European Union emissions trading system, the New Zealand ETS is working toward meeting its international obligations under the Kyoto Protocol and to reduce New Zealand's net emissions below business-as-usual (BAU). In 2008, New Zealand's liability under the protocol was estimated at NZD $593 million (Jiang et al. 2009). The New Zealand emissions trading system has been called the most ambitious national cap and trade emissions trading scheme to fight greenhouse gas emissions, coming at a time when developed countries, like New Zealand and the United States, are beginning to look further towards emissions trading as a cost-effective strategy to mitigate climate change (Moyes 2008). While the NZ ETS is not the first

trading system in the world, it is at the head of the pack when it comes to making strides toward reducing emissions, with a strong effort to internalize the full cost of its greenhouse gas emissions and transition to a “lower carbon economy”.

6.2 Scope of the NZ system:

According to the Kyoto Protocol’s first commitment period (2008-2012), New Zealand plans to reduce greenhouse gas emissions to 1990 levels (61.9 $MtCO_2e$/yr), requiring a decrease in emissions from the 2011 levels of 72.8 $MtCO_2e$. The country’s high per capita emissions can be contributed to a broad range of activities, mainly driven by economic dependence on emissions-intensive primary industry and a heavy reliance on private transportation (Moyes 2008). New Zealand also committed to the Copenhagen Accord, pledging a conditional emissions target range of 10-20 percent below 1990 levels by 2020, but instead, the country’s Climate Change Minister Tim Grosser announced in August 2013 that New Zealand would adopt an unconditional unilateral five percent reduction target below 1990 levels by 2020 (Sopher and Mansell 2014k). A long-term target for New Zealand is to reduce emissions to 50 percent below 1990 levels by 2020. Despite New Zealand’s international commitments, emissions in the country have increased considerable since 1990. Emissions were 25% over 1990 levels in 2005, and are projected to reach 48% above 1990 levels by 2020 without immediate action. This growth is caused by an increase consumption of fossil fuels for transport and electricity generation, as well as growth in agricultural emissions (Moyes 2008).

The New Zealand ETS covered six gases at its inception; carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF_6). A 2012 amendment to the system exempted synthetic greenhouse gases (HFCs and PFCs) contained in imported motor vehicles. The emissions controlled in the system are categorized into seven sectors: forestry, stationary energy, liquid fossil fuels, industrial processes, waste, specified synthetic greenhouse gases, and agriculture. One unique aspect of the NZ ETS is that the points of obligation are located as far upstream as possible, and the point of obligation differs from the point of allocation.

New Zealand is the first country to include emissions from agriculture in their emissions trading system. Forestry and agriculture are two important sectors in regards to climate change. Forestry offers the opportunity for natural carbon sequestration, and the agriculture sector is especially vulnerable to carbon leakage, both significantly impacting the system (Jiang et al. 2009). The Forestry Sector of the system includes forest land that is defined as an area at least one hectare in size that contains forest species and has or is likely to have trees covering 30 percent of each hectare (Sopher and Mansell 2014k). Within this sector includes pre-1989 and post-1989 forest, pre-1989 forests being areas forested on December 31, 1989 and remained intact through December of 2007 and post-1989 forests being forests established on unforested land after December 31, 1989 and land that was forest land on December 31, 1989, but was deforested between January 1, 1990 and December 31, 2007.

The NZ emissions trading system works in one-year compliance periods, administering allowances via free allocation with no auctioning to date. Free allocation is more restricted in the New Zealand system than other systems. Certain sectors of the economy are not entitled to any free allocation, while elsewhere most systems allocate a large number of allowances for free, enhancing political acceptability among participants and creating a cushioned transitional period (Moyes 2008).

The previous section has summarized the scope of the New Zealand ETS, including its commitment to the Kyoto Protocol, contributors to the high levels of emissions, categories of control covered in the system, and the break down of the system schedule.

6.3 Allocations in the NZ ETS:

The allocations used in the system are New Zealand Units (NZUs), the primary domestic units of trade, as permits to be domestically traded or Kyoto Compliant Emission Reduction Units (e.g. RMUs, and certified emissions reduction units (CERs)). Currently, there are no limits on trading domestic or approved international units, and there are no quantitative limits for banking of units or offsets. While there is no current banking limit, the borrowing of units from future allocations is not permitted.

Much like the European Union ETS, New Zealand is open to potential linkages with international markets and currently has a two-way linkage with Australia since 2011

(Jiang et al. 2009, Sopher and Mansell 2014k). Also similar to the EU ETS, New Zealand makes an effort to protect those at risk of losing competitive leverage by allocating units based on intensity for Energy Intensive Trade Exposed (EITE) emitters. The New Zealand ETS has no independent national cap on emissions, but relies solely on the international cap set by the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Moyes 2008).

The previous section has summarized the allocation allowances used in the emissions trading system, as well as potential linkage to create a global system. The next step is to review the pricing of emissions allowances used in the system, as well as the various fines used for non-compliance in the system.

6.4 Pricing and fines in the NZ ETS:

The price for each New Zealand Unit is current set at NZD $25, and participants in the trading system self-report annually and can volunteer for quarterly reporting. There is a current penalty in place amounting to NZD $30-60 per ton of CO_2 emitted exceeding the allocation limit, as well as a forced surrender of units. For a failure to comply, an emitter is subject to a NZD $24,000 fine, as well as a NZD $50,000 fine for the falsification of emissions reports. While New Zealand has not signed up to the second commitment period of the Kyoto Protocol, they are continuing with their yearlong compliance periods with an independent review panel every commitment period for five years. New Zealand also implements a registry for monitoring, reporting, and verification of emissions. To date, the New Zealand emissions trading system has contributed to increasing yearly afforestation and new plantings (2008-2011), and there was a five fold increase in renewable energy capacity consented between 2010 and 2011. New Zealand also works with two complimentary policies: Global Greenhouse Alliance on Agricultural Greenhouse gases and Energy Efficiency and Conservation Strategy (Sopher and Mansell 2014k).

6.5 Challenges in the NZ ETS:

The New Zealand emissions trading system has faced challenges since its creation, including: limited options for reducing biological agricultural emissions, the cyclical nature of forestry emissions, and the fact that New Zealand already generates a relatively large portion of its electrical energy from renewable sources. New Zealand is a unique case because almost 70 percent of its electricity is generated from renewable sources (Jiang et al. 2009). There is also the issue of who to hold accountable for the emissions in the first place. Going along with the Kyoto Protocol, where all greenhouse gas emissions are assigned to the producer with no consideration given to where the goods are finally consumed, New Zealand (as well as most emissions trading systems) focus on the a reduction in the production of greenhouse gases rather than the consumption due to a tendency of economic policy in market-driven economies not to interfere with consumer's preferences (Andrew and Forgie 2008).

While the solution of consumer responsibility seems like a viable option, especially with the amount of overseas and international trade today, both the producer and consumer responsibility perspectives have advantages and disadvantages regarding the New Zealand emissions trading system. Under the Kyoto Protocol, participating countries must keep track of their own emissions, while they are not typically responsible for those of other nations, making the producer responsibility perspective straightforward when it comes to data collection. On the other hand, the consumer responsibility perspective is favored by nations exporting many of their emissions-heavy exports (Andrew and Forgie 2008).

In New Zealand, the producer responsibility perspective seems ideal for the agriculture and forestry sectors due to the fact that they are responsible for about 50% of the country's global warming potential, while households and exports favor the consumer responsibility (Andrew and Forgie 2008). Even faced with challenges, the New Zealand ETS presents many unique aspects; the inclusion of land-based sectors, the absolute amount of net emissions attributed to New Zealand is ensured but the government of the country, not the trading system, and the point of obligation differing from the point of allocation (Sopher and Mansell 2014k). To conclude, the success of NZ's ETS will rely largely on the creation of an open, viable, and liquid, international carbon market. While

a global system is recognized as highly important by most cap-and-trade systems across the globe, at this point it is unlikely to occur unless the Kyoto Protocol and its commitments are furthered (Jiang et al. 2009).

The previous section has revealed challenges that have faced the New Zealand ETS as well as potential solutions.

7. The United States Emissions Trading System

Following the reviews of the EU and NZ trading systems, this chapter covers the emissions trading system in the Northeastern United States, the Regional Greenhouse Gas Initiative (RGGI). This section will cover the background of the systems, the scope and coverage, pricing of allowances and allocation methods, successes and failures, and possible future projections of the systems.

7.1 Background of RGGI:

This section will cover the background and history of the RGGI, and provide general information of how the system is run.

The Regional Greenhouse Gas Initiative is an effort to reduce carbon dioxide emissions from the electric power sector across nine Northeastern and Mid-Atlantic states in the United States through the coordination of state cap and trade programs. The system started in 2003, and was developed to address the risks arising from climate change. In December of 2005, the nine states involved in RGGI issued a memorandum of understanding (MOU) explaining the overall goal of the program: to create a cap and trade program aimed at stabilizing and reducing emissions within participating states, while also remaining consistent with economic growth and maintenance of a safe and reliable electric power supply system (Cramton 2007, Sopher and Mansell 2014n). The system also has secondary objectives outside its environmental goal, including: transparency, neutrality, risk minimization, liquidity, simplicity, and consistency (Cramton 2007).

The first round of allowances was auctioned in 2008, and the first compliance period of the system began in January of 2009. Since the inception of the program, states have withdrawn and joined. Maryland joined the system in 2007, while New Jersey withdrew in 2011. In March of 2014, the manner in which the state withdrew had violated the procedural requirements under state law, and the Appellate Division of the New Jersey Superior Court directed the state to undergo the required procedure of public-comments within 60 days of the court ruling (Mansell and Sopher 2014n). Currently, the states participating in the program include: Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New York, Rhode Island, and Vermont.

RGGI is comprised of individual, state-level CO_2 cap and trade programs that allow interstate allowance trading. To facilitate the establishment of similar programs in other states, RGGI states created a Model Rule that was first published in 2006, and each state subsequently established its own cap and trade program in accordance with this Model Rule with the following goals: 1) to set limits on in-state CO_2 emissions from electric power plants (based on a history of emissions), 2) to issue CO_2 allowances and 3) to establish state participation in regional CO_2 allowance auctions.

The MOU also outlines a comprehensive review of the program in 2012 that addresses the following issues: the environmental success of RGGI; the impact of RGGI on electricity price and system reliability; and, whether to consider any additional reductions (Cramton 2007, Sopher and Mansell 2014n). Finally, the MOU requires an evaluation of offsets including price, availability, and environmental integrity. The program review was completed by RGGI in February 2013, after releasing an updated Model Rule. All of the nine participating states adopted the amendments to the Model Rule, with only two states, Maine and New Hampshire, requiring legislation to do so (Sopher and Mansell 2014n).

7.2 Scope/Coverage of the RGGI:

This section will highlight the key policy features of the Regional Greenhouse Gas Initiative, including the cap/target of the program, and its scope and coverage.

7.2.a Cap/Target:

Like other systems, RGGI is based on caps, or targets. In this case the caps are distributed across the states of the system. This section will cover the caps and targets of the system, including the allowance budget and each state's allowance.

The RGGI operates with three-year compliance periods, the first of which started on January 1 2009, and ended December 31, 2011. The MOU sets the overall emissions budget at 188 million short tons of carbon dioxide for the first compliance period. For the second compliance period, which began in 2012, the annual budget was reduced to 165 million short tons of CO_2 (Figure 7.2.1) to account for New Jersey's withdrawal from the program (Cramton 2007, Sopher and Mansell 2014n). The third compliance

period is set to begin in 2015, and the annual emissions budget is currently set to reduce at 2.5 percent each year, for a total reduction of 10 percent by 2018. The update to the Model Rule is consistent with this reduction, but would lower the cap further to 91 million short tons of CO_2 in 2014, equal to 2012 emissions levels for the RGGI states, and would extend the annual reduction from 2015-2018 to 2015-2020.

The overall emissions budget is also apportioned to individual states, with each state's portion remaining constant until 2015, when it reduces by 2.5 percent annually to meet the total reduction goal of 10 percent by 2018. Table 7.2.1 below summarizes the allocated budget for each state in 2013 (Sopher and Mansell 2014n).

Table 7.2.1: State Carbon Emissions Budgets and Share of Regional Cap 2012-2014

State	**Budget** (in short tons)	**Budget** (as % total)
Connecticut	10,695,036	6.47%
Delaware	7,559,787	4.58%
Maine	5,948,902	3.60%
Maryland	37,503,983	22.70%
Massachusetts	26,660,204	16.14%
New Hampshire	8,620,460	5.22%
New York	64,310,805	38.93%
Rhode Island	2,659,239	1.61%
Vermont	1,225,830	0.74%
TOTAL	165,184,246	100%

Figure 7.2.1: State CO_2 Emissions Budgets and Share of Regional Cap, 2012-2014.

Source: www.rggi.org/design/overview/regulated_sources
(Sopher and Mansell 2014n)

The update to the Model Rule also includes provisions to adjust the overall budget to account for RGGI allowances that emitters banked during the first and second compliance periods. Soon into the first period of the program, it became clear that the number of allowances in the emissions budget was higher than actual emissions, causing the allowance prices to drop and making it particularly inexpensive to purchase and bank allowances for the future (Cramton 2007, Sopher and Mansell 2014n). It was estimated that the banked allowances was equal to 57 million sort tons of CO_2, motivating RGGI states to propose additional adjustments to the budget in the updated Model Rule. The

updated Model Rule lowers each state's emissions budget annually, according to the amount of allowances that states' emitters have banked.

The amount that each state's budget is lowered is determined by a three-step process: first, by January 15, 2014, RGGI calculated an adjustment for each state based on the number of allowances banked by its emitters in 2009, 2010, and 2011 (Sopher and Mansell 2014n). This calculation follows the formula below:

$$FCPIABA = (FCPA/7) \times RS\%$$

Where FCPIABA is the state's first compliance period interim adjustment for banked allowances quantity in short tons, FCPA is the state's total quantity of allocation year 2009, 2010, and 2011 CO_2 allowances held in its emitters' general and compliance accounts, and RS% is the states portion of the overall cap **(Sopher and Mansell 2014n)**.

Second, participating states will calculate an adjustment for each state based on the number of allowances banked in 2012 and 2013, following the formula below:

$$SCPIABA = ((SCPA - SCPE)/6) \times RS\%$$

Where SCPIABA is the state's second control period interim adjustment for banked allowances quantity in short tons, SCPA is the total quantity of allocation year 2012 and 2013 allowances held in all emitters' general and compliance accounts, as of March 15, 2014, SCPE is the total quantity of 2012 and 2013 emissions from all emitters in all RGGI states, as of March 15, 2014, and RS% is the states portion of the overall cap (Sopher and Mansell 2014n).

Third, the RGGI states will each lower their emissions budgets an amount equal to: the calculated FCPIABA for each year from 2014 through 2020, and the calculated SCPIABA for each year from 2015 to 2020. This final step would effectively adjust the overall cap down over a seven-year period, by a number of allowances at the end of the second compliance period. Recently, emitters have purchased less than 100 percent of the offered allowances, undersubscribing most of the recent auctions. The RGGI participating states retained these allowances, intending to retire the allowances at the end

of the second control period (Sopher and Mansell 2014n). The retirement of allowances will reduce the cap further, setting a more realistic goal for emitters in the future of the system relative to their first round of emissions.

The previous section has provided information on the cap and target of RGGI, including its member states, the allowance budget for each state, the system's compliance periods and methods of control, and the calculations used to determine budget adjustments.

7.2.b Coverage:

This section will provide information on the coverage of the RGGI program, including the emitting facilities covered and the general functioning of allowance surrender.

In 2010, emissions from the power sector in states participating in RGGI amounted to 137 million short tons, equivalent to 5.5 percent of total United States emissions from the power sector, which equals 2.26 billion metric tons of CO_2. All together, the RGGI states contain 13.1 percent of the U.S. population in 2011, seven percent of the U.S. CO_2 emissions, and 16% of the U.S. GDP (Sopher and Mansell 2014n).

RGGI covers carbon dioxide emissions from fossil fuel-fired plants within the nine RGGI states that meet the threshold of at least 25 Megawatts in size, with the point of regulation at the sources of electricity generation. This choice of point of regulation aids in determining which entities must comply with the regulatory system put in place by monitoring emissions, keeping records, and submitting allowances each period (Paltsev et al. 2008). During the first compliance period, RGGI regulated 211 emitters, dropping to 171 after the withdrawal of New Jersey. Currently, RGGI regulates 168 facilities (Sopher and Mansell 2014n). At the end of each compliance period, emitters are required to surrender the number of allowances equal to their emitted CO_2 levels during the period. The updated Model Rule emphasizes the RGGI states commitment to identify a workable policy to address emissions associated with imported electricity, which are not currently covered under the cap. The scope of the RGGI program may

expand in the future to cover emissions associated with imported electricity (Sopher and Mansell 2014n).

The previous section has included information on the coverage of the system regarding the number of emitters the system covers and the type of emissions included in the system.

7.3 Allowances and Allocation in RGGI:

This section will briefly summarize the system of allowances and allocation in the RGGI program.

Emission allowances can have a significant effect on equity aspects of the system. With the auctioning of allowances, the overall distributional effect depends on what is done with the revenue from the auctions (Paltsev et al. 2008). RGGI, Inc. makes about 90 percent of the CO_2 allowances available in quarterly central auctions on behalf of the RGGI states. In the context of this system, the auction design is meant to emphasize efficiency rather than maximize revenue (Cramton 2007). RGGI is one of the only cap-and-trade programs that auction nearly all of its allowances, instead of freely allocating them, and is recognized as a success in implementing auctioning as a means of distributing emissions allowances (Cramton 2007). The proceeds from each auction are distributed to the states, which then individually determine how to spend them. The auctions follow a single-round, sealed-bid, uniform-price format, in which each bidder can submit multiple confidential bids for a specific quantity of allowances at specific price. There exist qualification requirements to participate in the auctions, including provision of financial security, and buyers are subject to a purchase limit of no more than 25 percent of the allowances offered at a single auction.

The previous section has included information on the auctioning of allowances within RGGI.

7.4 Allowance Distribution:

This section will provide information on the distribution of allowances within the program and an overview of the auction process to distribute allowances. This section will also include allowance pricing information.

While the auctioning of all allowances is unprecedented and risky for entities at risk of carbon leakage, RGGI allows states to further allocate allowances to stabilize the uncertainty caused by the initial auction, where states are purchasing auctions rather than emitters (Cramton 2007). After the allowance auction, each state individually determines how to allocate allowances – either via free allocation or auctions, operating under two restrictions. First, 25 percent of allowances are to be allocated for consumer benefit or strategic energy purpose, such as promotion of energy efficiency, direct mitigation of electricity ratepayer impacts, promotion of renewable or non-carbon-emitting energy technologies, reward or stimulation of investment in the development of innovative carbon emissions abatement technology with significant carbon reduction potential, or funding administration of the RGGI program. Almost all allowances are suctioned, and the majority of the proceeds are allocated toward consumer benefit or strategic energy purposes. Second, RGGI requires states to recognize that in order to provide regulatory certainty, the specific rules regarding allocations should be completed as far in advance as practicable (Cramton 2007, Sopher and Mansell 2014n).

The first compliance period yielded sales of approximately USD $952 million, and the overall auction proceeds for the program amount to over USD $1.2 billion according to Congressional Research Services (2013). The participating states have put these proceeds back into the economy in many ways including: energy efficiency measures, community-based renewable power projects, assistance to low-income customers to help pay their electricity bills, education and job training programs, and even contributions to a state's general fund (Sopher and Mansell 2014n).

7.5 Flexibility Provisions:

This section will cover flexibility provisions that have been made in the RGGI program to make the program as efficient as possible while still meeting program goals and regulations.

There are several flexibility provisions within the RGGI program including the use of offset and early reduction credits, banking, compliance periods with flexible durations, and price collars (an auction reserve price and a complex "safety valve" mechanism). The updated Model Rule introduces a Cost Containment Reserve (CCR)

and modifies the way RGGI handles offset usage, as well as removes compliance periods with flexible durations (Cramton 2007, Sopher and Mansell 2014n).

The use of three-year compliance periods, as opposed to annual compliance, provides flexibility in the system. During the first and second commitment periods, RGGI used a trigger price mechanism to extend the duration of a compliance period. After the first 14 months of a compliance period, the duration of the period can be extended by up to three one-year periods if the average price of an allowance exceeds the trigger price for a period of 12 months (Sopher and Mansell 2014n). The trigger price is USD $10 (as of 2005 USD) as adjusted by the Consumer Price Index (CPI) plus two percent annually, beginning in January 2006. As previously mentioned, the updated Model Rule eliminates this provision.

The RGGI program allows its own offsets from the following project types: capture or destruction of CH_4 from landfills; SF_6 reductions from electricity transmission and distribution equipment, CO_2 sequestration through afforestation, CO_2 reductions through non-electric end-use energy efficiency in buildings, and, avoided CH_4 emissions through agricultural manure management operations (Sopher and Mansell 2014n). The use of these offsets is limited to 3.3 percent of a covered entity's reported emissions. During the first and second control periods, RGGI has provisions whereby if average allowance prices increase to above USD $7 or USD $10, allowance usage increases to 5 and 10 percent, respectively. At the USD $10 price trigger, RGGI can accept international offset units, such as CERs. Under the updated Model Rule, these provisions would be replaced by a CCR. In 2014, the CCR would contain 5 million allowances, and from 2015 on it would contain 10 million allowances. If auction bids exceed the CCR price trigger, allowances are made available immediately at or above the CCR trigger price. The CCR price is USD $4/ton in 2014, USD $6/ton in 2015, USD $8/ton in 2015, USD $10/ton in 2017, increasing 2.5 percent annually thereafter (Cramton 2007, Sopher and Mansell 2014n). The current reserve price (price at which no allowance can be sold under) is USD $1.98 per CO_2 allowance, and this price would be simplified under the updated Model Rule to increase the reserve price by 2.5 percent annually.

The previous section included information on the compliance periods of the system and their flexibility, as well as the allowance of individual offsets to aid in reaching their goal.

7.6 Economic Projections

This section will provide an overview of economic projections currently and for the remainder of the program.

If the cap remains unchanged from the initial program design, the allowance price is not expected to rise about the auction reserve price through 2018. When an emissions cap is set in a system such as RGGI, there is uncertainty as to how high the price of emission may rise, which often results in a price ceiling (Paltsev et al. 2008). Due to this, the use of offsets and trading on the secondary market has not yet materialized. However, with the release of the updated Model Rule and in anticipation of the lowering of camps, RGGI allowances are currently trading at about USD $3.50, much higher than the auction reserve price, and trading volumes have increased drastically.

7.7 Results, Unique Aspects, and Challenges

This section will cover the results to-date of the program, a summary of unique aspects of the program, and challenges that have been faced since its inception.

RGGI has achieved the emissions cap initially established in its 2005 MOU, and The New York State Energy Research and Development Authority (NYSERDA) calculated that emissions in the RGGI region declined 33 percent, from 184.4 million short tons in 2005 to 123.7 million short tons in 2009. Between 2008 and 2009 specifically, emissions decreased by 18.4 percent (Sopher and Mansell 2014n). Early on in the program, it was apparent that the program was over-allocated with CO_2 allowances. For example, in September of 2008, at the first auction, all 12.56 million allowances offered for sale were sold at a single price of USD $3.07 per allowance, while at the September 2011 auction, 18 percent of the 42.19 million allowances offered for sale were purchased at USD $1.89 per allowance. An economic impact study showed that RGGI was costing the power plant owners money due to a decrease in electricity sales from the promotion of energy efficiency through the program. However, the net present value

economic benefit of RGGI's auction proceeds exceeded the cost of RGGI's carbon price (Sopher and Mansell 2014n).

Three main points make the RGGI unique. First, RGGI is one of the only cap and trade systems that auction the majority of allowances to covered entities rather than using free allocation. Second, the RGGI program only impacts emissions within the utility sector, rather than extend its cap over multiple sectors. Finally, RGGI is composed of individual, state-level CO_2 cap and trade programs that allow allowance trading against one another, similar to the multi-national character of the European Union emissions trading system (Sopher and Mansell 2014n).

While the RGGI program has proven successful in many aspects, it has faced challenges along the way. First, the participation in the program is non-binding, so states have the option to exit the program, which leads to a cap-adjustment to reflect their exit. There is also the option for more states to enter the program. This aspect of the system forces the success of RGGI to rely on the resolve of its member states and their participation (Cramton 2007). Next, as previously discussed, over-allocation has resulted due to the business-as-usual (BAU) emissions for participating entities falling below the cap. This is due to a decrease in output as well as RGGI's success at reducing emissions through pricing and investing auction proceeds into energy efficiency and renewable energy (Sopher and Mansell 2014n). The updated Model Rule may fix this challenge. Finally, as the RGGI cap is lowered, attention may be required to the issue of emissions leakage, which the updated 2012 program review calls for explicit consideration of throughout the entirety of the program. As many other systems call for, RGGI realizes that a U.S. cap-and-trade system could be substantially affected by linkage to outside systems (Paltsev et al. 2008). While this linkage is in the long-term scope of most systems in place at this time, linking to foreign trading systems will result in the emergence of a common emissions price, and it is unknown whether this price will be higher or lower than the current RGGI price.

The previous section has covered the challenges faced in the RGGI program, potential remedies for these issues, as well as unique traits of the system.

8. Types of Allocation Systems

This chapter covers some of the characteristics of emissions trading systems, focusing on allocation systems. The two main allocation systems are free allocation and auctioning, with a third method of allocation being a hybrid, using both free allocation and auctioning.

8.1 Free Allocation

One of the main types of allocating CO_2 allowances in an emissions trading system is the concept of free allocation. In an emissions trading system that uses free allocation, the system manager essentially gives away allowances to participating entities. The percentage of the total number of allowances of freely allocated allowances can vary from system to system, from all allowances being freely allocated, to just a percentage while the rest are auctioned off to participants. All four of the in-depth case studies covered in this paper use the method of free allocation. The European Union's system (Chapter 5), New Zealand's system (Chapter 6), and the United States' RGGI (Chapter 7) all operate under a hybrid system with both free allocation and auctioning of allowances, while the United States' Sulfur Dioxide emissions trading program (Chapter 4) operates solely on free allocation.

Allowances are often freely allocated to firms that are considered 'high risk', meaning they are 'at risk' of carbon leakage. Carbon leakage is defined as an increase in carbon dioxide emissions in countries or regions due to emissions reductions in a country with a climate policy ("Carbon Leakage" 2007). Leakage can occur when a firm that may be unable to further reduce emissions must export their carbon-emitting practices to a country or region without a mitigation policy on emissions in order to continue production and remain cost-effective. Free allocation of units is designed to reduce the stress on these types of entities, referred to as emissions-intensive trade exposed (EITE) firms who may require up to 100 percent of their quota to be covered by freely allocated allowances (Sopher and Mansell 2014a).

While the primary positive aspect of free allocation of allowances is that it helps firms that may not be able to continue production otherwise, it also carries negative aspects as well. Mainly, the free allocation of allowances reduces the competition of

auctioning, which in turn lowers the drive for firms to seek out alternative methods to production and reduction of emissions. Additionally, the over-allocation of allowances will reduce the carbon price due to fewer entities competing and auctioning for allowances, with also reduces the incentive to cut emissions (Mills 2012). The free allocation of allowances is also based on historical emissions, making the process simple, but this approach also reduces the incentive to reduce emissions in the long term, as the higher the emissions in the current year, the more allowances will be freely allocated in subsequent years (Mills 2012).

The auctioning of allowances generates a large amount of revenue, which can be put back into the economy for many uses, including repairing infrastructure, creating more environmentally friendly systems and projects within the country or region, and stimulating the economy in general. As the number of allowances that are freely allocated increases, the less are auctioned, meaning the revenue created decreases as well (Mills 2012). In general, the free allocation of allowances reduces participating firms incentives to abate emissions or seek alternatives to production, and also reduces the revenue created that could be put back into the economy.

Another argument against free allocation also centers on the idea that the free allocation of allowances is a certain type of state aid, which raises doubts that the concept satisfies the overall goal of the policy (Johnston 2006). This type of aid could be considered an 'advantage' in the system, and also begs the question of how a sector or firm is deemed 'at risk', if not all of them.

8.2 Auctioning

While some allowances may be freely allocated in an emissions trading system, they are often auctioned as well. In a system, a governing entity will set an overall cap on emissions, and a certain number of allowances will be created to equal that set cap. These allowances, if not freely-allocated, are auctioned off either on markets continuously, or at designated times throughout a compliance period. The sale of emissions allowances via auction is a main characteristic of cap-and-trade systems (Shobe 2009). The auctioning of allowances on markets solidifies the system as being

market-based, and benefits the economic perspective of emissions trading. Generally, the price of carbon allowances in a system depends on the degree of international linkage.

A system could be established with no access to international units, no limits on the number of international allowances that can be used in the system, limits on the number of international allowances, or with no access to international units at all ("Cap-and-Trade" 2015). For a system with no access to international allowances, the price of carbon can be established using the price of domestic units that are surrendered at the end of each year, and by the balance of the supply and demand of units. Essentially, the lower the carbon cap, the fewer allowances available, and the higher the price ("Cap-and-Trade" 2015). In a system with allowed international units, the domestic price would equal the international price and be based on the international balance of supply and demand of units (the higher the reductions, the higher the international carbon price) ("Cap-and-Trade" 2015). The price of carbon allowances create an incentive to reduce emissions in participating firms, satisfying the main goal of the system and aiding in the abatement of carbon emissions.

The auctioning of allowances is often done by participating entities submitting a sealed bid to the governing entity, based on a floor price that has been previously set. In some systems, the allowances can be purchased from environmental groups or through a broker, in addition to the annual auctions ("Buying Allowances", n.d.). Participating firms are eligible to purchase allowances, as well as the general public. Members of the general public often purchase available allowances as an environmental statement, as the purchase of allowances with no intention of emitting prevents those allowances from being purchased and used by a participating entity, therefore reducing emissions ("Buying Allowances", n.d.).

The main positive aspect of the auctioning of allowances is that it creates incentive for participating entities to reduce emissions or seek alternative methods to production. With the burden of having to pay to produce emissions, firms will often take measures to reduce their carbon emissions such as a direct production reduction or the implementation of renewable resources or practices. Along with the incentive intrinsically reducing emissions, the auctioning of allowances also produces considerable revenue for the economy. As mentioned in the previous section, the revenue can be put back into the

economy to improve environmental infrastructure and fund environmental projects throughout the region or country.

The auctioning of allowances in a cap and trade system brings many advantages to the participating area. First, the system directly limits carbon emissions with the cap, and the fixed number of allowances ensures that the obligation will be met, making the system extremely effective ("Cap-and-Trade" 2015). Also, the revenue created by the auctioning of allowances, as previously mentioned, allows for assistance to participants as well as investment in sustainable development. Also, within a country with an emissions trading scheme, there is a minimization of fiscal risk since emissions trading gives a high level of confidence that emissions commitments and obligations will be met, reducing the need for international units ("Cap-and-Trade" 2015).

Four of the cap and trade systems covered in this thesis: Brazil, California, India, and Mexico. Both India and Mexico sell their allowances to then be traded among participants (Table 3.2). California auctions allowances quarterly, and Brazil auctions all available allowances among participants (Table 3.2). Most other systems operate with a combination of free allocation and auctioning. These systems include the European Union, New Zealand, Switzerland, Australia, and South Korea (who will auction up to 90 percent of allowances during the third phase of the system) (Table 3.2).

Many systems use a combination of free allocation and auctioning, with free allocation during the first compliance period, then reducing the number of allowances that are freely allocated and increasing the number of allowances auctioned during subsequent compliance periods. Currently, Tokyo is the only system included in this paper that operates fully with free allocation (Sopher and Mansell 2014f). The United State's RGGI freely allocated 90 percent of its allowances, and leaves it to the discretion of each member state to decide on an allocation mechanism. The Québec system freely allocated nearly all of its allowances, except to fuel distributors, and auctions the excess allowances to the fuel sector (Table 3.2). Both Norway (2013-2020) and Kazakhstan freely allocated all allowances during the first phase of their respective systems and plan to transition into total auctioning during the final phases of their systems (Table 3.2).

Location	Start Date	Total Emissions Level	CO2 Volume or Cap	Allowance Price (USD/tCO2)	Allocation Mechanism
UK	2001	12.5% below 1990 levels		$3.05-18.29	
EU	2005	20% below 1990 levels (2020), 80-95% below (2050)		$11.32 (ceiling set until 2022), about $4.42	Free allocation (Phase I and II), freely allocated and auctioned (Phase III)
Norway	2005		15 MtCO2e/year (Phase II and III)		Free allocation (Phase I), Half allocated/half auction (Phase II), Total auction (Phase III)
Alberta, Canada	2007	12%below baseline annually (2003-2005)	32.3 million tons CO2	$6.39-9.59 (2010)	
China	2008				
Japan	2008			~$8-11	
New Zealand	2008	10-20% below 1990 levels (2020)	61.9 MtCO2/yr	$1.47 (2013)	Free allocation and auctioning
Switzerland	2008	20% (10.5 MtCO2e) below 1990 levels (2020)	3.42 MtCO2 (2010)		Free allocation (2008-2012), free allocation and auctioning (2013-2020)
Brazil	2009	36.1-38.9% below BAU (2020)			Auctioned and exchanged on market
RGGI (USA)	2009	10% below 2009 levels (2020)	91 million short tons CO2 (2014)	$2.55 (2013)	90% auctioned quarterly to each state, state then decides (free allocation/auction)
Tokyo	2010	25% below 2000 levels (2020), 50% below (2050)	1044 MtCO2 (projected for 2020)	$100 (2012)	Free allocation
California, USA	2011	Meet 1990 levels (2020)	235 MMtCO2e (2015)	$10 (floor), $14.50 (2013)	Auctioned quarterly
India	2011			~$38-43	Purchased and traded
Australia	2012	25% below 2000 levels (2020), 80% below (2050)		$15.51-17.84 (2012-2013)	Free allocation and auctioning
Mexico	2012				Purchased/traded on the stock exchange
Kazakhstan	2013	50% below 1990 levels (2018)	147 MtCO2e		Free Allocation (Phase I) Auctioning (Phase II)
Québec	2013	20% of 1990 levels (2020)	54.74 MMTCO2e/year	$11.99 rising 5% each year after 2012, cap at $31.96-39.95	Free allocation (except for fuel distributors), excess allowances are auctioned
South Korea	2015	4% below 2005 levels (2020)	236 MtCO2e		Free allocation (Phase I), 97% free allocation (Phase II), 90% free allocation (Phase III)

Table 3.2: A Summary of Main Characteristics of Existing Systems

9. Creating an Ideal System

What would an ideal global cap-and-trade system look like? This chapter summarizes the characteristics of an ideal system and highlights existing systems that present these characteristics, and suggests a design for an ideal system that could potentially be utilized in our world today.

9.1 Defining an Ideal System

As seen in the case studies previously presented in this paper, there are many aspects to an emissions cap-and-trade system. While many of these systems share characteristics, they also present many unique aspects to the world of emissions trading systems. There are, however, common goals seen in almost all of these systems that could create an ideal system. An ideal system should carry two main goals:

1. Reduce the rate at which carbon emissions are released into the atmosphere that contribute to the warming of the planet in order to reduce the detrimental effects of climate change that we are facing as a world today, and
2. Conserve our finite resources and encourage the use of alternative energy to meet our needs.

To meet these goals, any emissions trading system will need a number of important characteristics:

1. The system must have a strict and ambitious total cap,
2. The system must cover all sectors in the region,
3. The trading system must actively link with other systems, and
4. The system must have a stable monitoring, verification, and reporting system.

For the first goal, in order for the effects of the system to be significant, the emissions cap must be strict enough to encourage the use of alternative energy and alterations to production. To meet the second goal, all sectors in the region must be covered under the system in order to see the largest reduction in carbon emissions and allow for uniformity. The third goal will allow for maximum flexibility among participants to achieve the target reductions. Lastly, a stable monitoring system will prevent false reduction reports and regulate non-compliance consequences to incentivize the use of alternative methods of production to meet reduction obligations.

One of the key features of an effective system is the concept of linking. While one global system is unrealistic, the linkage of multiple smaller systems is feasible. The linkage of systems will allow for participants in one system to purchase emissions allowances from another system in order to cover their emissions during the compliance periods. Without this option, many sectors will experience carbon leakage, where a participant must export its production to an area without an emissions trading scheme in order to remain under its limit (Karp 2010). The sharing of allowances reduces the total quantity of emissions released since even though a participant from one system is producing more emissions, emissions permits from another system, resulting in a reduction from the lending system, will cover them. An ideal system would need to seamlessly implement these aspects in order to see a significant reduction in carbon emissions while simultaneously meeting the energy needs of the covered region and remaining economically cost-effective for the participating entities.

9.2 Existing Systems

This section will cover existing emissions trading systems that exhibit the characteristics discussed in the previous section.

While all of the existing cap-and-trade systems have set caps to cover their emissions, not all of them monitor their respective systems in the same manner. Most of the systems covered in Chapter Three rely on a monitoring, verification, and reporting system to ensure compliance with the emissions obligations. This generally consists of a required report being turned in to the governing entity at the end of each year, after being verified by a third party entity, along with surrendering the corresponding number of allowances to cover emissions. The issue with this system is that false reporting is difficult to control, and each system has varying consequences for non-compliance that may not be strict enough to enforce proper monitoring and reporting. For example, in the Indian emissions trading system, the consequences for non-compliance are relatively non-existent, leaving little incentive for participants to correctly control their emissions (India 3.2.f). Also, Kazakhstan carries sever consequences such as fines and criminal prosecution for non-compliance, but these consequences did not start until after the first compliance period, hindering the success of the system (Kazakhstan 3.2.h). On the other

hand, Tokyo and Norway both have strict fines for non-compliance as well as the practice of public shaming of entities that fail to comply (Tokyo 3.2.n, Norway 3.2.j).

The key to an ideal emissions trading system is linkage between systems, which some of the most successful existing systems participate in. The biggest example of linkage is with the European Union emissions trading system. While the EU ETS itself is multi-national, it is one system that has established connections with the systems of Kazakhstan, Norway, Switzerland, Australia, and the United Kingdom. The United Kingdom's ETS began on its own, but was merged with the EU ETS when it began (UK 3.2.o). Both the Kazakhstan and Norway systems began on their own with design functions similar to those of the EU ETS in hopes of future linkage, which became a reality after the systems linked in stages between compliance periods (Norway 3.2.j, Kazakhstan 3.2.h). While the EU ETS and the Australian ETS have not fully linked, they do allow the sharing of allowances. This means that Australian participants are able to purchase EU allowances to cover their emissions and vice versa, allowing both systems to meet their obligations (EU Ch. 5, Australia 3.2.b). There are also plans in place for a link between the Australian ETS and the New Zealand ETS within the next year (New Zealand Ch. 6). The Californian ETS and the Québec ETS are also linked within the Western Climate Initiative (WCI), which links Canadian and American systems, allowing permits between the two systems to be shared (California 3.2.d, Québec 3.2.k).

9.3 The Ideal System

This section will outline a potential ideal system that is practical for our world today, and touch on aspects of a theoretical ideal system that would optimize the environmental benefits of an emissions trading system.

An ideal system that could be implemented in our world today would consist of a global linkage between multiple smaller national or regional systems. One total cap for all of the world's emissions producers is unrealistic and infeasible, but the linkage between systems is a practice that has proven successful and would yield optimal results. A total worldwide cap would prove difficult to distribute allowances fairly, while multiple smaller caps allow for more flexibility within a country or region. This would

require individual nations or regions to create a legislation to cap emissions at an ambitious level in order to reduce the effects of climate change caused by carbon emissions. This linkage would allow the purchase of permits between any system, allowing those who need to purchase additional permits to cover their emissions do so while those who have excess permits can sell them. The systems must also cover for participation. This will cover all entities emitting carbon into the atmosphere, forcing all emitters to consider alternative options or pay the price to purchase adequate emissions. The consequence for non-compliance would have to be strict and carry high fines, enough to incentivize compliance if only to avoid the fines. This being said, the system for monitoring and reporting would have to be regulated by a trustworthy third party to ensure the monitoring is correct and there is no false reporting in order to truly meet the reduction obligations. A trustworthy third party would have to be objective and possibly even verified by multiple parties to ensure fairness.

The first compliance period would carry obligations based on previous emission records, but for a significant reduction in subsequent years, it requires short compliance periods with new obligations set at the end of each period. At the end of each compliance period, once allowances from the previous period were surrendered and verified, a new cap for the upcoming compliance period would be set based on emissions from the previous period, with an additional reduction set to further control emissions toward potential future carbon neutrality.

A more complicated aspect of an ideal system is the concept of allocating allowances. For a system to aggressively reduce carbon emissions while stimulating the market and encouraging alternative methods to producing energy with the eventual goal of carbon neutrality, the practice of free allocation of allowances will not work. In existing systems, allowances are often freely allocated to entities for which it would be difficult to reduce emissions, which consequently removes the incentive to alter production methods to reduce emissions. If all allowances were auctioned, there would be a greater incentive to invest in renewable energy and environmentally friendly practices in order to avoid purchasing allowances in the future. The total auction of allowances would also create significant revenue that could be redistributed within the covered region to invest in green practices and abatement measures. The pricing of allowances will also have to

remain competitive based on global prices as well as prices from previous compliance periods.

10. Conclusions

This paper has focused on the controlling of carbon emissions throughout the world using a number of different methods. There are multiple mechanisms used in the capture and control of carbon emissions. Taxes and fines are often imposed on carbon emitters in an effort to reduce the initial amount of carbon released into the atmosphere. As mentioned, a tax has proven effective in incentivizing the reduction of total emissions as well as the use of alternative means of production if only to avoid paying the tax in the first place. A post-production response to controlling carbon is carbon capture and sequestration, covered in Chapter 2, preventing the release of carbon into the atmosphere and instead storing it in natural sinks and injecting it into the ground. Among these mechanisms lies carbon markets. The concept of trading emissions on a market was the focus of this paper, highlighting four of the world's systems: the United States' SO_2 Trading Program which offered many lessons to subsequent systems, the European Union Trading System, the New Zealand Emissions Trading Program, and the United States' Regional Greenhouse Gas Initiative. While these four systems were studied and analyzed in depth, a number of systems across the globe were also summarized to describe the many different characteristics contained in the realm of carbon markets.

This research has shown that four main obstacles exist in the world of emissions trading: setting global and regional caps, ensuring the coverage of all sources of emissions, creating a worldwide carbon market, establishing important monitoring, verification, and enforcement systems. By studying the emissions trading systems, this research has developed the framework of a potential ideal system for the controlling of carbon emissions throughout the world. After a further in-depth description of some of the key elements was covered in chapter eight, the penultimate chapter of this paper included a personal perspective of an 'ideal system'. This system was designed with an aggressive approach to the reduction of the world's emissions in hopes of slowing down the negative effects of climate change that our environment and our society are facing today.

The exercise of developing an ideal system teaches several lessons. First, the case studies shined light upon many aspects of systems that did not necessarily work to

achieve the ultimate goal of reducing carbon emissions. These failed mechanisms, such as voluntary programs that lack incentives or a command-and-control approach with limited flexibility, showed that the concept of emissions trading systems was still a work in progress, but contributed to the foundation of a potential future system that would achieve significant reduction goals and revealed the attributes an ideal system should have. Next, the very number of regional cap-and-trade systems indicates a global recognition of the effects of climate change caused by human interaction with the planet. The introduction of legislation such as mandatory systems and the creation of any system at all showed that the government, whether regional, national, or multi-national, recognized that the emissions being released into the atmosphere through production was harming the environment and steps needed to be taken in order to mitigate climate change by reducing and controlling the emissions. While the danger of climate change has been prevalent among scientists for years, it is refreshing to view how the government is taking note of such danger and making changes to avoid future damage. While the progress made in legislation and action toward lower carbon levels have been significant and inspiring, there is still work to be done.

There are still steps to be taken to successfully reduce the amount of carbon emitted into the atmosphere while also stimulating the economy of involved nations. For this, additional research is necessary. The next step in the process is to examine the physical application of each proposed characteristic in an ideal system, and evaluate its effectiveness in hopes of preparing the world's nations for the changes that will soon be necessary with the imminent effects of climate change. A close examination of the individual characteristics of an effective emissions trading system, including the linkage between systems and a sound monitoring and verification system, will provide the necessary analysis of the effectiveness of carbon markets, allowing for the potential creation of a world-wide system that could be the answer to mitigating climate change throughout the world and reducing the human impact on our environment.

Glossary:

ACCU – Australian Carbon Credit Units
ARB – Air Resources Board
AUD $ - Australian Dollars
BAU – Business as Usual
BEE – Bureau of Energy Efficiency
BMF/Bovespa - Bolsa de Valores, Mercadorias & Futuros de São Paulo
Btu – British thermal unit
BVRio – Bolsa Verde do Rio de Janeiro
CA $ - Canadian dollars
CAAA – Clean Air Act Amendments
CCA – Climate Change Authority
CCR – Cost Containment Reserve
CCEMC – Climate Change and Emissions Management Fund
CDM – Clean Development Mechanism
CER – Certified emissions reduction units
CER – Clean Energy Regulator
CERC – Central Electricity Regulatory Commission
CFI – Carbon Farming Intensive
CHF – Swiss Francs
CH_4 – Methane
CO_2 – Carbon dioxide
CO_2 Act – Act on Reduction of CO_2 Emissions
CO_2e – Carbon dioxide equivalent
CPI – Consumer Price Index
CPRS – Carbon Pollution Reduction Scheme
DOE – Department of Energy
EC –European Commission
EI ETS – Experimental Integrated Emissions Trading System
EITE – Emissions-intensive trade exposed
ENACC – National Strategy on Climate Change
EOR – Enhanced Oil Recovery
EPA – Environmental Protection Agency (United States)
EPC – Emissions Performance Credits
ERU – Emissions reduction units
ETS – Emissions trading system
EU – European Union
EUA – European Union allowances
FCPA – First Control Period Adjustment
FCPIABA – First Control Period Interim Adjustment for Banked Allowances

FYP – Five-Year Plan
GDP – Gross Domestic Product
GGETA – Greenhouse Gas Emissions Trading Act
GHG – Greenhouse gas
GNP – Gross National Product
Gtons – Gigatons
HFC – hydro fluorocarbon
IEA – International Energy Agency
IEX – Indian Energy Exchange
IPCC – Intergovernmental Panel on Climate Change
JI – Joint Implementation
JVETS – Japanese Voluntary Emissions Trading System
JPA – Japanese Emission Allowances
kL - kiloliters
LCFS – Low Carbon Fuel Standard
LULUCF - Land Use, Land Use Change, and Forestry
MOU – Memorandum of Understanding
MMtCO$_2$e – Million Metric tons of Carbon Dioxide Equivalent
MRR – Mandatory Reporting Rule
MRV – Monitoring, Reporting, and Verification
MtCO$_2$e – Metric tons of CO_2 (carbon dioxide) emitted
MtCO$_2$e/yr – Metric tons of carbon dioxide emitted per year
MW – Megawatts
MWh – Megawatt hours
NAAQS – National Ambient Air Quality Standards
NAPCC – National Action Plan on Climate Change
NCCP – National Climate Change Policy
NDRC – National Development and Reform Commission
NGERS – National Greenhouse and Energy Reporting Scheme
NMEEE – National Mission on Enhanced Energy Efficiency
NSPS – New Source Performance Standards
NO$_x$ – Nitrous oxides
NYSERDA – New York State Energy Research and Development Authority
NZ – New Zealand
NZD – New Zealand dollars
NZU – New Zealand Units
OAL – Office of Administrative Law
PAT – Perform Achieve and Trade
PE Act – Act on the Protection of the Environment
PECC – Special Program on Climate Change

PFC –per fluorocarbon
ppm – parts per million
PXIL – Power Exchange India Limited
REC – Renewable Energy Credit
RGGI – Regional greenhouse gas initiative
RMU – Removal unit
RPO – Renewable Purchase Obligations Standards
RPS – Renewable Portfolio Standard
SERC – State Regulatory Commission
SF_6 – Sulfur hexafluoride
SGER – Specified Gas Emitters Regulation
SO_2 – Sulfur dioxide
SO_4 – Sulfate
SP ETS – Sao Paulo Emissions Trading System
SPM – Summary for Policy Makers
tce – tons coal equivalent
UNFCCC – United Nations Framework Convention for Climate Change
US – United States (of America)
USD – United States Dollar ($)
WCI – Western Climate Initiative
$1995 – United States Dollar at 1995 currency levels

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