Vermont Common Asset Trust:
Addressing the Market Failures of Climate Change in Vermont

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List of Acronyms and Terms

"350" – 350ppm, level needed to effect change
CO2 – Carbon dioxide
CO2e – Carbon dioxide equivalent
EU ETS – European Union Emissions Trading Scheme
IPCC – Intergovernmental Panel on Climate Change
mmt – millions of metric tons
ppm – parts per million
UNFCCC – United Nations Framework Convention on Climate Change
VCAT – Vermont Common Assets Trust

Introduction

Based on overwhelming amounts of scientific evidence, global climate change is in dire need of being addressed (Stern, 2006). Human activities are the dominant contributor to the alteration of Earth's atmosphere (Ibid). With over one hundred years of industrialization there has been ever increasing consumption and burning of oil, gasoline and coal as well as deforestation, leading to significant impacts on our planet (UNFCCC, Feeling the Heat). Pre-industrial levels of carbon dioxide (CO2) emissions were approximately 275 parts per million (ppm) and since then have increased by one-third to 385 ppm (Stern, 2006). The concentration of carbon dioxide equivalent (CO2e) for all other greenhouse gases is approximately 430 ppm and prior to the industrial revolution it was only 280 ppm CO2e (Stern 2006).

Since the year 2000, the observed emissions growth rate has been faster than that of the worst case scenario put forth by the Intergovernmental Panel on Climate Change (IPCC). From 1990-1999 the emissions growth rate was 1.1% per year increasing to greater than 3% per year for 2000-2004 (Raupach et al., 2007). Raupach notes that the main drivers for the increase in emissions is the energy intensity of gross domestic product (energy/GDP) and the carbon intensity of energy (emissions/GDP) in addition to growing global population and growing per-capita GDP. With the recession that the world economy is facing today, the level of emissions could decrease. The pace of the economy is slowing and demand for goods is dropping as many jobs are being cut across all sectors. In addition to a reduction in demand for goods, many large scale companies will look to alternatives and ways to reduce their demand for energy.

Currently, projections estimate a rise in CO2 concentration of 2 ppm annually with the possibility of that rate accelerating each year if we continued doing business as usual. (Hansen 2008, Raupach et al., 2007). Remaining at this rate of increasing emissions, a doubling of pre-industrial levels to 550 ppm CO2e could occur by 2050 (Stern, 2006). However, as many economies worldwide are growing and investing in carbon intense infrastructure this doubling could be reached as early as 2035. In effect it would likely result in an increase of 2°C in global mean temperatures (Ibid). According to James Hansen, one of the world's leading climatologists, a safe level of atmospheric CO2 should be no more than 350 ppm CO2, or perhaps even less to "preserve a planet similar to that on which civilization developed and to which life on Earth is adapted" (Hansen, 2008). It is clear that actions need to be taken to halt the imbalance of the Earth's system.

This paper will identify some of the key components of addressing the issue of global climate change through the creation of a common asset trust. A common asset trust is just one policy tool that can bring about change regarding the complex issue of climate change. No single tool will provide the solution – many tools are needed with the support of many people and the support at all levels of institutions. It is also important to note that the creation of the Vermont Common Asset trust will not have a significant impact on global carbon emissions, but what it can do is set the precedent for others to follow. It is important that policies dealing with energy are first attempted on small-scale and as the kinks are worked out, they can be applied more broadly.

A Common Asset Trust as a Potential Solution

Our current economic system fails to adequately provide many ecosystem services and common assets. The waste absorption capacity of the atmosphere is rival and non-excludable when pollution is unregulated (Daly and Farley, 2004). A good or service is rival when one persons consumption or use reduces the amount available for everyone else to use. Excludability means that a person or institution can prevent others from using an asset. Resources that are non-excludable but rival are also known as open access resources (Ibid). With an absence of property rights, in the case of open access resources, often times the benefits outweigh the costs of obtaining or using them and they can be overexploited and potentially destroyed (Ostrom, 1990).

When a resource is non-excludable and rival it presents a management problem (Farley, 2008). Garrett Hardin wrote in 1968 on the “tragedy of the commons” referring to the use of common grazing pasture in England. In this instance the pasture was common property to all that could sustain a certain number of cattle indefinitely overtime. However, with the absence of institutions, when one person adds another cow to pasture beyond the sustainable level, only that person benefits from having an additional cow while the rest of the community shares in the cost of less feed for all other cattle. If every owner acted in this manner and kept adding cattle, it would eventually lead to the decline and, ultimately, destruction of the commons (Hardin, 1968).

It must be noted that the term, “tragedy of the commons” is a misnomer. Common property refers to property in which a community shares property rights as opposed to an individual. Therefore, “tragedy of the commons” is a misnomer because in most cases societies establish rules that manage common property sustainably (Boyce, 2007). The way in which Hardin referred to the commons is often confused with open access resources with a lack of property rights. The tragedy Hardin was referring to still occurs however; open access resources are generally burdened with degradation as opposed to those with rules established by a community (Bromley, 1991). Hardin later recognized his mistake for omitting the word “unmanaged,” a key adjective necessary for describing the situation (Hardin, 1998).

Much like the pasture, our atmosphere and other resources are largely under served by our economic system, leading to many of the issues faced by humanity. In the traditional sense markets do not naturally manage open access resources nor do they manage them with future generations in mind. They will only cater to market goods while many goods and services that are inherent to human welfare are underserved and are allocated inefficiently. With this, markets are poor indicators for how much of an ecosystem service is necessary for a healthy environment and for the welfare of future generations (Farley and Daly, 2004).

One way to account for the market failures in regards to the waste absorption capacity of air is by declaring the atmosphere and other ecosystem services as part of the commons. This would give greater incentive for preservation of such invaluable resources. The atmosphere is an ecosystem service belonging to all of humanity; past, present and future. Therefore it is essential that we are stewards of this and all resources to ensure that they are left intact for future generations.

Today, the term commons has taken on a different, more relevant meaning since Hardin’s article in 1968. As defined by Peter Barnes the term commons refers to, "all the gifts we inherit or create together" (Barnes, 2006). These gifts include but are not limited to air, water, ecosystems, music and language, all of which are shared by members in a community not just individuals.

Common assets have many qualities that lend themselves to be part of the commons. First, is that they are “all the gifts that we inherit or create together” (Barnes, 2006). This is because we aren’t the only humans to use the commons. We all have joint obligation to preserve them as future generations will need to rely upon them in the same way we do today (Ibid).

Our current abuse of the commons calls for a different management system. We need to account for negative externalities which occur when one person’s economic activity has a negative impact on another, with no compensation (Pearce and Turner, 1990). Negative externalities are those in which degrade our Earth's resources at unprecedented rates. Pollution, for many years, has been a negative externality in that we have had the ability to dump as much waste into the atmosphere with no limits and without paying the costs. A common asset trust would balance those negative externalities by giving the rights to make decisions to those who experience both the economic and ecological benefits. It is crucial that we who are alive today realize the impacts of our use of the natural world. If we stay on the same path, the Earth we leave to future generations will be impaired (Barnes, 2006).

Allocation Methods

Models can be used to design a policy that would capture the full cost of market production and to provide a significant economic indicator strong enough to address issues such as global climate change. Different policies for the inclusion of public common goods into market production cost have been used throughout history. In Vermont, we have seen models used for many public commons and these practices are much a part of its history and culture. Natural forestry, management of wildlife such as the bald eagle, peregrine falcon, deer, and fisheries have all been the focus of many policies used in Vermont. However, these types of policies can also be applied to address climate change. This paper identifies past models as tools that can be used in determining design, application, and implementation of the VCAT climate change policy.

Permits and Tax Policies

There exists two prominent policies for addressing the market failures of non-excludable rival goods; taxes and permit systems. The successes of each policy have been marked by their ability to monitor and manage the efficiency of each program. Both possess limits and even encroach upon issues of just distribution and responsibility. Careful considerations of both the immediate intended impact and possible unforeseen consequences further down the road should be made.

Many programs have focused around taxes as a viable program to reflect a more accurate account of the costs to natural resource public good degradation. The other option is permit systems that have been promoted with trading as an option. However, neither tax and permit programs have had the intended impact of addressing climate change without incorporating a cap. Caps have been most successful when implemented in phases that reduce the cap to a desired goal over time. This allows the greatest flexibility to the industry to respond to such a program as well as improves the success of effecting change.

The next four sections will discuss the pros and cons of previous policies that addressed the “tragedy of the commons” using taxes or permits, explain lessons learned and their potential application to Vermont and the VCAT program.

Tradable Permits as an Abatement Policy

The main appeal of permitting carbon emissions is the ability to set caps that can effect global climate change. A tradable permit system is recognized for its efficiency to address the issue of climate change while keeping the cost of implementation low when compared to alternative options (Grubb et al. 1999; Kerr 2007). The ability to both set emission level goals consistent with the 350ppm and Kyoto Protocols make permitting systems very popular. The relative low cost-share between the producers and consumers has also been a bullet point made by its proponents.

In a 2008 article in Environmental Science and Technology, Pelley writes about how British Columbia, Canada was able to gain support for and pass a CO_2 emissions program. Its support was said to be gained from making the program revenue-neutral, where all of the money generated would be returned to both individuals and companies.

Probably the most noted characteristic of permitting schemes is the separation between those who purchase permits from those who develop, implement, and evaluate its policy. The separation of these controls was considered an important factor to members of the European Union when developing their ETS (Grubb et al. 1999). This separation provides for policy to maintain its uninfluenced sovereignty.

If caps were incorporated into a permit system, then this would provide an additional benefit of not only addressing sustainable levels of emissions but the proper incentives to stakeholders. If emissions were capped then the incentive for the public would be to encourage greater reductions. These reductions would create a larger pool of revenue generated from abatement that could be used for public programs, provide proper price signals to firms that pollute harmful emissions, and encourage development of more efficient technologies.

Permit systems are criticized for their inability to recognize full program costs and often make unproven assumptions about program success. Major assumptions often include efficient allowance trading within the market place and that trading is always economically beneficial. Costs associated with running a permit system and ensuring its compliance is also underappreciated (Soleille 2005). If the case for implementing a permit system is to reduce emissions, fewer allowances should be given out then needed.

Past and Current Permit Policies

1977 – US Emissions Trading Schemes
The US program to reduce specific pollutants by using the historical emission levels or a set limit has been less than the success of its intention. The program has been subject to large transaction costs that limit trading and have offered no incentive for development into research for technologies that would allow for a greater economic benefit to firms.

1982 – Lead Reduction Program
This program was one of the first programs to freely allow permit trading. The policy ultimately lead to a total reduction of lead used in gasoline. Its success is attributed towards the program's ability to encourage trading which lead to the cost benefit to producers which then lead to the drastic reduction in fuel lead content (Kerr and Newell 2003).

1984 – Iceland Fishing Quotas
Highlighted as one of the most dynamically changing programs over its life-cycle, this program eventually evolved into the individual transferable catch quotas (ITQs). The program initially allocated quotas that were attached to vessels that did not allow transfer of the quotas to other vessels unless they were wrecked or sold abroad which lead to purchasing of vessels to destroy and attach quotas to private vessels. In 1991 transfer rights were permitted through sale of permanent quota shares or through leasing. Iceland's ITQ model has been replicated by many fisheries throughout the world (Eythorsson 1996; Palsson and Helgason 1995).

1986 – New Zealand Fisheries Trading System
This program is a cap and trade system run by the government to manage the harvests by commercial fisheries. Characteristics of this program include a total limit on catches and individual transfer quotas based on species specific sustainable harvest levels. Large penalties that include forfeiture of capital and large fines have sustained the program over the past two decades (Batstone and Sharp 1999).

1995 - The U.S. Acid Rain Program
The acid rain program was introduced in 1995 to the world and has become one of the most recognized US Cap and trade programs to reduce SO2 emission. The program is noted by its low cost to firms, below both EPA and industrial expectations (Schmalensee 1998).

2003 – New South Whales Greenhouse Gas Abatement Scheme
This program required electric generators and large consumers of power to purchase abatement certificates. Highly criticized by firms for its perception to be a tax, a new trading scheme that adopts a more American approach that demands permits be competitive. This new scheme emerged after the Garnaut Climate Change review conducted by Ross Garnaut, which emphasized the potential of a trading scheme in a greenhouse gas (GHG) market. This review is noted for its implications that permit trading schemes need to compensate economically marginalized populations and low income families.

2005 - European Union Emissions Trading Scheme (EU ETS)
This model is the largest program to date and incorporates a tradable permitting scheme to accomplish Kyoto target reduction of greenhouse gases. This scheme is highly popularized by its magnitude of participation to effect climate change and equally criticized for its implementation failures. The EU ETS has been successful in creating a net reduction in carbon emissions for the program phase periods. However this success has been shadowed by the over allocation of permits allowed by setting caps above the current emission levels and even further above the necessary caps argued by many needed to effect global climate change (Klepper and Peterson 2004; Barnes et al. 2006).

2008 - New Zealand Emissions Trading Scheme (NZ ETS)
The NZ-ETS seems to be a sound program that takes the lessons learned from the failures of the EU-ETS into account. The NZ-ETS was designed to be less susceptible to political lobbying. The NZ-ETS has simplified the emissions allocation process compared to the EU-ETS by having only one source for deciding the cap on emissions (Kerr 2007).

Lessons Learned – Permits

Systems for trading permits that limit emissions through caps are highly recognized as being very successful (Grubb et al. 1999). One of the largest challenges faced by programs implementing a cap and trade system are the barriers to trade, or the liquidity of permits. A transaction cost in the form of failure to trade is one of the key issues presented when evaluating the progress of the EU-ETS (Kerr and Mare 1997). Much of the issue can be defined by the allocation method used to distribute permits.

Dallas Burtraw, a senior fellow at the Resources for the Future in Washington, DC says that there have been three main approaches to dealing with the initial allocation of permits in a cap and trade system: historical, current or recent, and future or expected approach (Burtraw et al. 2006). However, the trend to add a new approach that initially provides that each individual has an equal right to the permits and therefore the revenue generated by its auction to market is gaining steam. The keys to this approach are that the total available permits available are determined by set caps and the initial distribution of permits is done so through an auction system.

Permit schemes have historically been implemented to limit the amount of emissions at its source. This limit is based on the purchase of the permit for the right to emit or a tradable permitting scheme. To accomplish this, the point of abatement has historically been designed to promote mitigation as far upstream as possible. This form of abatement upstream would decrease consumption downstream. The argument in the oil industry is that the higher costs at the pump would decrease consumption and encourage development for new innovative technologies such as better efficiency vehicles and new sources of energy use (Sergy et al. 2007).

Where upstream abatement may result in higher production costs, a downstream approach may make the cost of implementation to decrease. For the purpose of VCAT, a point downstream may be more appropriate. Abatement could then be placed at the state border allowing implementation and monitoring of the program to have a greater applicability.

Taxes as an Abatement Policy

In the case of carbon taxes, certificates would be issued for firms willing to pay the tax per metric ton. Antagonists feel that higher carbon taxes will result in a competitive loss in the international market (Norregaard and Reppelin-Hill). Programs marketed to consumers as revenue neutral have had a fair rate of success in gaining public support.

Past and Current Programs

British Columbia, Canada
British Columbia, Canada now charges $10 per metric ton of carbon dioxide where the price increases by $5 each year until and is planned to continue until it reaches $30/mt in year 2012. The government will then review their progress and determine if the incremental increases should continue (Pelley 2008).

The tax program in BC, Canada is planned as a revenue neutral program that will generate roughly $1.85 billion within the 4 year span and reduce carbon emissions by 5-10%. This policy received little to no resistance due to a prescribed piece of the program that requires that the entire revenue capture be returned to businesses and individuals through tax cuts and environmental rebates. It was said that Carole Taylor, British Columbia’s finance minister made the statement that BC will have the lowest combined corporate tax rate (25%) among the major economies of the world (Pelley 2008).

Alaskan Permanent Fund

Alaskan Permanent Fund (APF) generates revenue through the taxation of harvesting minerals at the point of extraction. The revenue generated from the taxes are then placed into a 'low risk' fund to create dividends that are then distributed equally to qualified residents of Alaska in an annual lump sum transaction.

Lessons Learned - Taxes

Tax systems have proved to provide an extremely efficient, tangible and marketable result when revenues are returned to its constituents. The Alaskan Permanent Fund, other dividend and double dividend tax programs, provide for large annual lump-sum transfers from revenues made to residents of Alaska and also provide a basic abatement program to include the full cost of production that firms can use to make decisions.

Antagonists however, feel that higher carbon taxes will result in a competitive loss in the international market (Norregaard and Reppelin-Hill). In the example of the Alaskan Permanent Fund, problems associated with taxes as an abatement policy had less to do with the taxes themselves then the speculative nature of investment. By investing into a speculative market, the emphasis is averted from the issue at hand, which is climate change. This provided little to no incentive for firms to change their paradigm, nor does it encourage development of sustainable technologies. Furthermore, the policy encourages further extraction of fossil fuels to increase revenues thus increasing consumption. The lesson from this example is the negative ramifications of not incorporating caps along with the taxes that would limit the consumption of natural resources.

Key Components to an Appropriate Model for Vermont

The main appeal of permitting carbon emissions is the ability to set caps that can help to mitigate global climate change. A program that sends a clear price signal that markets are able to respond to is key to implementing any program to address climate change (Pelley 2008). Permit markets are better suited to regulate a maximum quantity limit [cap] (Norregaard and Reppelin-Hill). In the case of the EU ETS, the excess number of allocated permits drove prices down to 0.5 Euros by April of the following year after its inception. The second year of the plan required member states to develop national allocation plans (NAP) to which 17 states proposed caps 15% above the actual 2005 emissions (Skjaerseth and Wettestad 2008). For a permit system to be successful in addressing climate change the number of permits issued must be less than the total emissions (Skjaerseth and Wettestad 2008).

Fixed, Loose and Tight caps

Permits present a wide variety of options for capturing the full cost of production within the current market model. Permits have the ability to take on many characteristics including the value of each permit, the quantity of permits available, the process by which they are distributed, and the type of transactions that are allowed. The value of each permit has historically been in increments equal to one ton of GHGs. The quantity of permits available would then be dependent on if the permit system was capped. Caps can be either considered loose, tight, or fixed. In a tight cap, the quantity of permits would nearly equal the cap for emitted pollutants. In a loose cap, the quantity of permits may fluctuate by a maximum deviation from the fixed cap.

Note that most successful programs have either had tighter caps with caps set at or near current emission levels or looser caps set at more stringent levels below current emissions. "A Tighter cap may be more appropriate in accomplishing Vermont's goals" (VT Dept. Public Services 2008).

Allocation Method

There are several options for permit allocation. How permits are distributed can have a multitude of effects that one should consider before implementing a program. The major points of interest are the initial distribution method, who is allowed to purchase permits, rules for trading, and the ability to bank permits. Permits can be issued directly to residents on a per capita base according to either, the total quantity of permits or a set cap. On the other hand, permits could also be distributed by those who are willing to purchase them at a set fee. The inherent problem of this approach is the valuation determination of each permit rests on the shoulders of the program administration (Skjaerseth and Wettestad 2008).

Revenue Neutral Program

Revenue neutral means that the program covers the cost of implementing the program, annual administrative costs, and provides a return on investment to each individual with the excess revenue generated. A system that is not revenue neutral could expect resistance by firms. Firms often define efficiency as the ability for an instrument to reduce emissions to a predetermined level at minimum abatement costs (Norregaard and Reppelin). A non-revenue-neutral permit auction system would likely increase the abatement costs and therefore be seen as inefficient by market firms.

Point of Abatement

For large international programs with a higher degree of political influence, point of abatement is recommended at the highest point upstream possible (Stavins 2007). In the case of CO_2, a point nearest to the fossil fuel extraction is best and "not at the point of combustion" (Stavins 2007). This approach may not be appropriate to a program such as VCAT. A point downstream may be more appropriate.

One suggestion is to have firms wishing to transport sources of carbon pollution such as fuel tanks to purchase permits in advance and then relinquish permits as needed when those resources cross state borders. The point of abatement would be at the Vermont state border requiring permits to be used when firms wanted to transport sources of carbon pollution into or out of the state.

Banking Permits

The ability to bank permits is a widely contested concept with both proponents and antagonists. The ability for a corporation to potentially pollute large volumes in a short period of time may have unforeseen consequences. By not allowing banking, this ensures that the distribution of pollution stays relatively stable from year to year. Making banking a temporary option in the early phases of the program would be most appropriate, and in the long run would be unnecessary to ensure program success.

Compliance and Enforcement

A permit market is only efficient and responsive to the degree of information available (Albrecht, Verbeke, and Clercq). Monitoring compliance with the program would be nearly impossible and quite costly due to the high degree of difficulty to obtain accurate information about emission levels (Norregaard and Reppelin-Hill). This encourages the notion that compliance should take place further upstream which would then reduce the administrative costs and eliminate the major problems of input/output abatement (Norregaard, Repplein-Hill and Stavins 2007).

Summary of Recommendations

Climate change presents a serious threat to humans both socially and economically (Stern 2006). While Vermont has the lowest carbon footprint in the U.S. (VT Dept. of Public Services), it is the collective responsibility of the present to preserve our natural environment for future generations (James and Lahti 2004). Various versions of a cap and trade system have been highly popular and are also the first on the list of policy recommendations proposed in the Vermont Comprehensive Plan 2008.

Recognition that this mechanism of change must be inclusive within the current market model is essential for the success of any carbon dioxide management strategy (VT Dept. of Public Services 2008). Framers of this program should seek support from likeminded organizations to further develop this model, such as: Vermont Department of Environmental Conservation, Vermont Fish and Wildlife, Vermont House of Representatives, Vermont Senate, Governors Office, and town officials. Controlling the emissions rate as suggested by RGGI, Stern Review, and Kyoto can be done in various ways and each method should be considered for its pros and cons prior to implementing any program.

Appropriate Caps on CO_2 Emissions: Sustainable and Equitable Distribution of CO_2

VCAT aims to set an appropriate cap on CO_2 emissions that addresses the global biophysical limits of the ecosystem to absorb CO_2, and sets a precedent to lower CO_2 emissions. Setting a cap on emissions in Vermont will have little to no impact on climate change, but as a pilot project the VCAT climate change policy will provide valuable information to national and international schemes.

In order to set an appropriate cap on CO_2 emissions, ethical standards have to be examined and created by which all those responsible would be held accountable. Overall, the appropriate cap on emissions should be determined by what is biophysically possible for the ecosystem to absorb and ethical

Biophysical Limits

The level of global emissions suitable for the atmosphere is intensely debated by many scientists. The Stern Review suggests that 450 ppm of CO_2 would stabilize the global climate at less than 2 degrees C higher than the current global mean temperature, although aiming for 500-550 ppm would be more politically achievable (Stern, 2006). Even at this cap, there is a serious risk of climate catastrophe. The Stern Review reveals probabilities of climate change impacts at different temperature increases including that impacts can be seen in food, water, ecosystems, extreme weather events, and risk of irreversible impacts.

In more recent research by James Hansen, leading NASA scientist, 350 ppm is the level at which we need to stabilize global atmospheric concentration of CO_2 if we hope to avoid catastrophic impacts. There’s a 25 percent risk tolerance for long-term CO_2 limit in the range 300-500 ppm, depending on climate sensitivity and non-CO_2 forcings (Hansen, 2008).

"If humanity wishes to preserve a planet on which civilization developed and where biological productivity can prosper, CO_2 emissions must be reduced from the current 385 ppm to, at most, 350 ppm", averred Bill McKibben speaking of James Hansen's 2008 article in a debate on October 29, 2008. Bill McKibben, an environmentalist and bestselling author, has heeded Hansen's call for a cap of global CO_2 emissions at 350 ppm, and has fashioned a campaign around Hansen's scientific discovery. McKibben wants to change the paradigm, or the worldview, about what is biophysically possible, getting everyone to accept that 350 ppm is the maximum acceptable level for CO_2.

The present global concentration of CO_2, 385 ppm, is already in a dangerous zone (Hansen, 2008). There is still a possibility to lower atmospheric CO_2 concentration to less than the current amount, despite rapid increases in CO_2 concentration [about 2 ppm/year] (Hansen, 2008). Swift policy changes would need to occur, which reduce global emissions to around 25% below current levels by 2050 (Stern, 2006).

The Kyoto Protocol suggests that industrialized countries lower CO_2 emissions 5.2% below 1990 levels (CO_2 concentration was 353 ppm in 1990). Table 1, below, illustrates the proposed caps of different scholars as well as the percent reductions in CO_2 needed to achieve those caps. The table is based off of the current level of CO_2 at 385 ppm (Hansen, 2008).

Table 1: Reduction of Emissions Required to Meet Proposed Caps*

Scholars	**Stock** *Suggested caps on CO_2 concentrations*	**Flow** *% Reduction of CO_2 emissions*
Stern Review (published: 2006)	450 ppm (Would stabilize Global climate <2°C)	80% reduction by 2050
James Hansen (published: 2008)	350 ppm	More than 80% reduction*
Kyoto Protocol **(published: 1992)	335 ppm	5.2% below 1990 levels from industrialized countries
IPCC (4th assessment, 2007)	450 ppm	Dependent on country's individual targets

*Information not available (choose not to specifically talk about emission reductions)
**Based on GHG concentration and emissions, not CO_2.

Vermont has a biological advantage for absorbing CO_2 emissions because the amount of forests and biomass in the region make it a large carbon sink. From 1990-2011, Vermont's net greenhouse gas emissions are negative, that is, Vermont absorbs more CO_2 than it produces (CCS, 2007) but we're only sequestering CO_2 now because we wiped out our forests earlier, and most of that CO_2 is now in the atmosphere.

In addition, Vermont residents emit about 15 mt (metric tons) of CO_2 per capita, which is 40% less than the national average of 25 mt of CO_2 (CCS, 2007). In 2005, Vermont accounted for 9.1 million metric tons (mmt) of gross CO_2 equivalent, which was 0.13% of total U.S. gross greenhouse gas emissions (gross emissions excludes carbon sinks, such as forests) (CCS, 2007). Even though Vermont's contribution to U.S. emissions is very small, the Governor of Vermont and Vermont's General Assembly called for reducing greenhouse gas emissions by 25% of 1990 levels for 2012; 50% by 2028; and 75% by 2050 (Final Report and Recommendations, 2007).

Waste Absorption Capacity

Many current policies surrounding climate change do not effectively allocate waste absorption capacity and fail to consider future generations. The ecosystem service of waste absorption capacity is non-excludable, because you cannot physically stop someone or something from using it.

"When the CO_2 absorption capacity is left intact and undisturbed, it contributes to the ecosystem service of climate stability" (Farley, 2008). No harm is caused by CO_2 when emissions are less than the waste absorption capacity of the ecosystems (CO_2 is absorbed by terrestrial and aquatic ecosystems, in addition to the atmosphere). Therefore, a cap on emissions would be effective if set at the waste absorption capacity along with a buffer to account for uncertainty (Farley, 2008).

<u>Cumulative Emissions</u>

One of the ways in which a limit on CO_2 emissions can be set for Vermont is through reducing the emissions of polluters based on the number and size of Vermont's industries.

Another form of capping emissions would be according to each state's ability to sequester CO_2 from the atmosphere. Vermont, having a large percentage of land covered in forests, would have a higher cap for emissions than a state with less land cover and thus a lower capacity to sequester carbon. Assigning a cap based on the ability to sequester CO_2 would provide an incentive to promote forest or green space growth.

If a chart can be developed showing the amount of CO_2 that can be sequestered by forests (since different species of vegetation have different sequestering abilities) it would be helpful in determining the appropriate cap. The Rubenstein School of Environment and Natural Resources at University of Vermont has done GIS mapping of species that may contribute to this research.

Although the United States is currently the largest emitter of CO_2 pollution per capita, in a study of fossil fuel pollution from 1751-2006, the United Kingdom held the position of highest polluter for cumulative emissions (Hansen's Letter, 2008). If per capita emissions cuts were based on cumulative emissions, the United Kingdom would hold the highest responsibility, followed by the United States. Hansen chooses to distribute CO_2 emissions per country based on cumulative emissions over the past two centuries, "Responsibility for global warming is proportional to cumulative CO_2 emissions, not to current emission rates" (Hansen's Letter, 2008).

Using a cap based cumulative CO_2 emissions in Vermont is also a consideration for VCAT. Looking at the past two centuries would require Vermont to move towards negative emissions, or in other words sequestering more than is emitted. One way to do this would be to re-circulate revenue from a cap and auction into alternative technologies that would help other countries reduce emissions.

<u>Ethics</u>

VCAT would be highly effective as an ethical standard. VCAT aims to create this ethical standard by setting an example, considering past pollution, and benefiting all citizens. The real global impact from VCAT would result from investing the proceeds in low carbon technology development, and then making them freely available to all, as said before.

Implementing new policies such as VCAT, establishes a responsibility for pollution that polluters would have to internalize. Having to pay for pollution is an incentive to lower CO_2 emissions and reduce the impact of global climate change. Instead of prices creating an incentive to lower emissions, lowering emissions could lead to a price increase. Herman Daly states it as,

“scale should be price determining, not price determined.”
A cap and trade system would use scale to determine price. Taxes would use price to determine scale.

Climate change is fundamentally an ethical issue (Gardiner, 2004). It should be a concern to both moral philosophers and humanity at large (Gardiner, 2004).Why and how VCAT should be applied touches on certain ethical issues such as emissions being equal among all people, what is a fair share of emission standards for regions like Vermont, and how to address past pollution. Below is a summary of ethical issues that need to be approached when determining the appropriate cap for sustainable and equitable distribution of CO2 emissions.

Summary of ethical possibilities for caps, and who is responsible for them:

1. Any ppm above pre-industrial levels carries a risk of climate change. How much risk we should accept is determined by our moral obligations to future generations. We get the benefits of excessive emissions now, and the future pays the costs.

2. There are also risks of reducing emissions too fast. A dramatic reduction in fossil fuel use to meet climate stability may not be able to feed 7 billion people. Would dramatic reductions in fossil fuel use lead to misery and hardship for billions? Perhaps new technologies will emerge allowing us to easily reduce emissions in the future, or to ameliorate the impacts of climate change.

3. As we balance 1 and 2, should we consider the impacts on humans alone, or on all species?

4. Global emissions must be reduced by 80-90%, therefore Vermont should reduce by 80-90%.

5. Global emissions must be reduced by 80-90% and all individuals on the planet should have the equal right to emissions. Vermont therefore should have to reduce it’s emissions to 10-20% of current per capita emissions, which means emission reductions on the order of 95-98%

6. The wealthy nations were almost solely responsible for increasing CO2 emissions from 287ppm to the current level, and therefore should be held responsible for this excess. In other words, if we have a cap and trade system, it should hold us responsible for all the CO2 we have put into the atmosphere that still remains there. Our right to emit is essentially negative. If we want to emit, we should have to pay low emitting countries for the right to do so. Hansen chooses to distribute CO2 emissions per country based on cumulative emissions over the past two centuries, "Responsibility for global warming is proportional to cumulative CO2 emissions, not to current emission rates" (Hansen's Letter, 2008).

7. Should poor states have to avoid adopting the same form of industrialization by which the rich states became rich?

8. Vermonter's are entitled to the carbon sequestration capacity of our state, which should determine how much we could emit. We should add forest growth rates to our emissions allowances.

9. Vermonter's should be responsible for the emissions of past forest clearing as well as past emissions, as in 3 above.

10. From 1990-2011, Vermont's net greenhouse gas emissions are negative, that is, Vermont absorbs more CO_2 than it produces (CCS, 2007) but we're only sequestering CO_2 now because we wiped out our forests earlier, and most of that CO_2 is now in the atmosphere. Do we get credit for undoing past damage?

The United States is the highest polluter in the world on a per capita basis, and emits, on average, four to five times more than other countries per capita (Stern, 2006). On the other hand, China has surpassed U.S. in total emissions. Wealth in developed nations was created by industrialization but has also led to the externalities of climate change that are felt by developing nations, most of whom share little of the responsibility for climate change (Shue, 1999).

Adopting the Polluter Pays Principle that all future costs of pollution should be internalized, would have an impact on the externalities in a forward looking approach that Vermont may want to aim for.

Ethical responsibility for CO_2 emissions reflects on elementary principles of cleaning up messes. If one learns that whoever reaps the benefit of making the mess must also be the one who pays the cost of cleaning up the mess, one learns at the very least not to make messes with costs that are greater than their benefits (Shue, 1999). The cost of pollution is put on those least responsible for it; therefore VCAT would create a system in Vermont for internalizing some of the external costs. The price of a product has to incorporate the costs of cleaning up the mess made in the process of producing the product, so the costs are not externalized, or dumped on other parties (Shue, 1999).

According to Henry Shue's second and third principles of ethics:

> "It is not fair to punish someone for producing effects that could not have been avoided, but it is common to hold people responsible for effects that were unforeseen and unavoidable," and, "Even if it is fair to hold a person responsible for damage done unintentionally, it will be said, it is not fair to hold the person responsible for damage he did not do himself."

Agreeing upon the just distribution of responsibility for pollution is one of the difficulties of setting an appropriate cap for CO_2 emissions. Each region holds a different history of levels of deforestation. On the same note, each region has varying abilities to reforest their land and to act as a carbon sink. Once the global limit for waste absorption capacity is determined, certain questions need to be asked such as: are Vermonters entitled to an equal share of global limits? Should we be entitled to less because we have a past history of greater use? Should we be entitled to more because our ecosystems are re-growing, or to less because our ecosystems currently store much less carbon than they did historically? Or should we just reduce carbon emissions by 80-90% by 2050? This is an important ethical discussion that needs to be examined before making economically and politically weighted decisions.

Revenues in the VCAT: Estimated revenues and potential distributions

Methodology For Calculating Revenues

In Vermont, the main contributors to carbon emissions are residential/commercial/industrial (RCI) oil use, gasoline and diesel used for transportation, jet fuel, and natural gas; combined, they represent 75% of CO_2 emissions in VT (Strait et al, 2007). The price elasticity of demand for these goods (jet fuel, gasoline, etc) is used to estimate revenues that will accumulate in the VCAT.

Elasticity of demand represents the change in quantity demanded of a good in response to a change in the price of the good. There are many estimates that show the short-run price elasticity of demand for many of these goods is very inelastic. Heating fuel and gasoline are necessities for many consumers and as prices increase or decrease quantity demanded remains relatively unchanged (reflecting the fact that they are necessities). For example, Boyce et al estimated that the price elasticity of gasoline is around -0.26 (Boyce and Riddle, 2007), which is considered very inelastic. This means that a 10% increase in the price of gasoline will result in only a 2.6% decrease in the quantity of gasoline demanded.

To calculate revenues, the carbon dioxide content per unit of each of these goods, along with the price per unit of these goods was taken from the Energy Information Administration (see EIA, 2008 for price information). The price per ton of CO_2, per unit of good was then calculated. It was assumed that a price to emit CO_2 (ex. Carbon tax, or permit) would result directly in an increase in the consumer prices of the carbon emitting goods.

The elasticity demand of each good was used to determine where the permit price is likely to lie if a cap on carbon emissions is implemented (see equations on the next page). Multiplying the carbon permit price by the quantity of emissions resulting from a cap reveals the revenues that will be generated.

It is important to note that short run elasticity of demand estimates, used in these calculations, only show short term responses to price changes. In the long run consumers/producers will generate substitutes in response to higher prices, thus increasing the elasticity of demand (Hultman and Kammen, 2003). For example, the price of gasoline rose recently and in reaction many people began biking, walking, and taking public transit as substitutes to consuming gasoline. If prices remained high for an extended amount of time, better transit systems, walking paths and human-scaled development would slowly decrease people's need for gasoline. One researcher estimated the long-run elasticity of demand for gasoline to be -0.56 (Espey, 1996). However, long run elasticity is very difficult to estimate accurately and for the practical purposes of this report long run elasticity is not used.

As a result of using short run elasticities, the calculations show less responsiveness to price increases than would likely occur if a cap was implemented. Therefore, revenues (and permit prices) are very likely to be overestimated.

Equations used

There are several knowns which we can use to calculate the Permit Price (ΔP) and total revenues (R). Elasticity is known ($\in$), the total quantity of emissions after a cap is known (C), the initial quantity of emission is known (Q_i), and the price for these goods, in terms of carbon emissions per unit is known (P_i).

The equation for elasticity is:

Equation 1: $\in = \dfrac{(\Delta P / P_i)}{(Q_f - Q_i)/Q_i}$

where ΔP represents the change in price due to a cap on emissions. This is a constant for all goods and can be thought of as the Permit Price. Using algebra we can solve for the quantity of emissions from the good after the cap (Q_f)

Equation 2: $Q_f = Q_i(\dfrac{\in \Delta P}{P_i} + 1)$

The cap is introduced as C. For a basket of carbon emitting goods (good a, good b, good c, continuing to good n) there exist an initial total emissions which is made up of Q_{ia}, Q_{ib}, Q_{ic}, continuing to Q_{in}. The quantity of emissions from an individual good after a cap is represented by Q_f. Therefore, the equation for C is:

Equation 3: $C = Q_{fa} + Q_{fb} + Q_{fc} ..... + Q_{fn}$

Equation 2 can be plugged into Equation 3:

Equation 4: $C = Q_{ia}(\dfrac{\in_a \Delta P}{P_{ia}} + 1) + Q_{ib}(\dfrac{\in_b \Delta P}{P_{ib}} + 1) + Q_{ic}(\dfrac{\in_c \Delta P}{P_{ic}} + 1)..... + Q_{in}(\dfrac{\in_n \Delta P}{P_{in}} + 1)$

In the equation for C there is now only one unknown, ΔP , so the equation can now be solved for ΔP . This was achieved using the computer program *Mathematica for Students*, to avoid possible algebraic errors attempting to solve for ΔP

Equation 5:

$$\Delta P = \frac{P_{ia} P_{on} P_{ic} .... P_{in}(C - Q_{ia} - Q_{ib} - Q_{ic} .... - Q_{in})}{P_{ib} P_{ic} .... P_{in} Q_{ia} \in_a + P_{ia} P_{ic} .... P_n Q_{ib} \in_b + P_{ia} P_{ib} .... P_{in} Q_{ic} \in_c .... + P_{ia} P_{ib} P_{ic} .... P_{in-1} Q_i \in_n}$$

Equation 5 allows us to calculate the permit price for a given cap in emissions, R. The next step is to calculate the Total Revenue (R) generated from the cap:

Equation 6: $R = \Delta PC$

Implementation of Cap and Trade System

In general, cap and trade systems *gradually* ratchet down emissions over time. The rate at which emissions are ratcheted down should reflect the ability of consumers and producers to substitute out of consuming and producing carbon emitting goods. In the short-run, there are technological barriers and cultural barriers that prevent quick reductions in carbon emissions (Stern, 2006). Therefore, a quick and rapid reduction in carbon emissions will lead to economic instability, caused by increases in the cost to produce and increases in the price of consumer goods. In the long-run, however, caps on emissions can more easily be dealt with by cultural changes and technological development. A gradual rate of reduction in carbon emissions allows for producers and consumers to adapt over time and will not lead to economic instability.

Using data gathered from developed countries around the world, Goodwin et al found that if there was a 10% increase in the real price of fuel, the efficiency of the use of gas increased by 1.5% within a year and over 4% in the longer run (about 5 years) (Goodwin et al, 2008). The amount of traffic decreased 1% in the short-run, while the fuel use decreased by 2.5%. Therefore, the majority of the 2.5% decrease in fuel use was actually due to using fuel more efficiently. This is a great example of how people can reduce their consumption not only by consuming less, but also by consuming more efficiently.

Increases in energy efficiency and efficiency of fuel use should be taken into account when ratcheting down a cap on carbon emissions. For example, the 4% increase in energy efficiency, observed by Goodwin et al, should be matched with a similar ratcheting down of the carbon cap. The cap could also be ratcheted down at a rate the keeps revenues going into the trust constant. To keep revenues constant, decreases in the carbon permit price (caused by consumers and producers substituting out of carbon emitting goods) would have to countered by a proportional ratcheting down of carbon emissions.

Estimates

Table 1 Estimated revenues at different caps

2005 CO2 emissions mmt (from RCI fuel use, and transportation)	Carbon Cap (percentage reduction in CO2 emissions)	Quantity of CO2 emissions after cap (mmt)	Estimated Permit Price ($/ton)	Revenue generated
7.02	1%	6.95	$15	$105,296,842.89
7.02	2.5%	6.84	$38	$259,253,590
7.02	5%	6.67	$75	$505,212,124
7.02	10%	6.32	$151	$957,244,026
7.02	14%	6.04	$212	$1,280,579,786

Kyoto Protocol Standards

The Kyoto Protocol calls for at least a 5% reduction in emissions based on 1990 levels (EUROPA, 2008). This would require Vermont to reduce emissions by 14% from 2005 levels. A $212 per ton CO2 price would be required to immediately achieve a 14% reduction in emissions. Table 1 shows that a $212 per ton permit price would generate over 1 billion dollars of revenues in a year. However, this reduction will not be feasible to achieve in one year.

VCAT is likely start with a less stringent cap. To achieve a 14% reduction over 20 years, only a reduction of about 1% is needed annually. The initial price for carbon that will likely arise from a 1% reduction in carbon emissions is about $15 per ton, which will generate an estimated $105 million of revenues annually.

Stern Review Recommendations

The Stern Review advises that global atmospheric concentrations should stabilize at 450ppm. This concentration would require the U.S. to reduce emissions by 80% below 2000 levels, by 2050 (Union of Concerned Scientists, 2008). If caps are ratcheted down starting in 2010 an annual reduction in emission of about 4% would be required to achieve a 80% reduction over the 40 years. A 4% reduction would generate over $400,000,000 of revenues annually.

Vermont General Assembly Recommendations

The Vermont General Assembly recommended emissions reductions of 75% by 2050. If a cap and trade system is implemented in 2010, a 75% reduction could be achieved if emissions are ratcheted down by 0.719% annually until 2050 (VDPS, 2008.) An annual reduction of 0.719% would generate approximately $76,000,000 of revenues annually.

Revenue Distribution

Table 2 shows that a cap that reduces emissions by 10% will result in up to a 63% increase in price for goods included in the cap. The sharp increase in the prices of these goods will most likely have the greatest impact on the poorest households in Vermont. According to the Vermont Fair Tax Coalition low-income households in Vermont will pay the highest percentage of their incomes on a carbon tax (Ramos R. and D. Brighton, 2000). This would also hold true for a carbon cap and trade system if progressive policies are not paired with the carbon cap. Creedy and Sleeman found that carbon taxes in New Zealand increased inequality, and were regressive. However, they said that these distributional effects could easy be solved by using the carbon revenue to reduce pre-existing taxes (Creedy, and Sleeman, 2006).

Table 2 Increases in Price due to a 10% Reduction in Emissions

	Gasoline (per gallon)	**RCI fuel use (per gallon)**	**Natural Gas (per thousand cubic feet)**	**Diesel fuel (per gallon)**	**Jet Fuel (per gallon)**
Increase in price	$1.34	$1.79	$8.25	$1.51	$1.45
Percentage increase in price	37%	41%	33%	35%	63%

Revenues should be distributed progressively, since carbon taxes and carbon emission caps are regressive (Rose and Oladosu, 2002). There several ways the carbon revenues generated by VCAT could be used; a lump-sum transfer to all Vermonters, investments into efficient technology, reduction of heating costs and lowering existing taxes. This section will review literature surrounding distribution of carbon revenues.

Lump Sum Transfer

Estimates in this paper show that a per capita annual payment from the trust (also known as a lump-sum transfer) might range from $121 (Vermont General Assembly recommendation) to $641 (Stern review) if 100% of the revenues are distributed back to the public. The VCAT proposal recommends that at least 25% of the revenues generated should be returned to Vermont citizens. This would put the range of payments between $30 to $160.

Boyce and Riddle designed a simplified model of a "cap and dividend" policy in the U.S. where 100% of the costs of carbon permits are passed onto consumers and the entire revenues generated by the permits are given back to the public in equal per capita payments. The dividend received by all Americans will equal $678 according to their estimates. The model showed that the bottom 60% of Americans (in terms of expenditure) will actually benefit from the policy, while the top 40% of Americans would experience an average net cost of $338 (Boyce and Riddle, 2007).

Butraw et al provide a detailed analysis of the distributional impacts of different revenue distribution policies when carbon permits are sold for $41 per ton of CO2. The impact of different policies on each income decile category is shown through changes in consumer surplus and expenditures. This study is very useful because it includes a regional analysis of the impacts of each policy, including the Northeast (Butraw et al, 2008). They found that a lump sum transfer of 65% of the revenues to the public would be mildly progressive. In fact, the bottom two income deciles in the Northeast bear the least negative impacts. However, the average for all income deciles is a decrease in net welfare of over 1% (Butraw et al, 2008).

A lump sum transfer policy may be desirable since it gives the public a stake in implementing more stringent caps. This policy encourages the public to put pressure on corporate lobbyists who don't want to pay for carbon permits/taxes and encourages the public to be informed about climate change and the VCAT (Flomenhoft, 2008).

Another benefit of a cap and dividend policy is that it rewards those who consume less, such as those 60% of Americans that experience a net benefit in Boyce and Riddle's estimates, and it punishes those who are consuming the most (also see Brenner et al, 2006). The policy will create incentive for Americans to consume more efficiently in an attempt to receive a net benefit rather than a net cost. The policy also satisfies the criteria of just distribution by reducing the impact of a cap and trade policy on the lowest income earners in Vermont.

There are some drawbacks to this policy. If a dividend check is given to all Vermonters, the money will likely not be spent on efficient technologies and it could potentially be spent on polluting goods. Another issue is that the dividend checks would mostly provide Vermont residents with private, market goods. Essentially, a lump sum transfer takes the revenues generated from a public good (i.e. climate stability) and transfers it to the private market. There will be little to no provision of public goods, such as public transportation. As the next section outlines, the revenues can also be used to provide public goods such as information and technology.

Efficient Technology Investments

Goodwin et al's finding that transportation energy efficiency will increase by 4%, if fuel prices rise by 10% supports the notion of investing revenues into developing energy efficient technologies. Investments could include expanding the Vermont Weatherization program, growing Efficiency Vermont, and investing money into research grants aimed at developing efficient technology.

Investing into green technology will allow for progress to a future of zero carbon dioxide emissions. Using the revenues to speed up the development of green technologies and increase implementation would allow for consumers to substitute out of carbon emitting energy sources. This policy would make carbon emitting energy less of a necessity, which would be reflected in a shift in the demand for carbon energy and a higher elasticity of demand for carbon emitting energy (meaning consumers can substitute out carbon energy).

Technological development can also transferred around the world at very little cost. The technologies that Vermont creates could be freely given to the global community. This would further develop the technology, reduce emissions to those who adopted the technology, and *further* reduce Vermont's emissions.

Overall, this policy has potential to distinguish Vermont as a world leader in fighting climate change. It could also provide a means for Vermont's impact on climate change to be more than symbolic.

Home Heating Cost

In Vermont, home heating is a large cost to consumers, and it also accounts for over 17% of Vermont's GHG emissions (estimated from Strait et al, 2007). A cap and trade system or carbon tax will be an unneeded financial burden on low-income Vermonters who might already have trouble affording the cost of heating. Butraw et al. examined the impact of leaving out natural gas and oil used for home heating from a cap and trade policy. They found that when combined with a lump-sum transfer, the bottom 20% of the Northeast experienced a very small decrease in overall welfare. This policy was the most progressive policy for the Northeast compared to any other policy they studied (Butraw et al, 2008).

Instead of omitting heating fuel from the VCAT air trust, the revenues from the trust could be used to fund efficiency rebates or other incentives. The regressive impact of including heating fuels in the trust could be reduced substantially if action is taken to reduce the impact of increased heating cost on low income Vermonters. Revenues generated from the trust could be used to fund a variety of programs such as the Weatherization program, and be used to develop more efficient or renewable heating technologies, such solar water heating, wood pellet heating, etc.

Current Energy Efficiency Programs in Vermont

Table 3 summarizes some of the major programs in Vermont that are investing into energy efficiency and green technology. There are several state run and private run programs. Most of these programs work in conjunction with one another. For example the Vermont Gas System programs work in partnership with Efficiency Vermont

Table 3 Programs operating in Vermont

Organization	**Program**	**Goals/Activities**
Efficiency Vermont	Vermont Energy Star Homes Program Website	Design assistance, rebates, testing, and energy rating
Efficiency Vermont	Residential Energy Efficiency Rebate Programs Website	Provides rebates on energy efficient consumer products such as CFL bulbs, washing machines, refrigerators, etc.
Vermont State Office of Economic Opportunity	Weatherization Assistance Program Website	Aimed towards low-income residents in Vermont. They provide free consultation/and home assessment, and energy efficient retrofits
Vermont Gas System (VGS)	Homebase Retrofit Program Link to report on program Website	Free energy audits on homes that use higher than average amounts of gas, and rebates of up to 1/3 the cost of recommended measures to reduce fuel use
VGS	The WorkPlace Equipment Replacement and Retrofit Program/New Construction Program Website	Increasing energy efficiency in the commercial sector through providing information, consultation, and financial assistance for owners, architects, engineers, or developers interested in making their new buildings energy efficient.. The equipment replacement program provides rebates on energy efficient equipment.
State of Vermont	Clean Energy Development Fund (CEDF) Loan Program Website	Provides loans of up to $1 million at a fixed rate of 2% to individuals, companies, nonprofits and municipalities who are developing or purchasing capital that provides clean-electricity.
Renewable Energy Resource Center	The Vermont Solar & Small Wind Incentive Program Website	Provides funding for renewable energy (solar and wind) projects

In 2005, for every dollar invested into the Vermont Weatherization there was a return of $1.98 (VDPS, 2008). The program provides services to over 1,400 housing units a year and provides services to low-income households. 1,400 households a year is significant, however, there are still "tens of thousands of qualifying homes" waiting in queue to be served (VDPS, 2008). The Weatherization program could provide long-lasting benefits to many Vermont residents if it is expanded. The carbon revenues from VCAT could fund an expansion.

The Regulatory Assistance Project (RAP) wrote a report that recommended that the Vermont legislature set goals to reduce annual fuel needs by an average of 25% for at least 60,000 homes in Vermont. To achieve this, efficiency programs would be expanded. The report estimated that each dollar invested into the program would yield $2.14 in savings (RAP, 2008). Carbon emissions were estimated to decrease by 3.1 million tons over the twenty year program, which accounts for 34% of emission in 2005 (Cowart, et al, 2008).

Reducing Pre-existing Taxes

Revenues could be used to reduce pre-existing distortionary taxes. One example cited by many articles is the use of carbon revenue to reduce income taxes (Burtraw et al, 2008, Mckitrick, 1997, Goulder et al, 1997). This approach is praised by economist for increasing the efficiency of the carbon reduction policy, however, there is very little accounting of the distributional impacts by these scholars (Goulder et al, 1997, Kraus et al, 2002). For example, Butraw et al found that using the revenues to reduce income taxes is very regressive; it benefits only the top 10% of Americans. Income based tax reductions will always be regressive since the highest income earners pay the most taxes, while the lowest income earners pay the least.

Revenues could be used to either reduce payroll taxes, or increase the income tax credit. Burtraw et al found this to be a slightly progressive use of the tax money. These policies should be researched more thoroughly in future research.

Conclusion

The information presented in this paper is the first step towards developing a common asset trust that will seek to address the dire issue of global climate change. It is evident that action needs to be taken sooner rather than later, however policies must be developed carefully, with ability to adapt to the uncertainty that prevalent in our world.

Addressing climate change will take more than just the establishment of VCAT, but will require that paradigms change concerning how we all view our future. At all scales: individual, community, towns, cities, states, nations, and the world; our vision for our future and our actions today will ultimately determine whether the VCAT program and others like it will be successful in addressing global climate change.

Recommendations for Future Work

Research of specific components should focus on their applicability to Vermont and the common asset trust program. Each component has a variety of implications and should be considered carefully. A more in depth look at appropriate allocation methods is incredibly important for the completeness of this report. There are many characteristics regarding certain methods that deserve more research with greater discussion as to their applicability and opportunities.

It would also be beneficial to talk with the authors of Senate Bill 44 and work more closely with them in the future. These legislators are the bridge for enacting this policy in the state of Vermont. In creating a policy such as a common asset trust the leverage points must be known to enact change at the appropriate levels.

The following recommendations are broken down into their respective categories:

Allocation Methods:
While Vermont has the lowest carbon footprint in the U.S. (VT Dept. of Public Services), it is the collective responsibility of the present to preserve our natural environment for future generations (James and Lahti 2004). Various versions of a cap and trade system have been highly popular and are also the first on the list of policy recommendations proposed in the Vermont Comprehensive Plan 2008.

Recognition that this mechanism of change must be inclusive within the current market model is essential for the success of any carbon dioxide management strategy (VT Dept. of Public Services 2008).

Framers of this program should seek support from likeminded organizations to further develop this model, such as: Vermont Department of Environmental Conservation, Vermont Fish and Wildlife, Vermont House of Representatives, Vermont Senate, Governors Office, and town officials. Controlling the emissions rate as suggested by RGGI, Stern Review, and Kyoto can be done in various ways and each method should be considered for its pros and cons prior to implementing any program.

Revenues: Estimation and Distribution

There are a number of assumptions behind the revenue calculations. Assuming the consumer price for a carbon emitting good will increase the exact amount of the carbon tax or permit price is not correct. A tax is always shared between consumers and producers (Nicholson, 2004). The share of the carbon tax that will be shared by consumers and producers should be taken into account.

The calculations also used short-run elasticity of demand. Short-run elasticity, as was explained earlier, will always show less responsiveness to price changes (or quantity changes) than long run elasticity. The calculations should take this into account.

The ratcheting down of emissions over time was included in the calculations of revenue; however, the method was questionable. Elasticity was assumed to stay constant after each reduction. The calculations also assumed that a 1% reduction annually would not accumulate. For example, a 1% reduction would be plugged into the elasticity equation for each year, even though each year, the accumulated reduction in emissions was greater. Further work should be done to model the effect of decreasing elasticities with increasing reductions in emissions.

The cost of a cap and trade system on the Vermont economy has yet to be looked at in depth. Only very rough generalizations can be made about the impacts. In general, the policy will be regressive (excluding any revenue distribution). There are many Vermont residents who are on the edge of poverty, or in poverty. These Vermonters could be pushed over the brink if we implement a cap and trade system. In order to develop a just policy, a detailed analysis should be carried out on the impacts of a cap and trade system on low-income Vermonters and small businesses.

There are more revenue distribution policies available to VCAT than were talked about in this paper. The revenues could be invested in public goods such as infrastructure, parks, or ecosystem services such as carbon sequestration. Carbon revenues could also be used to advertise for the public good. A climate change campaign could be a potential use of these funds. The Truth anti smoking campaign was shown to reduce youth smoking rates by 5%, showing that advertising for the public good has been effective in the past (Farrelly, M. 2005). These and other options should be considered by VCAT in future research.

Appendix A: *Mathematica* Output

Equation of Elasticity: $\epsilon = \dfrac{(P_F - P_i)/P_i}{(Q_F - Q_i)/Q_i}$,

where ϵ is elasticity. Q_F represents the quantity of emissions after a cap. Qi is the intial emissions

Equation of Elasticity: $\epsilon \dfrac{\Delta P}{P_i} = \dfrac{Q_F - Q_i}{Q_i}$

Below, the equation of elasticity is defined in terms of quantity of emissions after a cap, given by "Q_{aF}", "Q_{bF}", "Q_{cF}", "Q_{dF}", and "Q_{eF}" for goods a, b, c, d, and e (representing gas, diesel, natural gas, RCI fuel, and jet fuel)

"ΔP" represents the change in price, given by (final price − initial price)

"a", "b", "c", "d", and "e" represent <u>initial prices</u> for goods a, b, c, d, and e.

Clearly, Q_{ai}, Q_{bi}, Q_{ci}, Q_{di}, and Q_{ei} represent the initial quanities for goods a, b, c, d, and e. "ϵ_a" through "ϵ_e" represent the elasticities of the five goods.

$$Q_{aF}[\Delta P\_] = Q_{ai}\left(1 + \epsilon_a \frac{\Delta P}{a}\right)$$

$$Q_{ai}\left(1 + \frac{\Delta P\, \epsilon_a}{a}\right)$$

$$Q_{bF}[\Delta P\_] = Q_{bi}\left(1 + \epsilon_b \frac{\Delta P}{b}\right)$$

$$Q_{bi}\left(1 + \frac{\Delta P\, \epsilon_b}{b}\right)$$

$$Q_{cF}[\Delta P\_] = Q_{ci}\left(1 + \epsilon_c \frac{\Delta P}{c}\right)$$

$$Q_{ci}\left(1 + \frac{\Delta P\, \epsilon_c}{c}\right)$$

$$Q_{dF}[\Delta P\_] = Q_{di}\left(1 + \epsilon_d \frac{\Delta P}{d}\right)$$

$$Q_{di}\left(1 + \frac{\Delta P\, \epsilon_d}{d}\right)$$

$$Q_{eF}[\Delta P\_] = Q_{ei}\left(1 + \epsilon_e \frac{\Delta P}{e}\right)$$

$$Q_{ei}\left(1 + \frac{\Delta P\, \epsilon_e}{e}\right)$$

The elasticiy equations are solved simultaneously for ΔP subject to the condition that $Q_{aF} + Q_{bF} + Q_{cF} + Q_{dF} + Q_{eF} = R$, where R is the overall cap on emissions.

```
Solve[{Q_aP[ΔP] + Q_bP[ΔP] + Q_cP[ΔP] + Q_dP[ΔP] + Q_eP[ΔP] == R}, {ΔP}]
```

$$\left\{\left\{\Delta P \to \frac{a\,b\,c\,d\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,c\,d\,e\,Q_{bi}\,\epsilon_b + a\,b\,d\,e\,Q_{ci}\,\epsilon_c + a\,b\,c\,e\,Q_{di}\,\epsilon_d + a\,b\,c\,d\,Q_{ei}\,\epsilon_e}\right\}\right\}$$

The change in price as well as the final quantities are expressed in terms
of the known values of elasticity, initial price, initial quantity, and total cap on emissions.

$$\Delta P = \frac{a\,b\,c\,d\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,c\,d\,e\,Q_{bi}\,\epsilon_b + a\,b\,d\,e\,Q_{ci}\,\epsilon_c + a\,b\,c\,e\,Q_{di}\,\epsilon_d + a\,b\,c\,d\,Q_{ei}\,\epsilon_e}$$

```
Simplify[Q_aP[ΔP]]
```

$$Q_{ai}\left(1 + \frac{b\,c\,d\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})\,\epsilon_a}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,(c\,d\,e\,Q_{bi}\,\epsilon_b + b\,(d\,e\,Q_{ci}\,\epsilon_c + c\,e\,Q_{di}\,\epsilon_d + c\,d\,Q_{ei}\,\epsilon_e))}\right)$$

```
Simplify[Q_bP[ΔP]]
```

$$Q_{bi}\left(1 + \frac{a\,c\,d\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})\,\epsilon_b}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,(c\,d\,e\,Q_{bi}\,\epsilon_b + b\,(d\,e\,Q_{ci}\,\epsilon_c + c\,e\,Q_{di}\,\epsilon_d + c\,d\,Q_{ei}\,\epsilon_e))}\right)$$

```
Simplify[Q_cP[ΔP]]
```

$$Q_{ci}\left(1 + \frac{a\,b\,d\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})\,\epsilon_c}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,(c\,d\,e\,Q_{bi}\,\epsilon_b + b\,(d\,e\,Q_{ci}\,\epsilon_c + c\,e\,Q_{di}\,\epsilon_d + c\,d\,Q_{ei}\,\epsilon_e))}\right)$$

```
Simplify[Q_dP[ΔP]]
```

$$Q_{di}\left(1 + \frac{a\,b\,c\,e\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})\,\epsilon_d}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,(c\,d\,e\,Q_{bi}\,\epsilon_b + b\,(d\,e\,Q_{ci}\,\epsilon_c + c\,e\,Q_{di}\,\epsilon_d + c\,d\,Q_{ei}\,\epsilon_e))}\right)$$

```
Simplify[Q_eP[ΔP]]
```

$$Q_{ei}\left(1 + \frac{a\,b\,c\,d\,(R - Q_{ai} - Q_{bi} - Q_{ci} - Q_{di} - Q_{ei})\,\epsilon_e}{b\,c\,d\,e\,Q_{ai}\,\epsilon_a + a\,(c\,d\,e\,Q_{bi}\,\epsilon_b + b\,(d\,e\,Q_{ci}\,\epsilon_c + c\,e\,Q_{di}\,\epsilon_d + c\,d\,Q_{ei}\,\epsilon_e))}\right)$$

Appendix B: Data used for Revenue Calculations

	Gasoline (per gallon)	RCI fuel use (per gallon)	Natural Gas (per thousand cubic feet)	Diesel fuel (per gallon)	Jet Fuel (per gallon)
Price	$3.60[a]	$4.40 [a]	$25.00 [a]	$4.34 [a]	$2.29[b]
Metric Tons of CO2 per unit	0.01[c]	0.01 [c]	0.05 [c]	0.01 [c]	0.01 [c]
Price/ton C02	405.75	373.15	459.38	434.79	239.37
Price elasticity of demand [d]	-0.26	-0.27	-0.20	-0.26	-0.25
Total Emissions (millions of metric tons) [e]	3.50	2.24	0.44	0.67	0.17

a Taken from: Energy Information Administration (2008). "Vermont Energy Profile" http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=VT

b From: http://tonto.eia.doe.gov/dnav/pet/pet_pri_refoth_a_EPJK_PWG_cpgal_a.htm

c http://www.eia.doe.gov/oiaf/1605/coefficients.html

d From: Boyce J. and M. Riddle (2007)

e From: Strait, Roe, et al. (2007).

Appendix C: Elasticity Estimates

Source	Commodity	Short run elasticity	Long run elasticity
http://www.eia.doe.gov/oiaf/analysispaper/elasticity/	Residential electricity, natural gas, and distillate fuel Commerical electricity, natural gas, and distillate fuel	-0.34, -0.3, and -0.34 -0.2, -0.29, and -.38	
Hughes et al. (2008)	Gasoline	-0.1	
Dahl (1993)	Natural gas, fuel oil	-0.2	
Boyce and Riddle (2007)	Food Industrial goods Services Electricity Natural gas Heating oil Car fuels Air transport Other transport	-0.6 -1.3 -1 -0.2 -0.2 -0.27 -0.26 -0.25 -0.25	
McKitrick, R. (1997)	Bundle of goods (contribute to carbon emissions)	-0.22	
Berkhout et al. (2004)	Average price elasticity of electricity	-0.57	
Bernstein (2005)	Residential electricity Commercial electricity Residential Natural Gas	-0.24 -0.21 -0.12	-0.32 -0.97 -0.36

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