Local Solutions to Global Problems: Tumwater, Washington and the Development of a Climate Protection Program

by

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Abstract

This thesis explores the concept of climate change and the myriad problems it presents to Earth's natural and human systems, and also describes technological, political, and societal solutions that have been identified and implemented on various scales around the world. At the center of the thesis is a case study of the City of Tumwater, Washington, which signed the US Mayors' Climate Protection Agreement (which is based on the international Kyoto Protocol). In 2007, the City set about determining its baseline and current greenhouse gas emissions and also explored methods of reducing those emissions by 7% below 2000 levels by 2012. The central research question of this thesis is whether the City of Tumwater would be able to meet its climate change mitigation goal. Many technological and behavioral strategies were identified and presented to City Council, though it was determined that the City could not meet its goal without investing in renewable energy through its electricity provider. In two Council meetings in December 2007, the Council allocated funding for the 2008 fiscal year in order to make energy efficiency upgrades to its operations and also to continue its greenhouse monitoring efforts. It also included funding for further climate change mitigation efforts in its six-year capital facilities plan.

Table of Contents

Table of Figures

Table of Tables

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Chapter 1. A Review of Climate Change Issues

Introduction

Over the past several years, the issue of climate change has received considerable attention in scientific communities, media outlets and in the general population. The many threats that climate change poses, including sea level rise, precipitation shifts and species extinction, combined with the debates about approaches to mitigating anthropogenic influences on Earth's climate, have made this a widely discussed topic around the world. The publication of the Intergovernmental Panel on Climate Change's Fourth Assessment Report (FAR) in 2007 has made it clear that human beings are "very likely" the primary cause of heating trends in Earth's atmosphere and have set in motion a process that is already causing widespread effects that will ripple throughout the world, changing the ways of life of human beings and a multitude of other species.

Thesis Outline

Chapter 1 discusses the background of climate change science, including observed trends and impacts as well as future projections. Two scales of analysis are presented, at both the global and Washington State levels. Chapter 2 describes climate change mitigation efforts at all scales and provides a partial review of climate legislation. Much information for Chapters 1 and 2 came from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

The FAR reviews a vast amount of current climate change literature and includes its own analyses and projections of climate trends. Chapter 3 details the greenhouse gas emissions audit process undertaken for the City of Tumwater, Washington. Chapter 4 describes the process of identifying greenhouse gas emissions reduction strategies, while Chapter 5 provides a quantification of the emissions reduction potential of these measures. Chapter 6 details the City of Tumwater's political processes in adopting greenhouse gas reduction initiatives. Chapter 7 includes future recommendations for the City's Climate Protection Program.

Atmospheric Changes

In 2005, the atmospheric concentration of carbon dioxide (CO_2), the most prominent anthropogenic greenhouse gas, was measured at 379 parts per million (ppm), a third higher than the preindustrial concentration and likely higher than it has been in at least the past 650,000 years (Forster et al., 2007; Denman et al., 2007). This data was presented in the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report. The IPCC was created in 1988 by the World Meteorological Organisation and the United Nations Environment Programme. The reporting body consists of hundreds of experts who prepare and evaluate publications on the grounds of scientific, technical and socioeconomic content and accuracy. The IPCC is comprised of a Task Force on National Greenhouse Gas Inventories and three working groups. The first working group reports on "The Physical Science Basis of Climate Change", the second covers

"Climate Change Impact, Adaptation and Vulnerability", and the third deals with "Mitigation of Climate Change", (http://www.ipcc.ch/about/how-the-ipcc-is-organized.htm).

Anthropogenic Influence

Since the IPCC's Third Assessment Report, published in 2001, very high confidence exists among researchers that the net result of human activities since 1750 has led to a warming of Earth's atmosphere (Forster et al., 2007). Not all human activities have led to warming. The emission of aerosols such as sulphate, organic carbon and dust has produced a smaller cooling effect by their presence in both the atmosphere and on some land surfaces (Forster et al., 2007). It is becoming increasingly evident that the observed changes to Earth's climate and natural systems are not only the result of natural temperature increases.

Only models that include both natural and anthropogenic climate forcings are able to duplicate the observed increases in global mean surface temperature in the 20th century (Stott et al., 2006, as cited in Hegerl et al., 2007, p. 684). Because global mean surface temperature increases have been associated with anthropogenic forcing, the same conclusion can be drawn for trends influenced by higher temperatures, such as increased atmospheric water vapor content over the world's oceans (Hegerl et al., 2007). Recent glacial shrinkage is also probably related to anthropogenic climatic forcing (Reichert et al., 2002a as cited in Hegerl et al., 2007, p. 717). Overall, a combination of anthropogenic and natural climatic warming influences has led to observed changes in Earth's natural systems.

Observed Trends

Several trends have been observed in recent years that are linked to climate change with varying degrees of confidence. For eleven of the past twelve years, surface temperatures have been the warmest in the instrumental record, with a hundred year temperature increase of 0.74° C (1.3° F) (Trenberth et al., 2007). The warming rate of the past fifty years is twice that of the past hundred years (Trenberth et al., 2007). Additionally, ocean temperatures in at least the upper 3,000 meters have increased since 1961 (Levitus, 2005, as cited in Bindoff et al., 2007, p. 391).

Higher global temperatures are likely responsible for several documented effects around the world. Glaciers and snow cover have, on average, declined globally (Lemke et al., 2007). Although uncertainty exists, data suggest an overall decline in the global cryosphere during the 20th century, especially between 1993 and 2003 (Lemke et al., 2007). Satellite data has also shown that since 1978, annual average arctic sea ice extent has declined by 2.7% per decade (Comiso, 2003, as cited in Lemke et al., 2007, p. 351). Ice covers approximately 10% of Earth's land area, and the vast majority of the world's land ice exists in Greenland and Antarctica (Lemke et al., 2007). Overall, Greenlandic and Antarctic ice sheets are growing smaller (Hegerl et al., 2007). The amount of ice held in their massive ice sheets would, if fully melted, raise sea level by over 60 meters (Bamber et al., 2001; Lythe et. al., 2001; both as cited in Lemke et al., 2007, p. 361).

Indeed, sea level rise is another result of a warming climate. Douglas (2001) and Peltier (2001) found that sea level rose 1.8 mm per year during the previous 70 years (Douglas, 2001; Peltier, 2001; both as cited in Bindoff et al., 2007, p. 410). Miller and Douglas (2004, as cited in Bindoff et al., 2007, p. 410) concluded that in the 20th century, sea level rose at a rate of 1.5-2.0 mm per year. In the period of 1993 to 2003, the rate of sea level rise was measured at 3.1 mm per year (Cazanave & Narem, 2004; Leuliette et al., 2004; both as cited in Bindoff et al., 2007, p. 411). Greenland and Antarctica likely contributed to past sea level rise events, as well. During the last interglacial period, melting of Greenland's ice sheets likely resulted in a sea level rise of two to four meters (Jansen et al., 2007). Evidence exists that sea level during this time was four to six meters higher than present, so melting of Antarctica's ice sheets may have contributed to sea level rise as well (Scherer et al., 1998; Overpeck et al., 2006; both as cited in Jansen et al., 2007, p. 459). Current studies conducted over the past several years, though producing wide variations in estimates of ice loss from these areas, have led to an overall conclusion that melting of Greenland and Antarctic ice sheets have likely contributed to present sea level rise for the period of 1993-2003, if not longer (Lemke et al., 2007).

Gauging changes in precipitation trends is difficult due to regional variability as well as data gaps and limitations (Huntington, 2006, as cited in Trenberth et al., 2007, p. 265). Precipitation trends were calculated using Global Historical Climatology Network station data (from the National Climatic Data Center) in the IPCC's Fourth Assessment Report. Between 1900 and 2005, the

data show increases in annual precipitation trends for most of North America, regions of South America including the Amazon Basin, northwestern India (although a negative trend was reported for 1979-2005), and most of Eurasia. Negative annual precipitation trends were reported for the American Southwest and parts of Mexico, Chile and the western coast of the South American continent, Western Africa as well as Africa's Sahel region (Trenberth et al., 2007).

Several weather patterns have also been observed to change in the recent past. A drying trend has been observed for Northern Hemisphere land masses since the 1950s, brought on by decreases in land precipitation and warming of Earth's surface (Dai et al., 2004, as cited in Trenberth et al., 2007, p. 260). Additionally, there have been increases in the occurrence of heavy precipitation events over many land areas. This has been observed for parts of the Mediterranean region, South Africa, parts of Mexico, Japan and the northeastern United States. Although the occurrence of heavy precipitation events is increasing in these areas, annual precipitation and in some cases the number of days with perceivable precipitation have remained static or declined (Alpert et al., 2002; Brunetti et al., 2004; Maheras et al., 2004; Easterling et al., 2000; Fauchereau et al., 2003; Sun & Groisman, 2004; Groisman et al., 2005; as cited in Trenberth et al., 2007, p. 302) The number of colder days and nights appear to be declining, while the occurrence of hotter days and nights is increasing (Alexander et al., 2006, as cited in Trenberth et al., 2007, p. 309). Mixed evidence exists for trends in tropical cyclone activity. Potential Intensity (PI) of tropical storms can

be measured by analyzing vertical profiles of temperature and humidity, and studies have found increases of PI in the last several decades, although authoritative results are not possible due to data contamination (Emanual, 2003; Gettelman et al., 2002; Sherwood et al., 2005; Randel & Wu 2006; as cited in Trenberth et al., 2007, p. 304). Webster et al.(2005, 2006; both as cited in Trenberth et al., 2007, p. 305) found a global increase in the number and total proportion of hurricanes reaching Category 4 and 5 status since 1970, even as the total number of tropical cyclones declined in many regions of the world's oceans.

Through a variety of modeled simulations, the IPCC has concluded that global temperatures will rise by approximately 2-4° C by 2100 (Meehl et al., 2007). Snow and ice mass cover as well as sea ice extent are predicted to shrink. It is also "very likely" that the occurrence hot extreme temperatures, heat waves and heavy precipitation events will increase. These predicted trends become all the more alarming due to the persistence of CO_2 and other greenhouse gases in the atmosphere. Even with a serious worldwide effort to reduce the levels of emitted anthropogenic greenhouse gases, emissions (and temperatures) will likely continue to rise even if dramatic reduction plans are put into motion. It has been estimated that 50% of a future increase in atmospheric CO_2 concentration will remain in the atmosphere for thirty years, another 30% will be removed within a few hundred years, and the final 20% may remain in the atmosphere for several millennia (Prentice et al., 2001; Archer, 2005; as cited in Denman et al., 2007, p. 514). These projections heighten the urgency of reducing greenhouse gas emissions and preparing to mitigate and adapt to future climate change.

Global Effects

The level of consistency between modeled and observed changes has allowed scientists to state with increasing confidence that anthropogenic warming in the past several decades has affected many of the planet's physical and biological systems. Impacts on this level could lead to drastic alterations in ecosystem structure and function. The effects of future changes in Earth's climate will vary across the globe and many of the planet's natural systems will be affected, though some more severely than others.

Terrestrial and aquatic systems may undergo several changes if the current rate of warming continues into the future. River flows will be altered, though the effect will vary by region. Model results from the IPCC indicate that under one scenario, runoff in the higher latitudes of North American and the Eurasian landmasses increased by a range of 10-40%. Regions expected to experience a 10-30% decline in runoff by the year 2050 include the Mediterranean, parts of Africa, northern Mexico and the American west (Milly et al., 2005, as cited in Kundzewicz et al., 2007, p. 183). As glaciers and snow cover decline, the water supplies of people living in regions that depend on mountain meltwater, more than one-sixth of the world's population, will be threatened (Kundzewicz et al., 2007). Net carbon uptake by terrestrial ecosystems may weaken or even reverse, which could exacerbate anthropogenic climate change (Fischlin et al., 2007). Of the plant and animal species that have been studied thus far, the IPCC estimates that 20-30% are likely to be at increased risk

of extinction if the global average temperature increases by more than 2-3° C over preindustrial levels (Fischlin et al., 2007).

Productivity of staple crops is expected to increase in the mid- to high latitudes with a temperature increase between 1-3° C, so long as water and nutrients are available. Beyond this threshold, declines in productivity may occur. In the lower latitudes, productivity of staple crops is projected to decrease for even mild temperature increases (Easterling et al., 2007). This could increase the risk of hunger in areas where food supplies are already stressed. For the entire planet, food production capacity is expected to increase with local temperature increases of 1-3° C, but decrease beyond this threshold (Easterling et al., 2007).

Marine systems and environs are expected to experience increased risks in the future, including coastal erosion (Brown & McLachlan, 2002, as cited in Nicholls et al., 2007, p. 324). Additionally, warming-induced changes to natural systems will threaten aquaculture and fisheries (Easterling et al., 2007). Coral systems are similarly affected, and are projected to face increased threats associated with higher water temperatures, including bleaching (Hoegh-Guldberg, 1999; 2004; Donner et al., 2005; as cited in Nicholls et al., 2007, p. 321). Future climate impacts have also been modeled for coastal wetlands, with the results indicating that losses to ecosystems such as salt marshes and mangrove forests will occur as sea level rises (McFadden et al., 2007a; as cited in Nicholls et al., 2007, p. 328). This is important to note due to the importance of these systems as storm buffers and centers of high biological productivity. A decline in protective

vegetation combined with sea level rise is expected to place millions more people at risk of flooding by the 2080s (Nicholls et al., 2007).

Climate change will continue to affect human health, especially in regions with low adaptive capacity that do not have the resources to provide adequate medical care (Confalonieri et al., 2007). Future projections suggest that increased global temperatures may cause disease vectors to spread, although this factor depends on a given region's adaptation to disease. It is also expected that deaths and injury attributed to heat exposure will increase (Confalonieri et al., 2007). Although health effects will vary globally as global temperature continues to increase, overall threats to human health will persist in the poorer regions of the world until these areas experience growth and development and the societal coping mechanisms that will help reduce the incidence of climate change related illness and mortality (Confalonieri et al., 2007).

In summary, projected impacts of climate change include sea level rise, species extinction, declines in crop production and water availability, and increases in infectious disease and extreme weather events, among others. These impacts are already being felt worldwide, to varying extents. Many areas will experience similar problems, though the extent and impacts will vary depending on the adaptive capacity and conditions of a given region. It is clear, however, that the projected impacts of climate change are serious and warrant immediate attention in the policy arena.

Local Effects

Several studies have examined the effects of climate change on the Pacific Northwest. Not surprisingly, these are similar to those already occurring and projected to occur all over the world. The warming rate of the Puget Sound region during the 20th century was higher than the global average. Loss of snowpack and glaciers in the Pacific Northwest has been attributed to increased temperatures, and this will only continue in the future (Palmer, 2007). A study of nine North Cascade glaciers revealed a loss of 13-14% of glacial thickness between 1984 and 2007, an amount that represents 20-40% of the volume of these glaciers (North Cascade Glacier Climate Project, 2008). Recent mountain snowpack losses in the North Cascades are among the largest recorded in the Western United States (Ecology 2006, p. 20). Additionally, the South Cascade Glacier lost half of its volume between 1928 and 2003 (Josberger et al., 2006).

Snowpack and freshwater supplies are also expected to be impacted by precipitation shifts. More precipitation will fall as rain instead of snow in higher elevations, and spring melt will occur earlier in the year (Miles & Lettenmaier, 2007). Climate change is projected to increase winter flows and reduce summer flows in snowmelt influenced river systems (Palmer, 2007). Since 1948, declining snow storage has resulted in an 18% decrease of the proportion of annual river flow to Puget Sound in summer months (Mote et. al., 2005, as cited in Washington State Department of Ecology [Ecology], 2006, p. 20). Because glacial melt helps maintain river and stream flows during drier summer months, downstream water availability during the drier summer season will decrease

(Casola et al., 2005, as cited in Ecology, 2006, p. 20). Changes in annual river flow in Washington State will also alter hydropower production. Higher winter flows are projected to result in increased hydropower production ability in the winter, but lower summer flows will have the opposite effect. Higher demand for electricity during summer months compounds the problem (Miles & Lettenmaier, 2007).

Climate change will also affect the frequency of extreme weather events in the Pacific Northwest. Droughts are projected to become more frequent throughout the Pacific Northwest, and more flood events are projected for Western Washington (Palmer, 2007). Heat waves become more frequent with rising temperatures, with the greatest effects being felt by areas with milder summer climates, less air conditioning, and higher population density, conditions that describe many of Washington's major cities (Palmer, 2007).

In addition to higher air temperatures, projected increases in the temperature of streams, rivers and lakes in the Puget Sound region may pose threats to coldwater fish species such as trout and salmon, which are important both economically and as defining cultural symbols of the Pacific Northwest. Overall, climate change contributes to aquatic conditions that are known to be detrimental to most species of salmonids found in the Puget Sound region (Palmer, 2007).

Climate change may also be contributing to an increased occurrence of wildfires in the forests of the American West. While land use activities such as fire suppression also increase the risk of wildfires by fostering an accumulation of

biomass in forests, climate-influenced variables such as temperature, spring snowmelt timing and drought occurrence also contribute to wildfire frequency (Westerling et al., 2006). The relationship between wildfire activity and climatic conditions is present in historical and current records and is "particularly strong since 1977," (Miles & Lettenmaier, 2007). Westerling et al. found that wildfires in the Western United States have increased since the mid 1980s, both in frequency and amount of forested land burned. The greatest increases in wildfire frequency have occurred in the Northern Rockies, where the history of land use has less impact on fire risk, and wildfire frequency is more strongly associated with climatic variations (2006). As more forested land burns in the future and wildfire frequency continues to increase, more carbon is added to the atmosphere, which could trigger a positive feedback that further increases the amount of forested land burned in wildfires (Running, 2006).

Climate change is also expected to have impacts on Washington's agricultural production, though the effects will vary by crop type and also by agricultural methods (i.e. dryland versus irrigated agriculture) (Miles & Lettenmaier, 2007). The yield and quality of some crops is projected to decline, although increases in the concentration of atmospheric CO_2 could mitigate some of this impact if water supplies are available (Miles & Lettenmaier, 2007). Water supplies are expected to decline in some irrigated regions, such as the Yakima Basin (Scott et al., 2006, as cited in Ecology, 2006, p. 50). Additionally, increasing temperatures will reduce soil moisture content overall. Dryland agriculture will be affected by longer growing seasons, decreasing summer

precipitation and increased competition from weeds. A longer frost-free season may result in increased crop losses to pests (Ecology, 2006, p. 22). Overall, disease will become a larger problem (Miles & Lettenmaier, 2007).

The effects of climate change are not limited only to land surfaces, however. As with many other areas of the planet, sea level rise is expected to affect Washington's coastlines in the future. According to the Washington State Department of Ecology, some of the most densely populated coastlines of Puget Sound are experiencing the fastest rates of sea level rise and Washington's outer coast is also vulnerable to storm surges and increased wave heights associated with rising sea level (Ecology 2006, p. 24).

A 2008 report from the University of Washington's Climate Impacts Group reviewed projections of the influence of varying factors on sea level rise, and estimated future sea level rise for Washington's coasts for the years 2050 and 2100. Sea level will not rise by the same amount or at the same rate at all locations (Mote et al., 2008). The report provided low, medium, and high estimates, as shown below in Table 1. These and other predictions suggest that sea level rise will continue to present challenges and threats to human and natural systems.

The Climate Impacts Group prepared another report in 2007 that described the threats of sea level rise to Olympia, Tacoma and Seattle. The downtown areas of Olympia and Seattle and Tacoma's port district are at risk from an overall rise in sea level, although episodic flooding poses a greater threat than inundation. Beach erosion is projected to intensify and landslides are expected to become

Table 1. Sea level rise predictions for Washington State, 2050 and 2100. Mote et al., 2008. Negative values indicate a drop in sea level.

Sea Level Rise Estimate	2050			2100		
	NW Olympic Peninsula	Central & South Coast	Puget Sound	NW Olympic Peninsula	Central and Southern Coast	Puget Sound
Very Low	-12 cm	3 cm	8 cm	-24 cm	6 cm	16 cm
Medium	0 cm	12.5 cm	15 cm	4 cm	29 cm	34 cm
Very High	35 cm	45 cm	55 cm	88 cm	108 cm	128 cm

more frequent. As water levels rise, near shore marine species are expected to be negatively impacted, and rising water temperatures may also increase incidence of disease and the spread of exotic species (Miles & Lettenmaier, 2007).

In addition to its effects on natural systems, climate change is expected to increasingly impact human health as well. Heat wave intensity and frequency have increased in recent decades and incidence of heat-related deaths also seem to be rising (Ecology 2006, p. 60). As ambient concentrations of ozone and fine particulate matter increase with rising temperatures, health risks include lung cancer, asthma and cardiovascular disease. Increased temperatures may also contribute to the advanced spread of communicable disease (Miles & Lettenmaier, 2007). Indeed, the state is already spending money on West Nile Virus surveillance and the first case was reported in Washington in 2006 (http://www.doh.wa.gov/publicat/2006_news/06-143.htm).

All of the local, regional and global effects of climate change that are already taking place and will continue to occur in the future highlight the pressing

need to reduce global greenhouse gas emissions to mitigate against the threats of a continually warming climate. However, even if society could stabilize greenhouse gas emissions in the next several years, the inertia of the climate system would still cause changes in Washington's biological and physical systems. In addition, financial costs will be associated with climate change in several areas, including but not limited to fire preparedness and response, lost timber revenues and recreational income, and water conservation expenditures (Ecology 2006, p. 8).

Uncertainty

The study and interpretation of both natural and anthropogenic climate change also includes some uncertainties. Anthony Patt describes two types of uncertainty pertaining to climate change: gaps in knowledge and expert disagreement (Patt, 2006). Additionally, media portrayal of climate change can create confusion among the general public, depending on how information on climate change is delivered. Climate change science contains several unknown elements that make predictions about future changes and impacts the targets of skepticism and denial. Differing predictions by experts can be exploited by climate change opponents, resulting in increased confusion among non-scientists and delayed attempts at climate change mitigation and adaptation. Assessing the risks of climate change is more difficult than other risk analysis because the situation is characterized by high risks and high uncertainty (Schenk & Lensink, 2007).

Several components and observations in climate science bring uncertainty to the issue of climate change. For example, the magnitude of the cooling effect of clouds on Earth's atmosphere remains uncertain in radiative forcing (Forster et al., 2007) and uncertainties are also associated with tracking variables that affect precipitation changes (Huntington, 2006, as cited in Trenberth et al., 2007, p. 265). Antarctic sea ice extent exhibits variability over time but no clear pattern (Fichefet et al., 2003; as cited in Lemke et al, 2007, p. 354), and uncertainties exist when analyzing tropical cyclone trends (Trenberth et al., 2007). Uncertainties in the climate-carbon cycle feedback are not represented in climate change models, allowing their results to be brought into question (Meehl et al., 2007). Fortunately, each successive generation of climate models is better able to characterize physical processes than the last, partially due to continual improvements in computer technology, allowing for more variables to be included and future climate simulations to be run for longer intervals (Le Treut et al., 2007).

It is also difficult to simulate climatic changes on small scales, as natural climate variability is larger at this level (Randall et al., 2007). Some climate forcing mechanisms are omitted from models, and uncertainty still exists in the treatment of these forcings in those models in which they are included (Hegerl et al., 2007). Fortunately, models that operate on a smaller scale are constantly becoming more sophisticated, again with credit due to advancing computer technology (Le Treut et al., 2007).

Debate among experts also has the potential to add to the uncertainty surrounding climate change. Mann et al. first published a temperature reconstruction in 1998 that exhibited a hockey stick shape, with 20th century temperatures appearing higher than any of the previous 2000 years. Their data has been widely applied and even appeared in the IPCC's Third Assessment Report in 2001, though it subsequently came under criticism, perhaps most notably during a series of interchanges between the authors of the original study and responses written by McIntyre and McKitrick (McIntyre & McKitrick, 2005; Moberg et al., 2005).

McIntyre and McKitrick allege that an unusual data transformation that had not been reported by the authors had "mined the data" for hockey stick patterns. They concluded that the shape of the resulting temperature graph was one of "spurious significance," (McIntyre & McKitrick, 2005). The two groups debated each other in the literature although eventually the National Research Council stepped in and decided that Mann's predictions of temperature increases in the 20th century were credible (Committee on Surface Temperature Reconstructions for the Last 2,000 Years, Board on Atmospheric Sciences and Climate, Division of Earth and Life Studies, National Research Council, 2006, p. 4). The inclusion of Mann's study in the Third Assessment Report, even though it was eventually found to contain plausible conclusions, could detract from the trust held in the IPCC as a global authority on climate change as a result of misunderstanding by the general public. This could provide ammunition to those

with a corporate stake in keeping the status quo (or to anyone with such an agenda) to challenge the validity of subsequent documents published by the IPCC.

Global media outlets also have a hand in contributing to the uncertainty and confusion surrounding climate change. A survey of newspaper articles that contained stories about scientific claims regarding climate change revealed some trends in newspaper reporting that amplify climate change controversy. Nearly one-third of the material was framed with ambiguity, uncertainty and controversy in a manner that the author hypothesizes would cause confusion among newspaper readers, almost 150 million Americans (Antilla, 2005).

Newspaper articles were found guilty of "bias through balance" where scientific information defending the validity climate change was countered by the inclusion of opposing viewpoints from other scientists. The study revealed instances where misleading titles were used in articles dealing with climate change and cases where the language pertaining to what is known about climate change was altered to amplify the level of uncertainty in climate science. There was also language present in press reports that perpetuates the myth that a consensus on climate change has not been reached (Antilla, 2005).

Antilla notes that in some cases, testimony was given by "corporate scientists" with ties to the fossil fuel industry, and that climate change skeptics were often used as the primary sources of climate change information. The author also discusses the effect of corporations that provide financial backing to political allies in order to undermine the validity of climate science (Antilla, 2005).

A large body of evidence indicates that climate change is real and that human activity is involved. The effect of all of the uncertainty, controversy and debate regarding climate change is to threaten future efforts to adapt to and mitigate the effects that are with increasing certainty projected to impact human society at a global scale. Direct and timely action is necessary in order to prepare for future changes in Earth's systems as well as those changes that we are already experiencing.

Chapter 2. Past, Present and Future Mitigation

Introduction

In order to deal with the massive threats associated with anthropogenic climate change, several mitigation and adaptation strategies have been developed around the world. Mitigation refers to the reduction of greenhouse gas emissions while adaptation reduces the vulnerability of human systems to the effects of climate change. These two approaches may involve changes in technology, behavior and global policy. The best global strategy may indeed involve a combination of mitigation and adaptation (Klein et al., 2007), because no mitigation efforts will prevent the effects of a changing climate over the coming decades (Christensen et al., 2007; Meehl et al., 2007; both as cited in Klein et al., 2007, p. 748). Mitigation efforts in the next several years will however have a great impact on society's ability to achieve lower levels of GHG emissions stabilization (Fisher et al., 2007).

Adaptation and mitigation may be appropriate for differing scenarios, as reported by Settle et al. (2007). His research team concluded that adaptation may be a more suitable policy option when countries do not cooperate in lowering greenhouse gas emissions and when damage brought on by climate change is more sporadic in nature. Mitigation, they continue, is a better strategy if in the future, countries cooperate to reduce emissions and experience continuous damage from climate change (Settle et al., 2007). With several different sources calling for reducing current greenhouse gas emissions by as much as 70% by

2050 to avoid the worst climate impacts, it becomes clear that human societies must seek to implement both adaptation and mitigation strategies without delay (Mathews, 2007).

The pace and scale of global efforts to facilitate necessary technical, political and behavioral changes will greatly impact the extent to which climate change will affect Earth in the future. Avoidance of the worst predicted impacts of climate change—assuming great strides are made in both adaptation and emissions reductions—will not only save millions of lives and help keep the integrity of Earth's natural systems intact, it will put human society on the path to greater global sustainability. While many attest that society currently possesses all the technological know-how to effectively deal with the problem of climate change, what is done with this knowledge will determine the future of Earth's natural and human systems (Mathews, 2007; Pacala & Socolow, 2004).

Mitigation Strategies

Technological Strategies

A suite of technological strategies exists to advance global mitigation and adaptation to future climate change. While future innovations such as the complete development of a renewable energy based hydrogen economy and effective capture and sequestration of CO_2 emissions may be effective in reducing the effects brought on by climate change, there is no need to wait until these practices become well-established to begin working to reduce global emissions. Many future strategies will rely on methods that reduce CO_2 emissions, as this is

the dominant anthropogenic greenhouse gas. Reducing CO_2 emissions will require changes in a multitude of human systems.

Energy Supply

Perhaps the sector that could have the most pronounced effect on global GHG emissions reduction is energy supply. Several reduction strategies exist here, including changing current sources of energy to renewable and less-polluting sources and improving energy efficiency of end-use applications. There is certainly room for improvement over current energy systems. In 2004, coal provided 74% of China's electricity production and currently comprises over half of the United States' energy supply (Cherni & Kentish, 2007, http://www.energy.gov/energysources/coal.htm). Given that coal production emits a significant amount of GHGs (combustion of one ton of coal generates nearly three tons of CO_2) and that China and the United States are the world's two biggest sources of anthropogenic greenhouse gases, great emissions reduction potential lies in the promotion of renewable energy sources in these countries (Cherni & Kentish, 2007; Hong & Slatick, 1994). Examples of renewable energy include but are not limited to wind, solar and biomass power. Renewable energy must be included in future climate change mitigation strategies in order for these programs to be successful. Indeed, Byrne et al. (2007) attest that "rapid increases in the use of energy efficiency and renewable energy will be critical to a successful global response to climate change".

Shifts such as these are already evident. Renewables make up 25% of California's new installed capacity and 33%, 50% and 75% of current energy supply in Sweden, Norway and Iceland, respectively (Mathews, 2007). According to the American Wind Energy Association, in the fourth quarter of 2007 wind energy was generating nearly 17,000 megawatts of electricity, with enough projects under construction to add another 3,600 megawatts to the current generating capacity (http://www.awea.org/projects/). In 2006, solar power was providing 120 MW-dc of electricity (http://www.seia.org/Year_in_Solar_2006.pdf), or 92 MW after the electricity is converted to AC (http://rredc.nrel.gov/solar/codes_algs/PVWATTS/system.html). Biofuels are more controversial than wind, solar and other forms of renewable energy. Their impact on greenhouse gas emissions depends largely on production methods. When undisturbed land is converted in order to grow biofuels, or to grow crops displaced from other areas by biofuel production, CO_2 is released. It may take decades for that land to generate enough biofuels to balance out these CO_2 emissions. Producing biofuels by planting native plants on degraded or abandoned agricultural land results in relatively lower levels of CO_2 emissions (Fargione et al., 2008).

Given current energy trends, it becomes quite obvious that new sources of energy and increasing energy efficiency of current operations will become crucial to solving the climate problem, as evidenced by a study of current energy use in Japan's Shiga Prefecture. It showed that increases in energy intensity improvement and decreases in carbon intensity must be 200-300% greater than

the previous 40 year period in order to achieve a 60-80% reduction in CO_2 emissions (Shimada et al., 2007). Promoting the use of renewable energy and energy efficiency will make great strides in reducing carbon intensity and overall GHG emissions.

Transportation

Another area that holds great greenhouse gas mitigation potential is the transportation sector. It is also important to note that reducing automobile emissions has benefits beyond climate change mitigation; burning less fossil fuels and driving less overall reduces air pollution and leads to improvements in general health. Potential improvements in the transportation sector include using more fuel-efficient vehicles (including standard hybrid-electric and plug-in hybrid-electric vehicles), alternative sources of fuel and increasing the prevalence of both public transportation and non-motorized transportation, such as walking or biking. Increasing fuel efficiency standards for vehicles or switching to smaller, lighter vehicles can reduce the output of GHGs from the transportation sector, though consumer vehicle preferences play a role in the potential of this mitigation strategy; smaller, fuel efficient cars will do little to mitigate greenhouse gas emissions if they do not displace larger vehicles (http://www.wbcsd.org/plug ins/DocSearch/details.asp?type=DocDet&ObjectId=6094).

In 2007, President Bush signed the Energy Independence and Security Act of 2007, which set a national fuel efficiency standard of 35 miles per gallon for automobiles by the year 2020 (http://www.whitehouse.gov/news/releases/2007/

12/20071219-1.html). Previously, Corporate Average Fuel Economy (CAFE) standards had been set at 27.5 miles per gallon for passenger vehicles since 1990, with large passenger vehicles (greater than 8,500 lbs gross weight) being exempt from meeting fuel economy standards (http://www.nhtsa.dot.gov/CARS/rules/CAFE/overview.htm). Lobbying government agencies and automakers to take serious strides in making more fuel efficient vehicles and more stringent regulations of fuel economy can continue to help realize greater CO_2 emissions reductions from this sector.

Alternative fuels are another option in the technological mitigation toolkit, although concerns exist regarding production methods and displacement of agricultural land dedicated to growing food crops. Biofuels can be produced via methods that minimize the release of CO_2 from cropland (Fargione et al., 2008). Additionally, biofuels made from crop residues (i.e. corn stalks) do not directly interfere with food production. Grasses are a potential source of biofuels, and can be grown on land unsuited for agriculture and require less energy to produce, resulting in the emission of less greenhouse gases during production (IEA, 2006a, as cited in Kahn Ribiero et al., 2007, p. 342).

Hydrogen has the potential to become a more widely used energy source and a means of climate change mitigation in the next several decades as long as it is produced cleanly and has a viable infrastructure system for distribution. In the United States, the current administration's policy on this issue relies largely on fossil fuels to produce hydrogen. More funding for hydrogen development and a shift in the energy used to produce hydrogen could help this technology become a

better mitigation strategy (Byrne et al., 2007). Hydrogen fuel cell technology has made advances in recent years, in terms of durability, increased operation distance and a reduction in costs (Murakami & Uchibori, 2006, as cited in Kahn Ribiero et al., 2007, p. 345).

The aviation sector can also reduce greenhouse gas emissions in the future through the development of more fuel-efficient airplanes as well as altering the ways air traffic is managed. Currently, there are no fuel efficiency standards imposed on the aviation sector (Kahn Ribiero et al., 2007). Alterations to the overall designs and materials used in modern aircraft could result in greater fuel efficiency for the aviation sector (Kahn Ribiero et al., 2007). In addition, reducing the vertical cushion that is currently mandated to maintain a safe distance between aircraft from 2,000 to 1,000 feet could result in more planes flying at optimum altitudes and reduced fuel usage (Kahn Ribiero et al., 2007).

In addition to technology that can reduce transport sector emissions, changing transportation patterns may have some benefits, as well. Increasing the use of mass transportation systems, including bus and rail lines, mass marine transport and carpooling removes vehicles from the road and generally reduces overall greenhouse gas emissions (Kahn Ribiero et al., 2007). Creating and making alterations to communities to make them more conducive to non-motorized transport will help meet this goal, as well. Non-motorized activities are influenced by the character of surrounding development. Planning for "walkable" communities and installing bike lanes on roadways provides an opportunity to reduce greenhouse gas emissions associated with personal vehicle usage. The

density and land use patterns of communities determine what transportation systems are available; the residents of denser communities are not as reliant on personal vehicles. Coupling development with transport systems is paramount to increasing the use of both mass and non-motorized transit (Kahn Ribiero et al., 2007). Along with reducing overall greenhouse gas emissions, reducing pollution associated with traffic has other benefits including improved air quality, heightened energy security and reduced traffic congestion (Kahn Ribiero et al., 2007).

Buildings

A major area where greenhouse gas mitigation is possible is in new and existing buildings. Measures here include utilizing new technology to create more energy-efficient buildings and retrofitting existing buildings to use less energy. The Clinton Climate Initiative recognizes that cities emit 75% of greenhouse gases while only comprising 2% of total land area, and have targeted building efficiency upgrades as a means of mitigating future climate change (http://www.clintonfoundation.org/cf-pgm-cci-home.htm). Globally, barriers to the implementation of building efficiency programs include lack of financing and availability of energy efficient technology (Reddy, 1991; Brown et al., 1991; both as cited in Levine et al., 2007, p. 421), but the IPCC estimates that by 2030, 30% or more of projected greenhouse gas emissions could be avoided in a cost-effective manner by working toward greater building efficiency (Levine et al., 2007).

One method of realizing greenhouse gas reductions is through the construction of buildings that meet or exceed Leadership in Energy and Environmental Design (LEED) standards. A rating system designed by the United States Green Building Council (USGBC), the program rates building based on five components: "sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality." Currently, LEED-certified buildings are being constructed worldwide (http://www.usgbc .org/DisplayPage.aspx?CMSPageID=222).

Industry

Similar solutions are available in the industrial sector. For energy-intensive industry, upgrading technology to make operations as efficient as possible, and making these types of installations standard for all new construction projects will help to reduce GHG emissions associated with this sector (Bernstein et al., 2007). The use of renewable energy and instituting materials recycling programs may also reduce GHG emissions associated with industrial production. Like many other sectors, there are barriers to implementing these strategies in the industrial sector. Demand for greenhouse gas mitigation is not present in all parts of the world, and financial limitations discourage some companies from adopting new technology, despite the likelihood of payoffs in the long run (Canepa & Stoneman, 2004, as cited in Bernstein et al., 2007, p. 476).

Agriculture and Forestry

Another significant area where technological solutions can help reduce greenhouse gas emissions is the agricultural sector, including forestry. Different agricultural systems will have varied greenhouse gas mitigation potential (Smith et al., 2007). Improving grazing and crop land management by altering current practices can reduce greenhouse gas emissions from agricultural lands. Restoring degraded agriculture and livestock lands will have similar benefits. Reducing the amount of fossil fuels associated with crop harvest and the provision of feed stocks is another strategy of reducing greenhouse gas emissions from the agriculture sector (Smith et al., 2007).

Tropical forests are currently being destroyed at a rate of 1-2% annually. Burning of forest products and removing a potential carbon sink increase atmospheric concentrations of greenhouse gases (Mathews, 2007). Substantial greenhouse gas mitigation potential lies in reducing global rates of deforestation. Methods include the cessation of old-growth harvesting in tropical forests, reforesting logged areas in temperate and tropical forest systems and the establishment of tree plantations on other nonforested lands (Pacala & Socolow, 2004). Providing financial incentives for countries with forest resources could reduce deforestation worldwide (Mathews, 2007).

It is clear that global societies have many options when constructing climate change mitigation programs. A great deal of reduction potential lies in technologies and practices that currently exist, although there are many barriers to the implementation of mitigation strategies. These include, but are not limited to,

financial constraints and limits to the dissemination of information and technology. Social pressure and political will are also pieces of the mitigation puzzle that must be present if meaningful action against climate change is to occur on a spatial and temporal scale that will result in a more favorable future climate.

Societal Changes

Lifestyle Changes

Along with technologies that can help reduce global GHG emissions, changes in the ways people live their lives can make strides toward successfully combating climate change. The American public is currently in favor of mitigating climate change; in 2001 over 90% expressed support for renewable energy, 59% supported higher gasoline taxes if it would lessen climate change and 83% believed the federal government should show more leadership on the issue of climate change (Byrne et al., 2007).

Changes in lifestyle and consumption patterns that increase resource conservation can aid in the development of a low-carbon economy. Addressing per capita resource consumption may in fact be critical to avoiding the most intense deleterious effects of future climate change. In a study of future emissions reduction efforts of Japan's Shiga Prefecture, Shimada et al. note that technical measures alone will not allow full reduction potential to be met; addressing the area's socio-economic structure is almost as important (2007).

In order to help citizens worldwide adopt less GHG-intensive lifestyles, environmental education will have to play a large role in future GHG reduction strategies. Although the vast majority of Americans support more action in response to climate change, a case study conducted at Penn State University in 2001 reveals that graduates of the university know little regarding their "ecological identities"; forty percent of graduating seniors could not estimate global population to the nearest billion, and over 70% could not identify main geological features of the region surrounding the university they had attended (Uhl & Anderson, 2001).

The authors also hypothesized that the immense amount of materials consumed on college campuses may suggest to students that the Earth can always supply society with its needs, and the amount of waste produced by universities suggests that there is no need for recycling. The authors believe that a lack of so-called "ecological literacy" is a problem at most universities, underscoring the need for increased environmental education in order to produce more educated citizens that are concerned about overall planetary sustainability (Uhl & Anderson, 2001). As such, increased environmental awareness should be included in future campaigns and initiatives that address climate change.

As environmental awareness increases, global citizens may begin to adopt more sustainable and carbon-neutral lifestyles. Education can help grow markets for energy efficiency and its use in product and building design. Altered thinking patterns may change the relationship that humans have with the automobile; a more informed citizenry may opt for more efficient cars and/or drive less overall.

These are just a few examples of the benefits of creating an environmentally aware society. The ultimate goal is a healthier relationship between people and the Earth that ensures that abundant resources and a clean environment will be available for use by future generations.

Political Action

International Efforts

Much work has been done over the past several decades to lessen the effects of global climate change on human societies. Global conferences have been held, laws and agreements have been drafted, and scores of books and documentaries have addressed virtually every known aspect of climate change. There are many schools of thought as to which policies provide the best opportunities to deal with climate change in a timely and effective manner. Carbon taxation, mandatory emissions controls and voluntary cap and trade programs are only some examples of the myriad political strategies that have been introduced in the name of reducing the threats of future climate change.

Over the years several global conferences have been held to discuss the issues surrounding climate change, and there are currently two global frameworks that address climate change mitigation. The first is known as the United Nations Framework Convention on Climate Change, or UNFCCC. This was a product of the 1992 Rio de Janeiro Earth Summit Convention (Mathews, 2007). The convention called for governments to regularly compile and publish information about their greenhouse gas emissions and reduction efforts, work toward reducing

emissions within their borders and cooperate with other countries with respect to climate change adaptation efforts. The convention was ratified by 192 countries and went into effect in 1994 (http://unfccc.int/essential_background/convention/items/2627.php).

The UNFCCC, as a starting point, did not provide legally binding statutes or emissions reduction targets, although it did include a provision for further "updates" that could set mandatory GHG reduction goals. The Kyoto Protocol, a more well-known global climate change initiative, was spawned from the UNFCCC in 1997, where it was developed during the Kyoto Conference (Mathews, 2007). Though emissions reduction targets varied from country to country, the Protocol called for an overall 5% reduction in global GHG emissions below 1990 levels by 2012, and gave flexibility in the ways countries could reduce their GHG emissions and allowed for an international "cap and trade" system (http://unfccc.int/kyoto_protocol/items/2830.php; Mathews, 2007). Countries could increase carbon sinks, such as forests, or finance foreign projects that reduce GHG emissions (http://unfccc.int/kyoto_protocol/items/2830.php). Several criticisms have been directed at the Kyoto Protocol, among them the exclusion of developing nations from regulation, and questions regarding how significant of a difference the reduction targets could make in reducing threats associated with climate change (Mathews, 2007). Although the Protocol may not have been as stringent as its critics would have liked, it represented a real step forward in working to reduce global GHG emissions.

The Protocol was opened for signature in 2002 and went into effect in 2005, though the United States refused to sign due to the exclusion of developing countries from the Protocol's authority. Although nearly all industrialized countries signed the Protocol, many countries did not, including the United States and China. In 2000, these two countries were responsible for more than one-third of global GHG emissions (Baumert et al., 2005). Ultimately, time will tell the extent to which the Kyoto Protocol is able to have a pronounced impact on global climate change, though the exercise of bringing many nations to the table to discuss climate change mitigation may have a positive impact on similar future conventions.

In 2007, representatives from 180 countries gathered in Bali for a United Nations Climate Change Conference. The conference sought to continue developing climate solutions through global partnership, resulting in the adoption of "the Bali Roadmap, which consists of a number of forward-looking decisions that represent the various tracks that are essential to reaching a secure climate future." The Roadmap also included a plan to develop a negotiation process by 2009 (http://unfccc.int/meetings/cop_13/items/4049.php).

Climate Action in the United States

Although the United States failed to ratify the Kyoto Protocol, much work has been done at the national, regional, state and local levels. The EPA lists several voluntary federal strategies that have created partnerships between the federal government and the private sector in the name of combating climate

change. Some of these include the Climate VISION Partnership, which pairs federal agencies such as the Environmental Protection Agency (EPA) and Departments of Energy, Agriculture, Transportation with the oil and gas production, transportation, refining and other industries to work together to reduce emissions. Under the Green Power Partnership, EPA encourages organizations to purchase power derived from cleaner sources with fewer emissions (http://www.epa.gov/climatechange/policy/neartermghgreduction.html). Although these and similar initiatives may help to reduce greenhouse gas emissions, the threats associated with climate change deserve more stringent and direct action.

Perhaps the largest national initiative the United States is pursuing is a strategy to reduce greenhouse gas intensity by 18% by 2012. As defined by EPA, greenhouse gas intensity is "the ratio of greenhouse gas emissions to economic output." This scheme relies on organizations voluntarily providing the government with information on GHG reduction initiatives and may not lower overall emissions if the national economy grows as predicted (Byrne et al., 2007).

Other national policies that could have been signed into law did not survive the legislative review process. The Climate Stewardship Act of 2003, proposed by senators John McCain and Joseph Lieberman, called for a limit on American GHG emissions and the creation of a national trading system. The Act did not pass the Senate although the process showed bipartisan interest in addressing the issue of climate change. In the period of 2005-2006, four bills that would regulate many pollutants and create a CO_2 cap were introduced but did not

pass, although the Senate issued a resolution requesting mandatory control of emissions of those GHGs that would not affect the economy. In 2002, 2003 and 2005 the Senate passed bills that mandated that the United States acquire 10% of its energy from renewable sources by 2020, although no such policies were passed by the House of Representatives and were absent from the President's Energy Policy Act of 2005 (Byrne et al., 2007).

Although the continuing lack of strong federal leadership in climate change mitigation continues to be a source of frustration to those interested in reducing climate change's projected impacts, regional, state and local initiatives that mirror global efforts are springing up in many parts of the United States. In the Northeast, the Conference of New England Governors and Eastern Canadian Premiers created a Climate Change Action Plan in 2001. The plan sets a goal of reducing GHG emissions to 1990 levels by 2010, with further cuts to occur by 2020 (Byrne et al., 2007).

In 2003, the state of New York began a campaign to bring the Northeastern states together to work on reducing GHG emissions. Seven states are currently participating in what became known as the Regional Greenhouse Gas Initiative, and plans are underway to create a multi-state emissions cap and trade program aimed at reducing CO_2 emissions from the region's power plants (http://www.rggi.org/about.htm).

In 2007, five Western states—including Washington—established the Western Climate Initiative. The regional GHG reduction goal, announced in August of that year, is 15% below 2005 levels by 2020, with the

acknowledgement that successful avoidance of climate change's worst projected impacts may take a worldwide GHG reduction effort of 50-85% below current levels by 2050. To this end, several states in the initiative have established ambitious goals for reducing emissions. By 2050, California has set a goal of an 80% reduction below 1990 levels, Oregon is aiming for a more than 75% reduction below 1990 levels and New Mexico hopes to achieve a 75% reduction below 2000 levels. Washington's goal is a 50% reduction below 1990 levels by 2050 (http://www.westernclimateinitiative.org/ewebeditpro/items/O104F 13006.pdf).

By collaborating in regional partnerships and also through independent action, many states have been expressing leadership in GHG emissions reduction. Twenty-four states and Washington, DC have set varying targets for including renewable energy in their energy portfolios. Washington State has set a goal of obtaining 15% of its energy from renewable sources by 2020. A total of twenty-eight states and Puerto Rico have identified GHG emissions reduction goals (Byrne et al., 2007). Among these are some of the more populous states in the nation, including California, New York and Illinois.

The state of Washington has passed several pieces of legislation related to climate change mitigation. In 2007, Governor Christine Gregoire released an executive order entitled Washington Climate Change Challenge, a proclamation of the state's commitment to reducing its contribution to global climate change. Washington set a goal of reducing its GHG emissions 50% below 1990 levels by 2050. Some listed methods of achieving this goal include reducing expenditures

on fuel through the promotion of energy efficiency and constructing more environmentally friendly buildings. The challenge also outlined a plan to pursue all policies and strategies that would ensure that the emissions reduction goals were achieved (http://www.governor.wa.gov/execorders/eo_07-02.pdf).

To these ends, several pieces of legislation have been proposed or passed in Washington State. Engrossed Substitute Bill 6308, passed in February of 2008, directs the Department of Ecology to report on recommendations for the creation of a program to prepare for the effects of continued climate change. The passage of Engrossed Substitute Senate Bill 6001 in May 2007 created a legally binding process for achieving the state's 2050 GHG emissions reduction goal. Engrossed Second Substitute House Bill 1303 encouraged the use of cleaner energy in the public sector. Substitute House Bill 1929 recognized that greenhouse gas offsets and other mitigation projects provide a direct benefit to utility ratepayers, and authorizes utilities to pursue these projects. House Bill 2815, passed in 2008, called for statewide goals to reduce per capita vehicle miles travelled by 2050 in line with Governor Gregoire's Washington Climate Change Challenge. It also calls for a market-based system to reduce greenhouse gas emissions, rules to document greenhouse gas emissions, and the creation of more "green collar" jobs related to clean energy. The passage of Substitute House Bill 3141 in 2004 required new fossil fuel power plants with a generating capacity of 25 MW or greater to mitigate 20% of the CO_2 they emit over a thirty year period. The bill also applied to existing plants that increase CO_2 emissions by 15% or more after July 1, 2004. Under Engrossed Substitute House Bill 1397, passed in 2005, the

State of Washington formally adopted most of California's more stringent vehicle emissions standards. Engrossed Senate Substitute Bill 6508, passed in 2006, called for a range of fuel options for Washington consumers, ranging from zero to 100% renewable content.

After reviewing mitigation efforts coming from regional and state organizations, it becomes apparent that American action on climate change has gotten underway with little input from the federal government. At the lower end of the governmental spectrum, climate change mitigation has also been addressed at the local—city and town—level. On February 16, 2005—the day that the Kyoto Protocol took effect for the 141 signatory countries—Mayor Greg Nickels of Seattle issued a challenge to other American mayors to combat climate change by engaging their communities in reducing GHG emissions (http://www.seattle .gov/mayor/climate/).

In June of 2005, the US Mayors Climate Protection Agreement (MCPA) was passed by the US Conference of Mayors. It called for a 7% reduction of United States GHG emissions below 1990 levels by 2012, the level that the Kyoto Protocol had recommended for the United States. The document also urged the federal government to commit to reducing United States GHG emissions and listed ways that cities could work to achieve the emissions reduction goals laid out by the Agreement (http://www.seattle.gov/mayor/climate/). As of October 2008, 884 mayors representing nearly 81,000,000 citizens had signed the Agreement (http://usmayors.org/climateprotection/ClimateChange.asp).

To date, Seattle has announced great progress with working toward its greenhouse gas reduction goals. According to the 2007-2008 Seattle Climate Action Plan Progress Report, the city's 2005 greenhouse gas emissions were 8% lower than emissions from 1990. The city reports reductions in per capita electricity, water, and natural gas consumption. Reductions are credited in part to conservation efforts and investments in renewable energy, along with offsets provided by the city's utilities provider, Seattle City Light. Future plans include a focus on reducing greenhouse gas emissions in the transportation and the buildings sectors, among other efforts (http://www.seattle.gov/climate/docs/SeaCAP%20Progress%20Report2007.pdf).

America's local jurisdictions have not been alone in their fight against climate change. Various organizations have been working with communities to promote strategies and measures that can help reduce GHG emissions and advance overall sustainability. The International Council for Local Environmental Initiatives (ICLEI) works with cities that have committed to sustainable development. The organization provides technical training and information services in order to advance sustainability at the local level (http://www.iclei.org/index.php?id=global-about-iclei). In Washington, state agencies and utility companies such as Puget Sound Energy (PSE) offer rebates and grants to install new, more efficient technology. Puget Sound Energy also provides grants that assist cities and firms in hiring staff to monitor energy usage in their operations. Under the Energy Efficiency Building Retrofit Program, an offshoot of former President Clinton's Clinton Climate Initiative, cities have

access to funding for use in retrofitting existing buildings to achieve energy savings, typically in the neighborhood of 20-50% (http://www.clintonfoundation .org/110707-nr-cf-cci-pr-wjc-announces-major-partnerships-to-retrofit-public-and-private-buildings-nationwide.htm).

In the United States, federal legislation that mirrors and even exceeds efforts that have been made at the regional, state and local levels is necessary to aid in successful climate change mitigation. Policy creation is largely determined by governmental decision-making, which in turn stems from how the decision makers view their surroundings. Cost-benefit analysis and risk management are also considerations in the political process (Tol & Yohe, 2007). It is possible that in the future, progress made by local and state government may persuade the federal government to take comprehensive action in working to mitigate climate change. The American public is in favor of emissions-reducing strategies such as alternative power sources, and over 80% wish to see more federal leadership when it comes to climate change mitigation (Byrne et al., 2007). Because the United States is the greatest contributor to climate change, it is imperative that its GHG emissions are reduced along with the rest of the world's. Whether the federal government steps in to lead the United States in successfully reducing GHG emissions will help determine what degree of alteration Earth's climate will undergo in the future.

The stringency of the emissions reduction targets needed to avoid the worst impacts of future climate change underscores a need for greater global cooperation and serious mitigation and adaptation efforts at all levels—national,

regional and local. A combination of technology, political will and changes in overall human behavior will be necessary to successfully mitigate the worst predicted effects of global climate change. As previously mentioned, it has been estimated that cuts in global GHG emissions as high as approximately 70% below current levels may be necessary by 2050 in order to avoid the worst of the predicted effects of global climate change. Business-as-usual projections estimate doubled annual carbon emissions of 14 billion tons per year by 2054 if no mitigation action is taken. In order to stabilize atmospheric CO_2 levels at 500 ppm, we as a global society must limit annual carbon emissions to 7 billion tons (Pacala & Socolow, 2004). The news is not all bleak, however; it is estimated that "bottom-up" initiatives could reduce American CO_2 emissions by 65% below baseline projections (Byrne et al., 2007).

The tides may be turning in favor of federal action against climate change; in a recent ruling, the Supreme Court granted EPA the authority to monitor and regulate GHG emissions under the US Clean Air Act (Lifsher & Wilson, 2007). The Senate and House of Representatives are crafting legislation that may ban incandescent light bulbs by 2014 in favor of more energy efficient technology, including compact fluorescent (CFL) and light-emitting diode (LED) products (Fialka & Kranhold, 2007). In July of 2007, Senators Arlen Specter and Jeff Bingaman introduced the Low Carbon Economy Act of 2007, which features a cap and trade emissions reduction plan as well as provisions to assist developing nations in addressing climate change (http://specter.senate.gov/public/index.cfm?

FuseAction=NewsRoom.NewsReleases&ContentRecord_id=05B1466B-1670-48AE-A458-66837A7DB8C6).

Along with the Low Carbon Economy Act of 2007, several cap and trade programs were brought before the 110th Congress as of January 2008. These include, among others, the Lieberman-Warner Climate Security Act of 2008 and the Sanders-Boxer Global Warming Pollution Reduction Act. The bills all define caps on greenhouse gas emissions for three timeframes; 2010-2019, 2020-2029 and 2030-2050, and these caps vary in stringency. For example, the Lieberman-Warner Climate Security Act of 2007 calls for a cap on emissions equivalent to 71% below 2005 levels by the 2030-2050 period, while the Bingaman-Specter Low Carbon Economy Act calls for a cap at 1990 emissions levels by 2030 with provisions for a presidentially declared emissions cap equal to or greater than 60% below 1990 levels by 2050, hinging on international reduction efforts (http://pewclimate.org/docUploads/Cap&TradeChart.pdf). The future success of these or similar bills that address a nationwide cap and trade initiative will determine how effectively the United States is able to reduce its greenhouse gas emissions.

Climate Change Action in Tumwater, Washington

Along with hundreds of other cities in the United States, Tumwater, Washington has begun to take responsibility for its contribution to climate change, even as the federal government remains largely unresponsive. In 2006, Mayor Ralph Osgood signed the US Mayors Climate Protection Agreement and

in 2007, the city became a member of ICLEI, setting forth on a path that will reduce future emissions and enhance the overall sustainability of the community. Through research into current and past GHG emissions as well as best practices for managing future emissions, the city is taking part in a global effort to overcome what many consider to be the greatest environmental challenge in human history.

The central research question of this thesis is whether the City of Tumwater's municipal operations are able to meet the greenhouse gas reduction goals outlined by the United States Mayors Climate Protection Agreement, which would require a 7% reduction below 1990 levels by 2012.

Chapter 3. Quantification and Sources of Greenhouse Gas Emissions in Tumwater, Washington

City Overview

The city of Tumwater, Washington is located at the southern end of Puget Sound, in Thurston County, adjacent to the state capital of Olympia. Incorporated in 1869, the city consisted of approximately 16,000 residents as of February, 2008, and is the oldest permanent American community on Puget Sound (http://www.ci.tumwater.wa.us/History.htm). The city has an area of roughly eleven square miles (http://www.ci.tumwater.wa.us/City%20Departments/General %20Information.pdf).

Creation of a Climate Protection Program

The Climate Protection Program at the City of Tumwater began when City Councilmember Karen Valenzuela initiated conversation about the US Mayors Climate Protection Agreement at a city council meeting in September 2006. Councilmember Valenzuela believed that "in the absence of national policies, it is up to cities and towns to force the hand of the national government and become part of the solution." Her goal was to make climate change mitigation a value of the community (Karen Valenzuela, personal communication).

During the September Council meeting, she suggested that the General Government Committee, which oversees environmental and other issues, consider the US Mayors Climate Protection Agreement. In October of 2006, the General Government Committee met to discuss whether to recommend that Tumwater

sign the Agreement. Members of the community who were present at the meeting expressed support, and the issue was taken to the next City Council meeting on November 6. A public hearing to discuss signing the Agreement and becoming a member of ICLEI was set for December 5. During the hearing, many members of the community offered comments in support of Tumwater taking action against climate change. A resolution was passed for the city to sign the Agreement and become a member of ICLEI. Due to concerns as to the scope of the city's power to reduce emissions, only those emissions associated with city operations were considered part of the reduction efforts, though it was deemed possible for the General Government Committee to discuss expanding emissions reduction efforts to the entire community of Tumwater (Karen Valenzuela, personal communication).

Mayor Ralph Osgood signed the US Mayors Climate Protection Agreement in 2006, and in the early months of 2007, the city kicked off its Climate Protection Program. I was hired as an intern to carry out the process of conducting greenhouse gas audits and finding ways for the city to reduce its municipal greenhouse gas emissions, and Tumwater also became a member of ICLEI. Representatives from ICLEI's Seattle Office, especially Amy Shatzkin, Regional Program Officer for the Pacific Northwest, collaborated with the City of Tumwater on producing greenhouse gas emissions audits and providing materials to help the city identify and quantify emissions reduction efforts.

In order to help cities quantify their greenhouse gas emissions, ICLEI created a Milestone Guide, which provides step-by-step instructions to the

emissions audit process and drafting of comprehensive climate action plans. ICLEI's Milestone Guide outlines the five milestones of the Cities for Climate Protection Campaign that local governments agree to complete within three years of signing on with the organization. They include:

1. Conducting a baseline emissions inventory and forecast of emissions growth
2. Setting an emissions reduction target
3. Developing an action plan to meet the target
4. Implementing actions in the plan
5. Monitoring and verifying emissions reduction progress

ICLEI provides information for both government and community analyses, though it is not required that signatories complete both inventories simultaneously. As previously mentioned, city officials decided to focus on the municipal sector first in order to manage the size of the project and to be able to provide a concrete example for the greater community to follow.

In order to quantify greenhouse gas emissions, Clean Air and Climate Protection (CACP) software was provided to Tumwater after the city became an ICLEI signatory. The software was developed by ICLEI in conjunction with Torrie Smith Associates, The State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO), which is now known as The National Association of Clean Air Agencies (NACAA). Torrie Smith Associates is an environmental consulting firm that works to find sustainable solutions to energy problems. Based in Ottawa, Canada, the firm was founded in 1979 (http://www.torriesmith.com/). The NACAA represents over fifty states and territories and covers more than 160 large metropolitan areas in the United States. The association was formed more

than thirty years ago in an effort to increase the effectiveness of air pollution reduction efforts. Some stated goals of the organization are to encourage information exchange among agencies, increase communication and cooperation between regulatory agencies at the local, state and federal levels, and to advance good management of American air resources (http://4cleanair.org/about.asp).

The first step in the ICLEI process, conducting emissions inventories, involved identifying all the activities in Tumwater's municipal sector that release greenhouse gases. This enabled the city to accurately quantify its greenhouse gas emissions and discover ways to make reductions. ICLEI recommends using a baseline year at least fifteen to twenty years in the past for the inventory, and similarly, the US Mayors Climate Protection Agreement's efforts are based on reducing GHG emissions to below 1990 levels. To this end, 1990 was originally chosen as the baseline year for Tumwater's emissions audit. After meeting with the city's finance and public works departments and initiating dialogue with the city's energy provider, Puget Sound Energy, it was determined that 1990 was not a viable baseline year due to a lack of consistent data. City energy records are only kept for a period of six years and Puget Sound Energy's records department was unable to locate account information for the City of Tumwater that dated back to 1990. Audits were completed for the years 2000, which served as a baseline year, and 2006, which helped demonstrate growth in emissions for each sector.

The regional manager of ICLEI deemed it appropriate for the city to use a more current baseline year, as other signatory cities have made similar

concessions. In this case, the importance of utilizing complete data sets outweighed concerns about selecting a baseline year only six years previous to Tumwater's Climate Protection Program's inception (Amy Shatzkin, personal communication). The year 2000 was selected as a baseline year.

Forms for collecting greenhouse gas emissions source data were provided by ICLEI and were used as a guideline during the data collection process. ICLEI identifies the following sectors as possible contributors to municipal GHG emissions: city buildings, streetlights, water and sewage operations, vehicle pool, employee commute, and waste. The CACP software is designed to convert entered parameters, such as gallons of gasoline or tons of waste, into greenhouse gas emissions. The software has coefficient factors that are tailored to specific regions of the country, which helps yield more accurate data. More information on the CACP software is included in Appendix I.

2000 and 2006 Energy Audits

In order to identify sources of Tumwater's greenhouse gas emissions and obtain records and information that would be used for GHG emissions analysis, meetings were held with representatives from the public works, facilities, finance and human resources departments in order to determine sources of energy consumption throughout the City of Tumwater. In addition, utility bills and other records were collected and analyzed for the years 2000 and 2006. Once all energy records were compiled, emissions audits were created using the CACP software.

2006 Audits

Building Sector

One of the very first activities completed during the emissions audit process was to compile a list of city-owned facilities. This was done through both a tour of Tumwater's municipal sector and by reviewing Tumwater's 2006 utility bills from Puget Sound Energy. There are currently eleven buildings owned and operated by the city of Tumwater, including City Hall, two Public Works field buildings, a branch of the Timberland Regional Library, two fire stations, a Facilities building, Old Town Center, Tumwater Valley Golf Course restaurant and pro-shop (which includes energy usage from the golf course), and the Henderson and Crosby Houses, two historic buildings. Additionally there are some small structures associated with Tumwater's eight parks and playgrounds that include restrooms and picnic pavilions.

Electricity and natural gas data were collected for all buildings in Tumwater's municipal sector by tallying kilowatt-hours of electricity and therms of natural gas from Puget Sound Energy utility bills. Overall, the City of Tumwater utilized over 5.8 million kilowatt-hours of electricity and approximately 30,000 therms of natural gas in the year 2006. Approximately 28% of the electricity and 100% of the natural gas were consumed by the building sector. In addition, it was noted that the two city-owned historical houses, the Crosby and Henderson Houses, used approximately 800 gallons of diesel heating

fuel in 2006. Table 2 shows each building and the amount of energy it utilized in 2006.

Table 2. 2006 energy usage by the City of Tumwater's municipal buildings. Source: Puget Sound Energy utility bills and internal documents.

Facility Name	Electricity Use (kWh)	Natural Gas Use (therms)	Fuel Oil Use (gallons)
Old Town Center	107,000	6,629	0
Fire Department HQ	210,480	0	0
North End Fire Station	47,920	3,002	0
Tumwater Valley Golf Course	548,100	0	0
City Hall	199,120	5,675	0
Public Works Shop	54,600	5,629	0
Public Works Shop 2	248,480	1,319	0
Facilities Building	34,932	6,288	0
Library	234,760	0	0
Historic Buildings	0[1]	0	800
Total	**1,685,392**	**28,542**	**800**

Water and Sewer Operations

Water and sewage facilities were audited by examining utility bills from Puget Sound Energy and also during two tours of city facilities. Tumwater's water and sewage facilities include nearly forty water pumps, wells, and sewage lift stations. Also included in this category is a water treatment plant that handles water contaminated with tetrachloroethylene (TCE) and perchloroethylene (PCE). This federally listed Superfund site is managed by both the State of Washington

[1] The historic buildings did use electricity in 2006, although their usage was folded into other accounts and not separated out by facility.

and the City of Tumwater and represents approximately 30% of the electricity used by the city in 2006. The City lists over 15,000 water, sewer and storm drain accounts in its General Information file. Additionally, the city's water and sewer infrastructure includes nearly 183 miles of water mains, sewer lines and storm water pipes (http://www.ci.tumwater.wa.us/City%20Departments/General%20 Information.pdf).

It should be noted that while the Climate Protection Program focused on municipal greenhouse gas emissions, emissions from the water and sewage sector represent the greater community's use of these services. An analysis of utility bills from Puget Sound Energy showed that water and sewage operations consumed more than 3.3 million kilowatt-hours of electricity in 2006, or approximately 57% of the City of Tumwater's total electricity usage.

Tumwater is a partner in the Lacey-Olympia-Tumwater-Thurston County (LOTT) Alliance, a water treatment cooperative that receives between ten and twelve million gallons of wastewater per day at its Olympia treatment plant (http://www.lottonline.org/plant.htm). Several lift stations throughout the city of Tumwater allow sewage to reach the plant through a gravity feed (Wayne Lobaugh, personal communication). The facility reclaims wastewater for irrigation use in the city of Olympia and also purchases green tags to offset greenhouse gas emissions associated with its operations (http://www.lott online.org/conservation.htm). Work is currently underway to supply the City of Tumwater with reclaimed water from LOTT's Budd Inlet plant.

Streetlights & Traffic Signals

The City owns and operates numerous street and traffic lights situated along its seventy-six miles of streets and in its parks, having more than 58 individual locations listed on 2006 utility bills along with others that are grouped together under one listing. Tumwater uses high pressure sodium vapor streetlights and a mixture of incandescent and more energy efficient light-emitting diode (LED) traffic signals. A traffic signal conversion is currently underway; older traffic signals are being replaced with newer LED technology. As of November 2007, approximately ten traffic signals have been replaced and all of Tumwater's signals should be utilizing LED technology by 2013. Analysis of PSE utility bills shows that in 2006, the city's streetlights and traffic signals consumed 865,000 kilowatt-hours of electricity. This represents roughly 15% of the city's municipal electricity use for 2006.

Motor Pool

All data for 2006 motor pool operations came from the Public Works Department's fuel records. According to fuel transaction records for 2006, the City of Tumwater had approximately forty vehicles and/or pieces of equipment that consumed diesel fuel, and ninety that consumed gasoline. These include emergency vehicles such as police, fire and paramedic vehicles as well as work trucks, administrative vehicles and equipment for the Parks and Recreation department. The fleet also includes one hybrid-electric and one fully electric vehicle. Tumwater's vehicle fleet consumed approximately 20,000 gallons of

diesel fuel and 47,000 gallons of gasoline in the year 2006. A breakdown of fuel use by vehicle type is included in Table 3.

Table 3. Motor fuel usage by the City of Tumwater in 2006. Data from City of Tumwater internal records.

Vehicle Category	Diesel Use (Gallons)	Cost	Gasoline use (Gallons)	Cost
Full Size Auto	0	$0	12,915	$32,154
Mid Size Auto	0	$0	229	$568
Subcompact Auto	0	$0	100	$264
Heavy Truck	19,966	$50,034	2,491	$4,713
Light Truck/SUV	0	$0	30,534	$77,094
Vanpool Van	0	$0	394	$1,009
Motorcycles	0	$0	133	$355
Total	**19,966**	**$50,034**	**46,794**	**$116,156**

Employee Commute

Data for energy consumption from employee commute came from surveys conducted for Washington State's Commute Trip Reduction Program. Several estimates and assumptions had to be made with this data. The surveys are conducted every two years, and data for 2005 had to be used in the analysis for 2006. The data only included 108 employees that work at the City Hall Campus, which includes City Hall and two Public Works buildings. The data was extrapolated out to estimate total employee miles driven by all of Tumwater's municipal employees.

Estimates of employee schedules were used to find a total number of employee miles driven in 2005. It was estimated that 50% of Tumwater's

employees work a compressed week, where 50% worked a traditional five day, forty hour work week. Compressed schedules were either a 9/80 schedule (80 hours in 9 days) or a 4/10 schedule (40 hours over 4 days). It was also assumed that each employee reports to work for fifty weeks of the year (Debbie Lund, personal communication). According to the survey, the average one-way trip for each employee at the City was 8.6 miles in 2005, giving a round-trip total of 17.2 miles for each employee. Using the estimated employee numbers, it was shown that in 2005, City employees traveled slightly more than 600,000 miles for commute trips. A breakdown by schedule type is included in Table 4.

Table 4. Total commute miles driven by City of Tumwater employees in 2005 by schedule type. Source: internal records.

Schedule Type	Number of Employees	Commute Days/Year	Commute Miles/Day	Total Miles by Schedule
40 hours in 5 days	76	250	17.2	326,800
40 hours in 4 days	38	200	17.2	147,060
80 hours in 9 days	38	225	17.2	130,720
Total	**152**			**604,580**

Waste

Data for Tumwater's waste and recycling programs was provided by Pacific Disposal, Tumwater's trash and recycling service provider. According to their records, the City of Tumwater disposed of approximately 11 tons of garbage and recycled 36 tons of material in 2006[2].

[2] After information regarding greenhouse gas reduction initiatives had been presented to City Council, it was noted that the data for waste collection may have contained errors. The data show the amount of garbage collected declining from over 50 tons in 1999 to approximately 11 tons in 2001, where it remains constant through the end of 2006. The amount of recyclables reported remains constant at approximately 30 tons from 1997 to 2003, and then begins to climb. These

2000 Audits

Electricity Usage for Buildings, Water/Sewage and Lighting

In order to quantify electricity and natural gas usage for the city for 2000, Puget Sound Energy was contacted for assistance, as the City of Tumwater did not have its copies of the 2000 utility bills on hand. Puget Sound Energy forwarded a list of all of Tumwater's Statement Accounts for that year. According to that report, municipal operations consumed approximately 4.2 million kilowatt-hours of electricity and roughly 28,500 therms of natural gas in 2000. The data was not furnished by sector, and in order to get an estimate of the share of buildings, water and sewage operations, and lighting, energy data for the years 2001 through 2006 was used to construct an overall average ratio of energy usage. It turned out that for those years, electricity usage for buildings, water and sewage operations and lighting accounted for 28.1%, 60.4% and 11.6%, respectively. The figures provided by PSE indicate that in the years between 2000 and 2006 municipal electricity usage increased by 39.3% (approximately 6.5% annually) while natural gas consumption increased by 0.3% between 2000 and 2006.

Motor Pool

Data for Tumwater's 2000 motor pool fuel consumption came from the Finance Department's aggregate of monthly fuel reports that were collected by the Public Works Operations Manager. Once again, city vehicles included

figures could be accurate, although the data seemed strange. Inquiries to Pacific Disposal were not answered, and so this data set should be regarded with skepticism.

emergency, administrative and other work vehicles. City vehicles utilized approximately 45,000 gallons of fuel in 2000, although this data is not readily separated into gasoline and diesel amounts. Using the Public Works department's fuel data from several years, an average fuel mix trend of 70% gasoline to 30% diesel became apparent. This was applied to the 2000 fuel usage data to estimate that in that year, the city consumed approximately 31,500 gallons of gasoline and 13,500 gallons of diesel fuel.

Commute Trip Reduction

In order to obtain CTR data for the year 2000, travel trends from the 1999 and 2001 surveys were averaged to produce a number for 2000, 18.3 miles per day for each of 182 total city employees. Again, it was assumed that half of the employees worked traditional 40-hour weeks, while half participated in a compressed work week, either a 9/80 or 4/10 schedule. After analyzing the CTR data, it was shown that in 2000, employees traveled approximately 522,000 miles for commute trips.

Waste

Pacific Disposal provided data for Tumwater's 2000 garbage and recycling habits. According to their records, the city produced approximately 38 tons of garbage and recycled 30 tons of material in 2000, including mixed paper, cardboard, and aluminum cans. As mentioned previously, this data is somewhat suspect.

Greenhouse Gas Emissions Totals

Once the City of Tumwater's energy consumption data had been collected for the years 2000 and 2006, the CACP software provided by ICLEI was utilized in order to obtain greenhouse gas emissions totals. All of the energy and resource use data were entered into the software, which uses several coefficients in order to report on the greenhouse gas emissions associated with the specified energy use. The software reports greenhouse gas emissions in equivalent-CO_2 (e-CO_2) where the known greenhouse gas concentrations and amounts from each fuel or energy source are converted and expressed in terms of CO_2. Table 5 shows the greenhouse gas contributions of each sector for the years 2000 and 2006. Emissions data is also represented in Figure 1.

Table 5. Greenhouse gas emissions by sector for 2000 and 2006. Source: Report from CACP software. Greenhouse gas emissions expressed in tons of e-CO_2.

	2000	Percentage of 2000 Total	2006	Percentage of 2006 Total	Emissions Growth by Percentage	Average Annual Change
Buildings	777	24.7	1,083	24.3	39.4	6.56
Water/Sewage	1,292	41.1	1,810	40.7	40.1	6.68
Streetlights	247	7.9	472	10.6	91.1	15.18
Vehicle Fleet	478	15.2	712	16.0	49.0	8.16
Employee Commute	325	10.3	368	8.3	13.2	2.20
Waste	22	0.7	6	0.1	-72.7	-12.11
Total	**3,141**	**100.0**	**4,451**	**100.0**	**40.4**	**6.73**

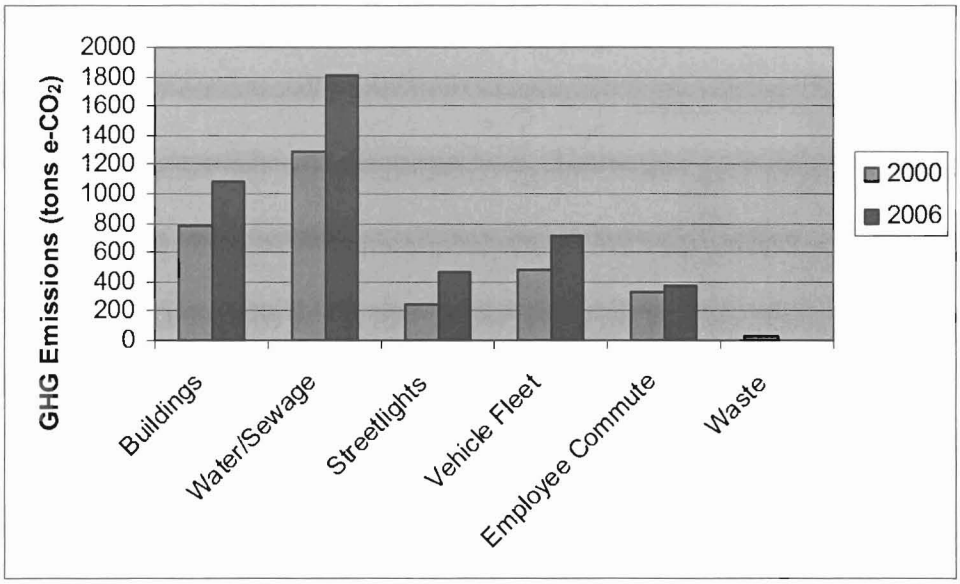

Figure 1. Tumwater greenhouse gas emissions by sector, 2000 and 2006. Reported in tons of e-CO_2.

Tumwater's municipal greenhouse gas emissions grew by approximately 40% between the years 2000 and 2006. Given this overall rise in greenhouse gas emissions, it is logical to conclude that GHG emissions for 1990 were lower than they were in 2000, but there was no way to test this hypothesis in the absence of a complete data set. Once levels of greenhouse gas emissions had been collected for the baseline and interim years, the next step was to identify measures the city could adopt in order to reduce its overall greenhouse gas emissions to comply with the US Mayor's Climate Protection Agreement and ICLEI.

Chapter 4. Identification of Greenhouse Gas Emissions Reduction Measures

In order to construct a comprehensive list of actions the City of Tumwater could utilize to reduce its greenhouse gas emissions, several meetings were held with representatives from various municipal departments within the city and also with outside municipalities. Additionally, outside organizations were contacted for assistance and some ideas came from meetings held with the City of Tumwater's General Government Committee, all over a period of several months. The City of Tumwater's historic homes were not included in any greenhouse gas reduction projects, as altering their insulation, windows, lighting and other features would possibly compromise the historic integrity of the buildings.

Puget Sound Energy Audit of Tumwater City Hall Energy Consumption

In April of 2007, a representative from Puget Sound Energy visited the city in order to investigate Tumwater's municipal buildings for energy-saving opportunities that could help the city reduce its greenhouse gas emissions. The audit consisted of a walk-through of City Hall as well as providing the representative with information regarding the operation of city buildings. City Hall was chosen to serve as a template; the reasoning being that once all measures were identified for that building, they could be applied to other buildings.

Lighting retrofits were one of the first measures identified. According to the U.S. Department of Energy, lighting accounts for 30% of energy use in typical office buildings, and several strategies were identified in this area (http://www.eere.energy.gov/buildings/info/office/). A great deal of the lighting

technology on the main floor of City Hall and parts of the first floor (underground) was found to be of the T12 fluorescent variety. The T12 light bulbs in use in Tumwater's City Hall and other buildings consume 40 watts of electricity apiece, not including energy used by the magnetic ballasts associated with these lights. As was noted during the audit, a switch to smaller, more efficient T8 fluorescent tubes, which consume 32-34 watts apiece, and more efficient electronic ballasts would help the city to reduce its energy consumption and greenhouse gas emissions (Personal communication from Bill Steigner and Greg Adamich). These lights are also currently operating in some of Tumwater's other city buildings.

Other lighting opportunities were discovered in the City Hall lobby, where it was noted that 75-watt incandescent light bulbs were in use in several recessed can lighting applications. The city could switch to 13-watt compact fluorescent fixtures to reduce its energy usage. Finally, it was found that the city is currently using incandescent technology in its emergency exit signs, each of which currently consumes 30 watts of electricity. It was noted that light-emitting diode (LED) technology is currently available for this and many other applications, and in this case, would operate approximately 90% more efficiently (http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs).

The next set of strategies identified was an upgrade to City Hall's heating, ventilation and air conditioning (HVAC) system. As the name implies, these systems typically consist of a heating component, such as a boiler, air conditioners, an air handler to distribute heated and cooled air, and a ventilation

system to keep fresh air coming into the system. In the case of City Hall, two boilers provide heat for the HVAC system. The city could look into retrofitting the system with more efficient boilers, as those in operation date back to the building's opening in 1988. Another HVAC measure that was identified was the partitioning of system operations between the police station (housed inside City Hall) and the other portions of City Hall. The entire building is currently on the same system; there is only one zone to be heated or cooled. Among the advantages of more modern HVAC technology is to separate buildings into distinct zones that can be heated, cooled or shut down entirely. This would be beneficial in City Hall, as HVAC operations are only needed in the police station during the night. Currently, the entire building is conditioned all day, every day of the year. In addition to zone regulation, newer systems have more advanced computer controls that further help reduce HVAC energy usage, which can make up more than one-third of the energy use in a typical office building (http://www.eere.energy.gov/buildings/info/office/; Greg Adamich, personal communication).

It should be noted that the City Hall HVAC system contains a flaw that dates back to its original construction. When it was designed, the system was supposed to have two air handling systems; one each for heated and cooled air. When the system was finished, however, budgetary constraints had led to a single air handling system, meaning that the entire building could only be heated or cooled at one time. Although changing the original design of the HVAC system

helped reduce costs, it increased the amount of energy needed to condition the air inside City Hall (Greg Adamich, personal communication).

In addition to technological strategies, several behavioral and or policy measures were identified as well. It was noted during the PSE audit that City Council could approve a range of temperatures in the thermostats that would enable the city to lower its energy consumption and that there were several applications for more efficient office equipment throughout City Hall. Additionally, the auditor made a general suggestion that the city could incorporate energy efficient design into new building construction (Bill Steigner, personal communication). Once GHG reduction measures had been identified for City Hall, meetings were held with representatives from the Facilities Department to construct a comprehensive list of measures that could help reduce greenhouse gas emissions from Tumwater's municipal buildings sector.

Meetings with Facilities (Building Sector)

In a series of meetings with Facilities Department staff, greenhouse gas reduction strategies that expanded upon recommendations made for City Hall were outlined for Tumwater's other municipal buildings. All of the specific building recommendations are summarized in Table 6, and there were also general recommendations that could apply in many or all of Tumwater's municipal buildings. Categories for proposed solutions included lighting, HVAC, windows, insulation and water conservation. Two of the City's newest buildings, the Timberland Regional Library and the North End Fire Station, were

constructed recently and already include some of the most efficient technology for lighting as well as space heating and cooling that is currently available (Greg Adamich, personal communication).

At the opposite end of the energy spectrum, one building did not demonstrate any potential for improvement. The second Public Works building, located inside a compound where Tumwater's municipal vehicles are also stored, utilizes electricity to power high-intensity lights, fuel pumps, and some vehicles which must be plugged into electrical outlets overnight. Due to the inherently large amounts of energy needed for these operations, there were no energy reduction strategies outlined for this building.

Additionally, a renovation for the golf course pro-shop/restaurant building had already been under discussion when the Climate Protection Program began. The renovation, once complete, will outfit that facility with more energy efficient windows and doors as well as water heating and refrigeration systems. The fresh air intake system will also be coupled with the hot water circulating pump in order to heat the incoming air and reduce the amount of energy needed to provide warm air to the building in colder months. One area not being addressed at the golf course is indoor lighting, which currently consists of some T12 fluorescent and 75-watt incandescent technology (Chuck Denney, personal communication).

Early into the process of uncovering methods to reduce Tumwater's municipal greenhouse gas emissions, it was discovered that lighting retrofit opportunities existed in one of the Public Works shops, the Facilities building, Old Town Center and the Tumwater Valley golf course pro shop/restaurant

building. These buildings were all identified as having less efficient T12 light bulb and magnetic ballast technology.

Improvements to existing HVAC and heating systems in city buildings were the next strategies discussed in meetings with Facilities staff. The older, less efficient boilers in operation in Tumwater City Hall, the HVAC system in the main Public Works shop, the heating system for the Facilities building and the boiler in the basement of Old Town Center were all identified as equipment that could be upgraded in order to reduce energy use and its associated greenhouse gas emissions. Additionally, it was acknowledged that the hot water tank in Old Town Center could also be replaced with a newer, more efficient model.

Two buildings were targeted with suggested improvements in windows and/or insulation. The Facilities building, which was originally built for storage and not as office space, contains minimal insulation along with inefficient single-pane aluminum frame windows. Improvements to both the windows and insulation of the Facilities building were identified as another measure the city could use to reduce its municipal greenhouse gas emissions. In addition, the ceiling above the two-story high gymnasium inside Old Town Center would benefit from a thicker layer of insulation.

Table 6. A listing of possible energy reduction strategies for Tumwater's municipal buildings, by project type. Source: Internal data.

Lighting Retrofits	HVAC/Heating System	Windows	Insulation	Water Systems
City Hall	City Hall	Facilities Bldg	Facilities Bldg	All
Public Works Shop 1	Public Works Shop 1		Old Town Center	
Facilities Building	Facilities Building			
Old Town Center	Old Town Center			
Golf Course Bldg				

General Recommendations

Several items were listed as general recommendations that the City of Tumwater could adopt in order to lower its municipal greenhouse gas emissions. First, it was acknowledged that water-saving technology such as flow restrictors and aerators could be applied to showerheads and faucets in city buildings to help conserve water and thus save energy. The City of Tumwater has an active water conservation program that works with citizens to reduce water usage in the community, and the equipment to retrofit municipal plumbing fixtures is readily available. A related suggestion was to lower the temperatures in water heaters around the city, where appropriate, to reduce energy usage.

In addition to water-saving technology, it was recognized that the city could reduce future greenhouse gas emissions by switching its office and kitchen equipment to more efficient technology when current equipment reaches the end of its useful life. It was also recommended that the city strive to improve energy efficiency standards of new construction projects, going beyond current building codes and utilizing energy-efficient building techniques and office equipment to reduce the greenhouse gas emissions associated with future city expansion.

Another suggested measure was a behavioral awareness campaign that could educate employees about reducing energy usage to help the city meet its climate protection goals. Several strategies include turning off lights and equipment when not in use, closing blinds at the end of the day in winter months and improving employee participation in city recycling programs. The campaign could disseminate information in the form of guidebooks, posted fliers and

messages on the city's internal email system. The city already had some experience with this concept. In 2003, increasing energy costs helped push municipal energy conservation; among other measures, stickers were posted beneath light switches to remind employees to turn off lights when not in use (Doug Baker, personal communication).

In addition to greenhouse gas reduction strategies that were uncovered through research and consultations with outside and internal personnel, members of Tumwater's City Council and General Government Committee also had recommendations for meeting Tumwater's greenhouse gas reduction goals. Committee and council members suggested that research be performed on LED office lighting, electric vehicles and solar power, among other measures. Suggestions made at city meetings were researched and reported on at subsequent meetings. Although not all suggestions made by committee and council members were applicable to Tumwater's unique situation, some of their measures were included in the initial committee discussions that would ultimately decide what greenhouse gas reduction strategies the City of Tumwater would adopt.

PSE Water Audit & Internal Meetings for Water Sector

In 2006, nearly 60% of the City of Tumwater's municipal electricity usage and over 40% of the city's greenhouse gas emissions were attributed to the water and sewage sector. Meaningful reductions in Tumwater's annual greenhouse gas emissions would have to include measures to reduce energy usage in this sector, so another energy audit was conducted by Puget Sound Energy, focusing on

Tumwater's water and sewer systems. The top three electricity consuming—and greenhouse gas contributing—facilities were targeted for energy audits. These were the Palermo Pump Station, Bush Treatment Plant and C St. Booster Station, which together in 2006 consumed 84% of the electricity used by the water and sewer sector, and 48% of the electricity used by the municipal sector as a whole.

In the opinion of the PSE auditor, the observed water and sewage systems already use the most efficient equipment and processes available. Water and sewer operations inherently require a massive amount of energy, working against the flow of gravity to move liquids throughout the entire community of Tumwater. One recommendation was that the city perform an equipment inventory during its next city-wide five-year water systems audit, in order to uncover opportunities to upgrade the equipment and reduce energy usage associated with the water and sewage sector (Bill Steigner, personal communication).

As the PSE energy audit uncovered few suggestions on methods by which the City of Tumwater could reduce greenhouse gas emissions associated with its water and sewer operations, a meeting was held with Tumwater's Water Resources Program Manager to discuss the city's water conservation efforts. Tumwater has an active indoor water conservation program which includes the distribution of free low-flow toilets and accessories, water saving kits that include low-flow showerheads and faucet aerators, incentives and rebates for LOTT customers to purchase appliances that utilize less water, and customer education regarding water conservation. The City of Tumwater has also given water-saving

kits to non-LOTT customers so that water conservation could be more widespread throughout the community. In 2006, a conservation education program was conducted in area schools, and education materials are included with customers' water utility bills. LOTT also maintains a water conservation website that offers tips on how members of the community can reduce their water usage, thereby reducing their GHG emissions (Dan Smith, personal communication).

The City of Tumwater also conducts its own independent water conservation programs. In an irrigation audit, the top twenty water users were identified and offered a $1,000 rebate to make physical improvements to current systems in order to reduce water use. The city has run water efficiency education programs on local television and also held an irrigation workshop for residential customers in July of 2007; discussion topics included planting techniques, drip irrigation and maintenance issues (Dan Smith, personal communication).

On a broader scale, it is hoped that within ten years the city will be able to use reclaimed water from LOTT's operations for irrigation. Currently, hookups for reclaimed water are required in newly developed areas. The city offers outdoor water efficiency kits that include hose nozzles, rain gauges and irrigation literature, and has also given away irrigation timers that sense how much water is on the ground and decrease or increase output accordingly. Overall, the city's indoor water conservation efforts have been considered successful, though the program may be nearing its full potential. The future of Tumwater's water conservation efforts will focus on reducing water usage outdoors (Dan Smith, personal communication).

Motor Pool

Greenhouse gas reduction measures for the City of Tumwater's motor pool were derived through interviews with Tumwater's Public Works staff and by visiting the City of Olympia's motor pool. Olympia is undertaking its own climate protection measures, and the Public Works department adopted goals of reducing both greenhouse gas emissions and overall fuel use in its motor pool. Resolutions aimed at reducing pollution from the vehicle fleet were adopted in 2004 and 2005. In 2007, Olympia crafted a Green Fleets Initiative, which outlines methods that can be used to reduce greenhouse gas emissions and sets policies to help achieve these goals (http://www.olympiawa.gov/NR/rdonlyres/226AB400-C52F-483C-BE5A-7BF433BE7F49/0/Policy_Green_Fleets_2007.pdf; Dave Seavey, personal communication).

The City of Olympia worked to reduce the size of its vehicle fleet, purchase hybrid-electric vehicles and promote vehicle-sharing between departments. Each department that utilizes city fleet vehicles became responsible for managing their own fuel budgets, which helped lead to an overall reduction of fuel usage. Vehicles were outfitted with tire-pressure sensors to help decrease excessive fuel usage, and the city also began a pilot vehicle-monitoring program to monitor how the vehicles were being operated when out in the field. Olympia's Public Works department also began to utilize biodiesel as a means of reducing greenhouse gas emissions. In 2004, the city began to use B20 fuel (20% biodiesel, 80% conventional diesel). Beginning in 2006, B40 (40% biodiesel, 60% conventional diesel) was implemented for the city's vehicle fleet

(http://www.olympiawa.gov/community/sustainability/sustainabilityfuelemissons.htm; Dave Seavey, personal communication).

Building on the lessons learned from Olympia and adapting strategies to Tumwater's unique condition, several measures were identified to help reduce fuel usage and greenhouse gas emissions from the city's motor pool. Recommendations for the vehicle fleet included removing mid-size automobiles from the fleet and using the city's hybrid-electric vehicle more often, purchasing hybrid and/or more fuel efficient vehicles when older vehicles were retired from the fleet, and initiating tire pressure monitoring and electronic vehicle monitoring programs, among others.

Research was conducted on electronic vehicle monitoring programs, whereby GPS technology is installed in vehicles, transmitting driver behavior trends to a central computer. Accompanying computer software would allow the city's fleet supervisor to observe how the vehicles were being used in the field; hard acceleration and braking events as well as excessive speed are brought to the supervisor's attention in the software program. These driving behaviors can decrease vehicle fuel efficiency, resulting in higher fuel usage and the emission of higher levels of greenhouse gases. In addition, the software can track the routes driven by the city's vehicles, bringing unnecessary trips to attention (Don Hults, personal communication). Combined with employee education, these tools can improve gas mileage and lower greenhouse gas emissions.

Other strategies identified included transporting heavy equipment to worksites via trailer versus driving the machinery, which overall exhibit very poor

fuel economy, expanding the use of vehicles which can perform more than one function (interoperable vehicles), thereby lessening the need for several vehicles at a single worksite, and purchasing electric trucks for Parks and Recreation employees. The use of biodiesel fuel was discussed, although there was concern about storage, as the city has limited fuel storage capability (Dave Barclift, personal communication). One final suggestion was that the city purchase carbon offsets for the vehicles that are used frequently. While not a method of reducing greenhouse gas emissions, it was thought that investing in cleaner technology was another way the city could commit to combating the challenge of global climate change.

Employee Commute & Waste

Greenhouse gas emissions from Tumwater's employee commute sector have typically been addressed through the implementation of a Commute Trip Reduction (CTR) program, which provides incentives for employees to reduce the amount of single occupancy vehicle trips, which both relieves traffic and reduces greenhouse gas emissions from the transportation sector. In order to further reduce emissions from this sector, a strategy of ramping up Tumwater's CTR program was suggested. This could involve strategies such as providing bus passes to employees and promoting bicycle and pedestrian travel.

Another facet of the CTR program is non-traditional work arrangements. In order to reduce emissions associated with employee travel, Tumwater city employees could be encouraged to adopt compressed work weeks, though several

employees already take advantage of this schedule and there may not be much more opportunity in this area. Another strategy suggested was for employees to telecommute when possible. The City of Tumwater currently has no telecommuting policies, although some type of policy could be created. (Eric Trimble, personal communication).

For the waste sector, the strategies of reducing employee waste generation and increasing recycling efforts were identified. Reducing employee waste fits in with a previously mentioned measure, an employee behavioral awareness program designed to promote overall sustainability in city operations. In a meeting with Mike Matlock, Tumwater Planning and Facilities Director, it was agreed that the city could and would begin to expand recycling efforts in city buildings.

Public Outreach

Because the City of Tumwater's Climate Protection Program dealt almost exclusively with municipal operations, there were few opportunities for public outreach. Plans were made to develop a website that discussed the city's commitment to minimizing its impacts on climate change. Additional topics to be posted on the site included an overview of climate change issues and its impacts on Washington State as well as a comprehensive list of strategies and resources that citizens of Tumwater could use to help the city in its fight against climate change. It was thought that this would be one way for the city's Climate Protection Program to reach out to the greater community of Tumwater.

Another suggestion for public outreach was introduced by City Councilmember Bruce Zeller. He asked that research be conducted into the feasibility of installing LED technology inside city buildings and also setting up an educational display so visitors to city buildings could learn more about energy efficiency and Tumwater's efforts to combat climate change. City Administrator Doug Baker suggested a storyboard display that could be featured in the lobby of City Hall, along with a pilot installation of LED lights. A recessed LED lighting fixture was ordered to replace a traditional incandescent light in City Hall. Before this could serve as a pilot project with demonstration materials, however, the light was removed due to an employee complaint. The LED fixture, while using one-sixth the energy of the standard incandescent bulb, emitted enough light to cause visual discomfort to the employee. In order for this LED study and public demonstration to move forward, research must be conducted to determine the feasibility of installing dimmer switches with future LED fixtures.

As mentioned previously, Tumwater has an actively operating water conservation program. Water conservation kits are made available to citizens and conservation literature is also mailed out with citizens' water bills. Although more research was not put into this area, finding innovative new ways to help citizens conserve water would be another approach to reducing the community's contributions to global climate change.

Chapter 5. Greenhouse Gas Reduction Quantification of Measures

After determining what steps the City of Tumwater could take to reduce its greenhouse gas emissions, the next step was to quantify the amount of reduction that each measure could deliver. This was done with the CACP software provided by ICLEI, consulting with city staff, and in some cases by taking physical inventories of current technology in use throughout the city. The resultant figures represent estimates, as it is not always possible to determine exactly how much reduction in energy usage and GHG emissions will occur until measures are put in place due to limited efficiencies and human behavior, among other factors.

Greenhouse Gas Reduction by Sector

Building Sector

For the building sector, meetings were held with Greg Adamich, a Level II Buildings and Grounds Maintenance Worker, in order to determine the amount of energy that could be saved by implementing various measures. His knowledge of both Tumwater's current operations and the energy specifications of existing technology proved invaluable during the process of quantifying greenhouse gas emissions reductions. He was able to determine potential energy savings of adopting new technology, which later were translated into greenhouse gas reductions using the CACP software.

In order to determine the energy savings of a comprehensive lighting retrofit, a physical count was made of all the T12 light bulbs that are still in use in

Tumwater's municipal buildings. Based on the number of T12s, Greg Adamich was able to estimate how many magnetic ballasts were in place to operate those bulbs, and how many electronic ballasts would be required to fully convert Tumwater's interior fluorescent lighting system to be more energy efficient.

There was also some emissions reduction potential found in the prospect of replacing recessed incandescent light bulbs with more efficient LED bulbs in general lighting applications. Recessed can lights that employed incandescent lighting were inventoried, and estimates were made as to the greenhouse gas reduction potential of switching these bulbs to lower wattage LEDs. Because LED and compact fluorescent (CFL) bulbs have similar wattages, those recessed cans currently utilizing CFL technology were not counted in the inventory. The number of incandescent exit signs used in the event of power outages and fires were inventoried, as well. LED technology can be used in this application, and those fixtures use less than 10% of the energy consumed by current technology.

For other equipment in municipal buildings, Greg Adamich provided estimates as to how much energy could be saved by adopting newer technology. These figures were applied to a breakdown of energy use in typical office buildings, provided by the United States Department of Energy. For example, it was estimated that new boilers for City Hall would be 20% more efficient than the current models. In a typical office building, water heating accounts for 9% of energy use. So replacing the boilers in City Hall and Old Town Center would save the city 20% of 9% of the energy used in those buildings each year. That particular measure would save approximately 15,000 kWh of electricity per year,

based on 2006 energy usage. Using ICLEI software, this translates into a GHG reduction of 8 tons of e-CO_2 per year, an overall reduction equivalent to roughly 0.5% of Tumwater's GHG reduction goal.

Motor Pool Sector

Greenhouse gas reduction potential was also estimated for the motor pool. Measures identified included electronic vehicle monitoring and tire pressure monitoring programs. An estimate of fuel savings potential from the AccuTag Vehicle System product information listing (5% for city driving, which represents virtually all municipal traffic in Tumwater) was applied to all vehicles that were considered eligible for monitoring (vehicles with the heaviest usage). This enabled an overall fuel savings estimate to be created, and once entered into ICLEI's software, a greenhouse gas reduction figure was generated. Similarly, using the estimate that keeping tires properly inflated can boost fuel efficiency by 2.5%, a figure for the tire pressure monitoring initiative was derived.

Other Sectors

Estimates could not be easily derived for the other sectors, including water usage and employee commute. Although ramping up the city's CTR program and trying to further enhance the community's water conservation program and upgrade plumbing fixtures around the city were measures identified during the initial study, it was not possible to measure the energy saving outcomes before these programs were implemented, and these measures are also partially

dependent on the future growth of Tumwater's municipal government. Likewise, greenhouse gas emissions from streetlight usage and waste generation will depend on the city's growth over the next several years. While predictions are available for the growth of Tumwater's population over the next several decades, the city's government may not grow at a similar pace.

Sum of Measures

Once energy reduction estimates had been made for the measures identified, the CACP software was used to generate figures for greenhouse gas reduction potential. Table 7 shows the sum of all of the measures that were identified (as was presented to Tumwater's General Government Committee and City Council) and also cost estimates that were derived from city staff and outside representatives.

It became obvious that the measures outlined would not be nearly enough for the city to meet its reduction goal of 7% below 2000 levels—the measures identified would only take Tumwater 6% of the way to its ultimate goal of a GHG reduction of 1,530 tons per year.

Additional Measures

Additional measures were researched, including installing solar panels and purchasing green tags and carbon offsets through Puget Sound Energy's Green Power program and TerraPass, respectively. Tumwater City Councilmember Pete Kmet encouraged conducting research on solar energy, which could be used to

Table 7. Itemized greenhouse gas reduction potential for various strategies derived for the City of Tumwater. Sources: Energy and GHG reduction are from CACP software reports. Cost information is from personal communication.

Measure Name	Cost	Energy Reduction (per year)	GHG Reduction (tons/year)	% of Goal (1,530 tons)	Cost/Ton Reduction
Fluorescent Light Retrofit	$16,957	39,170 kWh	20.173	1.32	$840.58
LED Exit Sign Retrofit	$9,400	11,934 kWh	6.146	0.40	$1,529.45
Purchase New Boilers for City Hall and Old Town Center	$80,000	15,306 kWh	7.883	0.52	$10,148.42
Facilities Heating System	$6,000	4,367 kWh	2.249	0.15	$2,667.85
Old Town Center Water Heater	$800	3,178 kWh	1.637	0.11	$488.70
Old Town Center Insulation	$6,000	6,688 kWh	3.445	0.23	$1,741.65
City Hall Water Heater	$8,000	3,136 kWh	1.615	0.11	$4,953.56
City Hall Lobby LED Retrofit	$2,500	1,972 kWh	1.016	0.07	$2,460.63
Facilities Windows & Insulation	$60,000	1,091 kWh	0.562	0.04	$106,761.57
Tire Pressure Monitoring	$1,200	1,450 gal fuel	15	0.98	$80.00
Electronic Vehicle Monitoring	$80,000	2,900 gal fuel	30	1.96	$2,666.67
Water Conservation Retrofit	Labor costs	Depends on hot water usage			
Sum of All Actions	**$270,857**		**90**	**5.89%**	

generate a portion of electricity for each building. As a pilot study, estimates were derived for solar energy systems that would provide either 10 or 25% of the electricity required on an annual basis by Tumwater City Hall, and also for a system that could power the city's farmers' market.

Green tags represent the purchase of electricity from renewable sources. They can be counted toward overall greenhouse gas emissions reduction, as the purchase supports the operation of a renewable energy source, including but not

limited to wind and solar power. They do not include hydropower, which is not considered clean energy by all. Dams carry the stigma of being harmful to salmon and drastically altering river systems, among other concerns. Under Puget Sound Energy's Green Power Program, the utility funds the generation of electricity from renewable sources, and passes this cost on to consumers interested in supporting clean energy. One green tag represents 1,000 kilowatt hours of renewable energy (https://www.greentagsusa.org/GreenTags/index.cfm).

In addition to participating in Puget Sound Energy's Green Power Program, the purchase of carbon offsets for the city's vehicle fleet through was also researched. In this case, automobile GHG emissions are offset by investing in wind energy projects, farm biomass power projects or landfill gas capture (http://www.terrapass.com/projects/). The purchase would be made from a company called TerraPass, which specializes in selling carbon offsets.

It is important to note that the purchase of green tags and carbon offsets do not represent an actual reduction in resource use by the purchaser. Green tags help to reduce the greenhouse gas emissions of the overall power grid by encouraging the development of renewable energy. Carbon offsets represent funding for initiatives that reduce greenhouse gas emissions, including but not limited to renewable energy production. Carbon offsets and green tags are not necessarily locally generated. For example, project locations listed in the portfolios of TerraPass and Bonneville Environmental Foundation include Minnesota, North Dakota, Kansas, Alaska, Maine, and Kentucky (http://www.terrapass.com/projects/portfolio.html; http://www.b-e-

f.org/renewables/supply.shtm). These companies are based out of San Francisco, California, and Portland, Oregon, respectively. While green tags and carbon offsets should not be considered "silver bullets" in the fight against climate change, they represent action that can be taken to promote measures that reduce greenhouse gas emissions.

Once again, ICLEI's CACP software was utilized to estimate the greenhouse gas reduction potential of each strategy. Solar information came from Washington Solar, a company that sells photovoltaic arrays with various generating capacities. Reduction potential of green tags and carbon offsets was figured by entering an overall electricity reduction into the CACP software for Tumwater's stationary sources of electrical consumption, and by utilizing calculators on the TerraPass website for the vehicle pool.

The purchase of green tags and carbon offsets was not considered a solution to Tumwater's goals to reduce greenhouse gas emissions. The idea represents the knowledge that other reduction measures would not be enough to bring Tumwater to its goals, and would serve as an interim measure until other methods of reducing GHGs were identified. For example, one scenario was to offset Tumwater's water and sewage operations, which accounted for 41% of the city's GHG emissions in 2006, but for which there was little or no further action identified that could be taken to reduce these emissions. The purchase of green tags, beyond other measures, could help the city reduce its emissions even further than 7% below 2000 levels; indeed, the original goal of the US Mayors Climate Protection Agreement was a 7% reduction below 1990 levels. Table 8 shows the

additional measures that could further reduce Tumwater's greenhouse gas emissions.

Table 8. Additional measures that could be taken to reduce the City of Tumwater's greenhouse emissions.

Additional Measures	Cost	Energy Reduction	GHG Reduction/Offset (tons/year)	% of Goal (1,530 tons)	Cost/Ton Reduction
Solar Power					
10% Power for City Hall	$51,000	19,800 kWh/year	10.197	0.67	$5,001
25% Power for City Hall	$126,000	50,375 kWh/year	25.944	1.70	$4,857
Power for Farmers Market	$55,000	1,944 kWh/year	1.001	0.07	$54,945
Green Tag Purchases					
Offset Water/Sewer Electricity Usage	$19,900 per year	0 kWh	1,810	118.30	$11
Offset Building Electricity Usage	$9,900 per year	0 kWh	846	55.29	$12
100% Electricity Offset	$34,900 per year	0 kWh	2,999	196.01	$12
Carbon Offset Purchases					
For Unleaded Vehicles Driven 1K – 5K miles/year	$4,000 per year	0 gallons	442	28.88	$9
For Unleaded Vehicles Driven > 5K miles/year	$2,900 per year	0 gallons	363	23.73	$8

Reduction Efforts Currently Underway

Part of the ICLEI process is identifying GHG-reducing measures the city is already implementing, regardless of whether they were initiated for that purpose. Many of these proved impossible to quantify, either because no records were kept, the measure was planned but not yet implemented or was simply on a

scale that did not lend itself to measurement. By meeting with various officials and staff members in the city, eight measures were identified. Of these, water conservation was previously described.

Tree Planting

Tumwater's Stream Team has been very active in planting trees around the community, mainly in riparian areas. Some of their most notable projects have been planting at the golf course and at a twelve acre parcel along Percival Creek, which drains into Capitol Lake and ultimately into Puget Sound's Budd Inlet. The work is done by Stream Team volunteers, using mostly hand tools. The trees planted are those requiring little maintenance. Exact numbers of trees are impossible to measure, but Debbie Smith, the Stream Team coordinator, estimated that in the past several years the program has planted 10,000 or more trees and shrubs. In addition to the Stream Team, Tumwater Parks & Recreation plants trees as well. Over 250 trees are planted at Tumwater's golf course each year. Trees are also planted at Tumwater's city parks at irregular intervals (Debbie Smith and Jeff Vrabel, personal communication).

Recycling

The City of Tumwater already participates in a recycling program with Pacific Disposal. Materials such as mixed paper (including glossy paper such as magazine and newspaper ads), cardboard, aluminum cans, plastic bottles and film (such as plastic grocery bags) are now collected from all of Tumwater's municipal

buildings. This program is a step above what was in place in early 2007, when only mixed paper (not including glossy paper) and cardboard were collected from all municipal buildings, and aluminum cans were collected once a year from City Hall (Jeff Vrabel, personal communication). The expanded operations began in the fall of 2007, and data on whether the expansion has resulted in increased recycling is not yet available.

Hybrid & Electric Vehicles

The City of Tumwater has purchased two vehicles that produce fewer emissions than standard automobiles. The city purchased an electric automobile to be used for parking enforcement, and a hybrid electric vehicle for use as a general motor pool vehicle. The electric vehicle replaced a small pickup truck, and the hybrid-electric vehicle replaced a standard mid-size sedan. Both vehicles replaced were approximately ten years old and were sold at auction in 2006. Unfortunately, it was not possible to obtain greenhouse gas emissions reduction data on these new vehicles. Mileage records were not kept for the electric vehicle, so it was not possible to determine how much electricity it consumed, or how much gasoline it replaced (Dave Barclift, personal communication). Mileage statistics were also unavailable for the other vehicle, as well.

Golf Course Measures

Two greenhouse gas reduction measures have either already occurred or are slated for Tumwater's golf course. In 2002, the city replaced its forty

gasoline-powered golf carts with electric powered carts. A second measure at the golf course, previously mentioned, entails a rehabilitation of the pro shop and restaurant building. Already in place was a plan to overhaul the building, including installing energy efficient double-paned windows and doors, air-tight metal door frames, a more efficient water heating system, a coupled water and air heating system, and a more energy efficient refrigerator for the restaurant (Chuck Denney, personal communication). No estimations on the electricity savings from this project were provided, and thus a measure of greenhouse gas reduction could not be created.

Fluorescent Lighting Upgrades

The standard fluorescent lighting used in Tumwater's municipal buildings has been T12 technology, until recent years, when more energy efficient T8 technology was adopted. The city's T12 fluorescent lights are replaced with T8 bulbs on a replacement schedule, that is, when the older bulbs burn out. In addition, the magnetic ballasts used in conjunction with the T12 bulbs are being replaced by electronic ballasts, which save energy and contain fewer toxic materials. The city's Facilities Department has kept no data on how many lights have been replaced, so it was not possible to create a greenhouse gas reduction figure for this measure (Greg Adamich, personal communication).

Energy Conservation

In 2003, rising energy prices forced the city to implement an energy conservation program. This was mainly done by an informational campaign, reminding employees to turn off lights and machines when not in use. Overall energy usage in the city's buildings has been on the rise since 2001, with a slight decrease between 2005 and 2006, so the efficacy of this program is somewhat questionable. It is possible that growth in city operations outpaced energy conservation efforts.

LED Traffic Signals

The city has been conducting work on its approximately twenty traffic signals, replacing incandescent light bulbs with more energy efficient LED bulbs. This project is scheduled for completion in the next four to five years, with roughly ten traffic signals already having been replaced.

Chapter 6. Adoption Process for Greenhouse Gas Reduction Measures

Path of Measures through Process

In October 2007, a Capital Facilities Plan (CFP) worksheet detailing the financial aspects of implementing the proposed GHG reduction measures was created. Table 9 shows the actions to be taken, spaced out over the next several years. The Capital Facilities Plan, mandated by Washington State's Growth Management Act, is a six-year plan for addressing capital projects. It is updated each year and provides a moving six-year timetable. It is worth noting that the approach taken in implementing Tumwater's Climate Protection Program was unique. This program represented the first instance of a Council Committee putting together a project along with CFP and budget proposals (Doug Baker, personal communication).

Table 9. Greenhouse gas reduction measures proposed to Tumwater's General Government Committee.

	Measure	Cost
2008	Fluorescent light retrofits in city buildings, LED exit sign retrofits	$27,000
2009	Purchase new heating system for Facilities Building	$25,000
2010	Initiate vehicle usage monitoring program	$80,000
2011	Install new boilers in City Hall and Old Town Center	$80,000
2012	Upgrade windows and insulation in Facilities Building	$60,000
Total		**$272,000**

In October 2007, the 2008-2013 Capital Facilities Plan proposal was presented to Tumwater's General Government Committee. At that same meeting, information was presented regarding Puget Sound Energy's Resource Conservation Manager (RCM) program. Puget Sound Energy provides grants to help cover the costs of hiring a Resource Conservation Manager, who would work with the city to monitor and plan for efficient uses of its various resources. The grant would cover up to 25% of the RCM's first year salary, with the rest to be paid by the city. In later years, energy savings accrued through the hire of the RCM should theoretically offset the cost of that person's salary. Puget Sound Energy reports that in the first year of the program, a cost savings of 3-5% is possible, with overall savings of 10-15% after three years. For the scale of Tumwater's operations, the position would consist of a quarter-time equivalent employee.

The General Government Committee recommended that the 2008-2013 CFP proposal be passed on to City Council for review. The GGC recommended that the city hire a Resource Conservation Manager, with funding proposed to come from the 2008 Budget. The Committee also recommended that in 2008, the city begin purchasing green tags to offset the emissions associated with Tumwater's electricity usage in the water and sewage sector at a cost of approximately $20,000 per year. Further, the GGC recommended that in 2010, the city increase its green tag purchases to cover 100% of the city's electricity usage, for a total cost of $35,000 per year. Councilmember Valenzuela also suggested that the city look into attaining LEED certification on any new

construction projects for the city (Tumwater General Government Committee Minutes 10/25/2007). .

The General Government Committee's recommendations were passed on for review at the City Council's November 6, 2007 meeting. Councilmember Bruce Zeller recommended placing $25,000 into the Capital Facilities Plan to fund energy efficiency upgrades in 2008, and suggested addressing the purchase of green tags in 2009. The Council approved $25,000 for a Capital Facilities Plan project, and also approved the inclusion of $12,000-$17,000 in the General Fund Budget in order to cover the costs of hiring a resource conservation manager. The results of these proposals were to be discussed at the Council's November 20, 2007 meeting (Tumwater City Council Minutes 11/6/2007). On that date, a motion to approve the Budget proposal was passed. The final budget was adopted at the City Council meeting on December 4, 2007. (Tumwater City Council Minutes 11/20/2007, 12/04/2007). The Capital Facilities Plan, which included $25,000 for projects designed to reduce greenhouse gases, was adopted on December 18, 2007 (Tumwater City Council Minutes 12/18/2007).

Work on Tumwater's Climate Action Plan, part of the ICLEI process, was completed in August 2008. This document includes a business-as-usual GHG emissions growth forecast to help the city keep its emissions reductions on track. The document also outlines all the GHG reduction measures that have thus far been identified for Tumwater and provides guidance for implementing these strategies.

From a governmental standpoint, the Climate Protection Program was successful in securing funding for capital projects and hiring personnel to carry out work that will help the city with its greenhouse gas reduction goals. Because the Capital Facilities Plan is reviewed each year, the potential still exists for the other GHG reduction measures (or any new measures developed in later years) to be introduced into the plan in any given year.

The reduction measures outlined in Table 7, which represent real potential GHG emission reductions based on current municipal operations (versus green tags and carbon offsets) do not sufficiently enable the City of Tumwater's municipal operations to reach the goal of compliance with the US Mayors Climate Protection Agreement. The only feasible method of reducing current GHG emissions to 7% below 1990 levels by 2012 is to purchase green tags through Puget Sound Energy's Green Power Program, purchase carbon offsets for city vehicles, or find ways to otherwise offset emissions. Additionally, because energy usage records were not available for the year 1990, it is not possible to know at what point the City of Tumwater meets its climate protection goals, even with the purchase of green tags. Working with a complete data set for the year 2000 was deemed more important than trying to estimate resource usage and greenhouse gas emissions for the year 1990.

This conclusion is an important lesson for any community seeking to reduce its climate impacts. There may not be concrete ways for individual communities to reduce greenhouse gas emissions by the amount required to avert

the worst impacts of climate change (70% or more below current levels by 2050) without investing tremendous capital in sustainable energy systems, including renewable energy and alternative fuels. In Tumwater's case, the city could reduce its current GHG emissions by roughly 2% by implementing the measures addressed in Table 7. While the measures outlined above are by no means exhaustive, this case study shows that reducing greenhouse gas emissions to levels that will avert the worst impacts of climate change will require innovative solutions beyond what local governments can realistically provide for their communities.

Chapter 7. Future & Recommendations for the City of Tumwater

As of December 18, 2007, the City of Tumwater had the first provisions of its Climate Protection Program in place. Funding had been secured to hire a resource conservation manager to monitor resource usage at the city, and $25,000 was included in the 2008-2013 Capital Facilities Plan to be used for technological improvements that will help the city reduce its energy usage and take steps toward reducing greenhouse gas emissions. Because many of the GHG reduction measures were not adopted as of that date, Tumwater's Climate Protection Program could feasibly produce even more results in the future if provisions are put in place to ensure that the program is continued in later years. Several recommendations for the advancement of Tumwater's climate protection goals were made throughout the process of developing measures for greenhouse gas reduction and working with the city's government.

During preliminary City Council considerations, it was decided that Tumwater's climate protection efforts should first focus on addressing municipal greenhouse gas emissions in order to gain perspective on the scope of the work and provide the greater community with an example to follow. In future years, the city should complete the entire community analysis utilizing ICLEI software and support from staff within that organization. This work could be completed by the resource conservation manager, city staff, or another intern of the city's choosing. Helping bring the community on board and finding ways to reduce GHG emissions associated with Tumwater's 16,000 residents would also greatly advance the city's climate protection efforts. Municipal governmental operations

typically constitute 2-5% of the emissions of the overall community (Amy Shatzkin, personal communication).

In order to sustain the momentum that Tumwater's Climate Protection Program has generated thus far, some type of oversight should be adopted by the city. Because the program began under Tumwater's General Government Committee, one option would be to have the Committee hold continuing discussions about the program and how to advance greenhouse gas solutions. Another method would be to convene a special panel consisting of city staff, who are familiar with the city's operations and may be able to craft strategies and measures to help the city further reduce its GHG emissions. A third option would be to have this duty fall under the resource conservation manager position.

Whatever form the oversight takes, it would be important for the participant(s) to keep abreast of developments in clean energy, energy efficiency and conservation strategies, and current climate policy. Oversight could also ensure that other "unofficial" recommendations are carried out, such as inventorying Tumwater's water and sewage equipment during the next five-year water systems audit. Another responsibility could be to compile records of city energy usage, in order to assist in future greenhouse gas emissions audits. As mentioned previously, city and public utility records were found to be unreliable to construct a 1990 baseline for emissions audits.

The City of Tumwater's Capital Facilities Plan is reviewed every year, and this provides ample opportunity for the city to implement climate protection measures in future years. The Climate Protection Program proposal included in

the 2008-2013 CFP included a potential timeline for the implementation of various measures (Table 9). In order for the city to continue the progress it has already made in climate protection, it is critical that these and/or other greenhouse gas reduction strategies be included in future CFPs.

Finally, it is important that the city continue to entertain the option of participating in Puget Sound Energy's Green Power Program or a similar initiative. During the November 6, 2007 City Council meeting, Councilmember Bruce Zeller suggested that the city revisit the notion of green tags in 2009. By that time, approximately two more years of energy usage data will be available above what was used in the 2006 energy audit. If measures adopted in 2008 help reduce greenhouse gas emissions, it may be possible that the city will not need to purchase as many green tags as previously described. During the course of quantifying measures that Tumwater could adopt to reduce its GHG emissions, green tags and carbon offsets were never considered a permanent solution to the climate change problem—rather, it was recognized that they may provide the only means of meeting the city's GHG reduction goals, as the sum of all other measures examined did not bring the city to its stated goals.

Conclusion

The far-reaching impacts associated with climate change warrant significant global attention. The consequences of inaction are dire, ranging from declines in global water and food supplies to increases in violent weather events and sea level rise, all of which place both human and natural systems in jeopardy. The concentrations of greenhouse gas emissions already in the atmosphere have accelerated increases in temperature that will impact the planet, and the severity of these impacts in future years and decades will largely depend on which of the forecasted emissions scenarios becomes reality. Significant emissions reductions are required in the coming decades, and increases in energy usage and global population further complicate the task of bringing greenhouse gas emissions under control.

The US Mayors Climate Protection Agreement, patterned after the Kyoto Protocol and developed in the society responsible for the largest share of anthropogenic greenhouse gas emissions, provides a basis for future climate protection planning in a country with a national government that has thus far been largely unresponsive on the issue of climate change. American participation in the Agreement suggests that momentum is building behind the concept of combating climate change, although only time will be able to demonstrate the efficacy of such measures.

The City of Tumwater, Washington is taking action to reduce its contribution to global climate change. Though the emissions reductions being sought by Tumwater, and all the cities and countries participating in versions of

the Kyoto Protocol, represent only a fraction of the total reductions needed to thwart the most severe climate impacts of climate change, the city has taken its first steps toward providing critical leadership in the immense undertaking of protecting Earth's climate and its inhabitants from what may be the largest threat in human history.

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Appendix I: ICLEI Software Information

Below are excerpts from the Clean Air and Climate Protection Software manual. This software was used in creating Tumwater's emissions audits and for quantifying the GHG emissions reduction potential of each strategy that was identified.

Software Overview

The Clean Air and Climate Protection (CACP) Software calculates the greenhouse gases and criteria air pollutants produced by energy use and solid waste disposal, and helps you quantify measures designed to reduce these emissions. While the software can help you complete an emissions inventory, you may also enter inventory data from another source directly into the software. For example, if you have emissions levels from EPA's State Inventory Tool, you may enter this information in place of using the CACP Software inventory modules and proceed directly to evaluating emissions reduction measures.

The software takes data you provide on energy use and energy use reductions and converts it to emissions using specific emission factors (coefficients) that relate the emissions of a particular pollutant (e.g., carbon dioxide) to the quantity of the fuel used (e.g., kilograms of coal). For electricity, the emission factors are based on end-use energy consumption, meaning that emissions per kilowatt hour (kWh) are based on kWh consumed, not produced. This way a jurisdiction can account for emissions resulting from its consumption

patterns and therefore be in a better position to design effective strategies to alter or reduce these emissions.

Calculating carbon dioxide (CO_2) emissions is relatively straightforward as emissions are determined directly by the amount of fuel or energy used. On the other hand, emissions of criteria air pollutants are dependent on the technology being used as well as fuel. Therefore, the software contains thousands of emission coefficient sets for a range of fuels and technologies, based largely on EPA's AP-42 database.

The greenhouse gases CO_2, nitrous oxide (N_2O), and methane (CH_4) are aggregated and reported as carbon dioxide equivalents (eCO_2), a commonly used unit that combines greenhouse gases of differing impact on the earth's climate into one weighted unit.

Emission Factors/Coefficients

As discussed in the "Software Overview" section (above), the software uses various emission factors to calculate the greenhouse gas and criteria air pollutant emissions resulting from electricity usage, fuel consumption, and waste decomposition. The software contains thousands of emission coefficients for a range of technologies, regional electricity mixes (see the software's Help files for information on how these coefficients were derived), and fuels. This menu provides a way to view and modify existing coefficients, as well as providing options for defining completely new sets of emission factors.

Emission factors can be viewed in terms of a number of different units (e.g., tons/Btu, grams/kWh, etc.). To change the units, click on the default units

listed in the center left of the emission coefficient window, and select the new units from the drop down list. You can change any number in the coefficient sets by clicking on that number and overwriting it.

Grid Average and Grid Marginal Electricity

Although there are no emissions associated with electricity at the point of use, there are significant emissions of CO_2, NO_x, SO_x, and particulates (PM) at the fossil fuel (coal, oil, and natural gas) power plants that generate the vast majority of electricity. The CACP software uses these emission factors to account for the upstream emissions created by these plants. The United States electricity grid is not uniform. Some regions produce cleaner electricity than others. Therefore, the software provides default emission factors for 13 distinct NERC regions as well as Alaska and Hawaii.

The Average Grid Electricity coefficients are essentially the ratio of total emissions to total electricity consumption, whereas the Marginal Grid coefficient sets represent emissions associated with the last kWh generated (or that which is "on the margin"). Marginal coefficients may be significantly higher than average grid coefficients because electricity production at the margin tends to be produced by the dirtiest coal and diesel thermal power plants. These are often the plants that are taken off line first when demand decreases....

For both types of electricity, Grid Average and Grid Marginal, the coefficients change from year to year depending on the relative quantity of fossil fuel used in electricity generation in a particular year. Grid Average coefficients change modestly year to year, whereas Grid Marginal coefficients can fluctuate

significantly. The software contains default historical values for of these coefficient sets, as well as forecasted values to the year 2020. Future emission factors are based on modeling work done using the National Energy Modeling System (NEMS).

Transport Average: Average Emission Factors for Vehicle Classes

The software contains emission factors for mobile sources broken down by 14 fuel types, and a varying number of vehicle types per fuel.... For each vehicle/fuel combination, the software contains distance-based emission factors and fuel economy associated with each vehicle class (e.g., light truck, auto-compact, transit but, heavy truck, etc).

For each vehicle/fuel combination, the software contains historical and projected emission factor and fuel efficiency values for the years 1990 to 2020. This accounts for changes in the average on-road vehicle fleet over time (e.g., aging of the fleet, transition to newer models and vehicle types, etc.). There is only one universal coefficient set, based upon current technology practices, for some alternative or new fuels (e.g., CNG/auto) for which there are not enough data available to compute historical or future emissions patterns.

Transport Standards: Emission Factors Based on Actual Emission Standards

Because many transportation-related measures designed to mitigate greenhouse gas and criteria air pollutant emissions rely on switching to a vehicle stock with better emission standards, the software contains emission standards for vehicle classes that conform to the Tier1, TLEV LEV, ULEV, and SULEV

standards (the emissions standards are included in Appendix D). Under this tab, you can modify existing coefficient sets, or add new standards as any other set of emission factors in the software.

Waste

Greenhouse gas emissions from solid waste management vary greatly depending on the disposal practices and the type of waste being processed. State and local governments may deposit waste in landfills, incinerate it, or send part of it for composting. Therefore, the software incorporates emission factors for seven common waste management techniques: landfilling, open dumping, incineration, open burning, composting, reducing, recycling, and waste left uncollected.

From a lifecycle standpoint, waste emissions are more complex than determining the CO_2 released by decomposition. For example, if you deposit waste in an anaerobic landfill, some of the carbon that would naturally decompose and return to the atmosphere as CO_2 is "sequestered" in the landfill and thus is not released. Additionally, some of the carbon is converted to and released as methane (CH_4), a much more potent greenhouse gas. Furthermore, waste reduction practices such as recycling avoid additional emissions by reducing the energy required to produce a new product, because the use of recycled materials reduces the amount of raw material that needs to be processed in the creation of new products.

For each management practice and waste type, the software computes total emissions based on the following factors:

- At site methane emissions
- At site carbon sequestration
- Upstream energy
- Upstream forest sequestration
- Upstream non energy

Appendix II: More Information on Climate Change Issues

Climate Change Information

Intergovernmental Panel on Climate Change: http://www.ipcc.ch

International Council for Local Environmental Initiatives (ICLEI):
http://www.iclei.org

Washington State Department of Ecology – Climate Change Webpage:
http://www.ecy.wa.gov/climatechange/index.htm

United Nations Environment Programme Webpage:
http://www.unep.org/Themes/climatechange/

United Nations Framework Convention on Climate Change:
http://www.unfccc.int

United States Environmental Protection Agency – Climate Change Webpage:
http://www.epa.gov/epahome/learn.htm#climate

Renewable Energy, Energy Efficiency and Carbon Offset Information

American Wind Energy Association: http://www.awea.org/

National Renewable Energy Laboratory: http://www.nrel.gov/

United States EnergyStar Program Webpage: http://www.energystar.gov

TerraPass, Inc.: http://www.terrapass.com

Initiatives on Climate Change & Sustainability

Bonneville Energy Foundation's Green Tag Program:
https://www.greentagsusa.org/GreenTags/index.cfm
http://www.b-e-f.org/renewables/supply.shtm

City of Olympia Sustainability:
http://www.olympiawa.gov/community/sustainability/

City of Seattle Climate Webpage:
http://www.seattle.gov/html/CITIZEN/climate.htm

City of Seattle Mayor's Office – US Mayors Climate Protection Agreement: http://www.seattle.gov/mayor/climate

Lacey, Olympia, Tumwater, Thurston County (LOTT) Alliance – Water Conservation: http://www.lottonline.org/conservation.htm

Puget Sound Energy's Energy Efficiency & Renewable Energy Webpage: http://www.pse.com/energyEnvironment/renewableenergy4/Pages/Default.aspx

William J. Clinton Foundation: Clinton Climate Initiative Webpage: http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative