City of Burlington Climate Action Plan

Final Report:
Cost-Carbon-Benefit Analysis




Prepared For:

The City of Burlington
Burlington, VT 05401

Prepared By:

SPRING HILL | SOLUTIONS

209 College Street, Third Floor East
Burlington, Vermont 05401
802.864.2372
info@springhillsolutions.com

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Acronyms and Abbreviations

BED	Burlington Electric Department
BURDES	Burlington District Energy System
CAP	Climate Action Plan
CBES	Commercial Building Energy Standard
CFL	Compact fluorescent light bulb
CHP	Combined heat-and-power
CSWD	Chittenden Solid Waste District
CVOEO	Champlain Valley Office of Economic Opportunity
CVSWMD	Central Vermont Solid Waste Management District
DPW	Department of Public Works
EE	Energy efficiency
EPA	Environmental Protection Agency
ft	Foot or feet
GHG	Greenhouse gas
ICLEI	International Council for Local Environmental Initiatives
IECC	International Energy Conservation Code
IRR	Internal rate of return
kg	Kilogram
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
mmBtu	Million British thermal units
MSW	Municipal solid waste
NGP	New Generation Partners
NPV	Net present value
O & M	Operations and maintenance
P&Z	Planning and Zoning
PAYT	Pay As You Throw
POWER	Property Owners Win with Efficiency and Renewables
PV	Photovoltaic
RBES	Residential Building Energy Standard
RE	Renewable energy
tCO_2e	Tons of carbon dioxide equivalent
UTC	Urban tree canopy
UVM	University of Vermont
VEC	Vermont Environmental Consortium
VESH	Vermont Energy Star Homes
VMT	Vehicle miles traveled
VT	Vermont
VTC	Vermont Technical College
VTUCFD	Vermont Urban Canopy and Forestry Department
yr	Year

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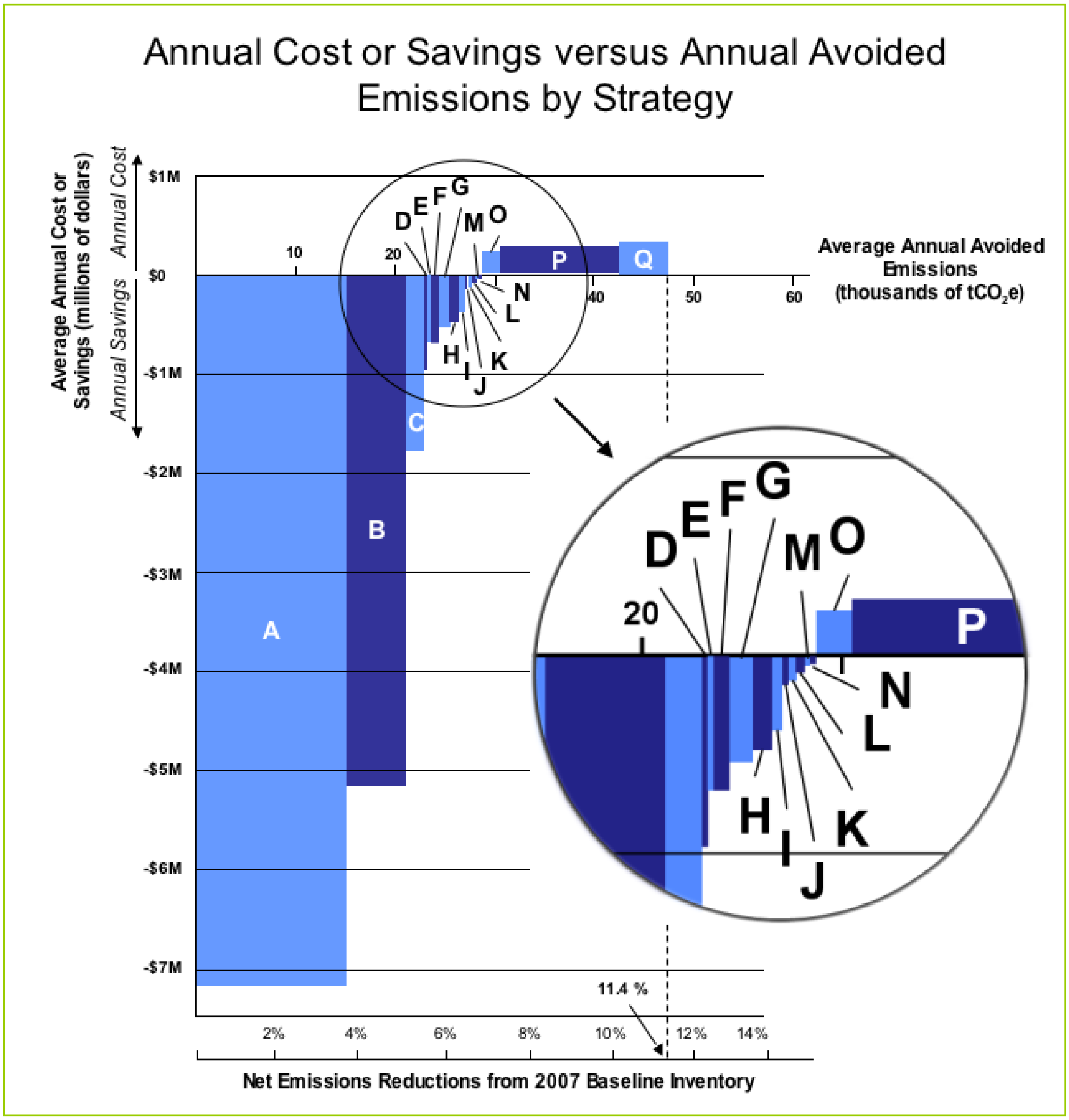
1. Executive Summary

The City of Burlington is in the process of updating its Climate Action Plan - first developed and released in 1999. A municipal GHG emissions inventory was conducted and emission reduction targets of 20% below 2007 levels by 2020 and 80% by 2050 were established. The City of Burlington then facilitated a series of public, multi-stakeholder meetings that yielded over 200 recommended GHG mitigation strategies. Following a preliminary strategy filtering process, a cost-carbon-benefit analysis of the remaining strategies was performed and a cost-carbon abatement curve was created that shows the relative “carbon bang for each investment buck” for each strategy analyzed. The results of this analysis are detailed in this report.

The overarching purpose of this work is to analyze and describe the financial characteristics and GHG reduction potential of the strategies assessed and to determine which strategies might reduce emissions most cost-effectively. The analysis utilized seven assessment parameters for each strategy: initial capital investment, total capital investment, average annual costs/savings, internal rate of return, net present value, average annual avoided emissions, and cost per ton of avoided emissions.

A discussion of the analysis methodology as well as the financial and environmental parameters used is provided. Each strategy description includes the current status of the measure (if applicable), the proposed changes from business-as-usual, the leading assumptions, and how the strategy performed according to financial and environmental parameters. High-quality, local and regional data was used to the extent practicable. Local and regional experts were consulted to obtain data and provide guidance on current practices, reasonable assumptions, and potential for each of the strategies analyzed. Consistent with climate action planning methodology, our analysis aggregates all costs, savings, and GHG reductions - regardless of who would bear abatement costs or benefit from savings - to reflect the society-wide net impact of implementing a given strategy.

To most effectively support the selection of actionable carbon reduction strategies and to provide a foundation for the City’s CAP, the strategies analyzed are presented in a cost-carbon abatement curve in Figure 1ES below. This graphical format, based directly on results from the strategy analysis, illustrates the strategies that will reduce GHG emissions most cost-effectively.



*Consistent with climate action planning methodology, our analysis aggregates all costs, savings, and GHG reductions - regardless of who would bear abatement costs or benefit from savings to reflect the society-wide net impact of implementing a given strategy.

Figure 1ES: Cost-Carbon Abatement Curve

A - Reduce community VMT.
B - Implement POWER program.
C - Require new commercial construction to follow Core Performance guidelines.
D - Implement McNeil district heating project.
E - Reduce government VMT.
F - Implement BED AMI program.
G - Implement government vehicle retirement and replacement program.
H - Implement residential PAYT program.
I - Implement “Solar on Schools.”
J - Implement government alternative-commuting program.
K - Implement BED “Renewable Energy Resource Rider” program.
L - Implement deep energy efficiency program in government buildings.
M - Replace existing streetlights with LEDs.
N - Require new residential construction to be VESH qualified.
O - Implement residential organics collection program.
P - Increase the UTC.
Q - Implement a digester for organic waste.

Of the strategies analyzed, three (Reduce community VMT, Implement POWER program, and Require new commercial construction to follow Core Performance guidelines) offer the greatest potential for annual cost savings. Collectively, these three strategies comprise nearly half of the estimated carbon reductions and will save the City, citizens, and other stakeholders more than $14 million each year. If all of the strategies analyzed were implemented, 47,392 tCO2e would be avoided. This would be equivalent to an 11.4% reduction from the 2007 baseline inventory.

Ultimately, the City of Burlington will consider this analysis, along with other strategies that were not analyzed, to determine which strategies correspond best with their priorities, financial resources, co-benefits, public will, and a range of other factors. To maximize avoided emissions, cost-effectiveness, and operational efficiencies, some strategies may best be implemented in conjunction with others.

Implementing some combination of these and other strategies will enable the City of Burlington to make significant progress towards achieving its GHG emissions reduction goals. Our analysis addressed the economic, financial, and GHG emissions impacts of each strategy. It did not, however, address all critical information that should be considered when deciding whether to implement these strategies. To understand the full impact of a strategy, both in financial and environmental terms, further analysis is needed before implementation occurs.

2. Introduction

Since 2008, the City of Burlington has been in the process of updating its Climate Action Plan (CAP) - first developed and released in 1999. After conducting a comprehensive greenhouse gas (GHG) emissions inventory using the International Council for Local Environmental Initiatives (ICLEI) municipal GHG inventory framework and software, the City facilitated a series of public, multi-stakeholder meetings that yielded over 200 recommended carbon mitigation strategies. With the help of American Recovery and Revitalization Act funds, Spring Hill Solutions, a Burlington-based carbon-management, clean energy, and business sustainability consulting firm, was contracted to filter, analyze, and prioritize these strategies. The goal of this process is to define a set of actionable GHG mitigation strategies that will: (1) form the foundation of the City's CAP; (2) provide the City with a framework to guide decisions on emissions reductions strategies, and (3) better prepare the City to reach its GHG reduction target of 20% of 2007 emission levels by 2020 and 80% by 2050.

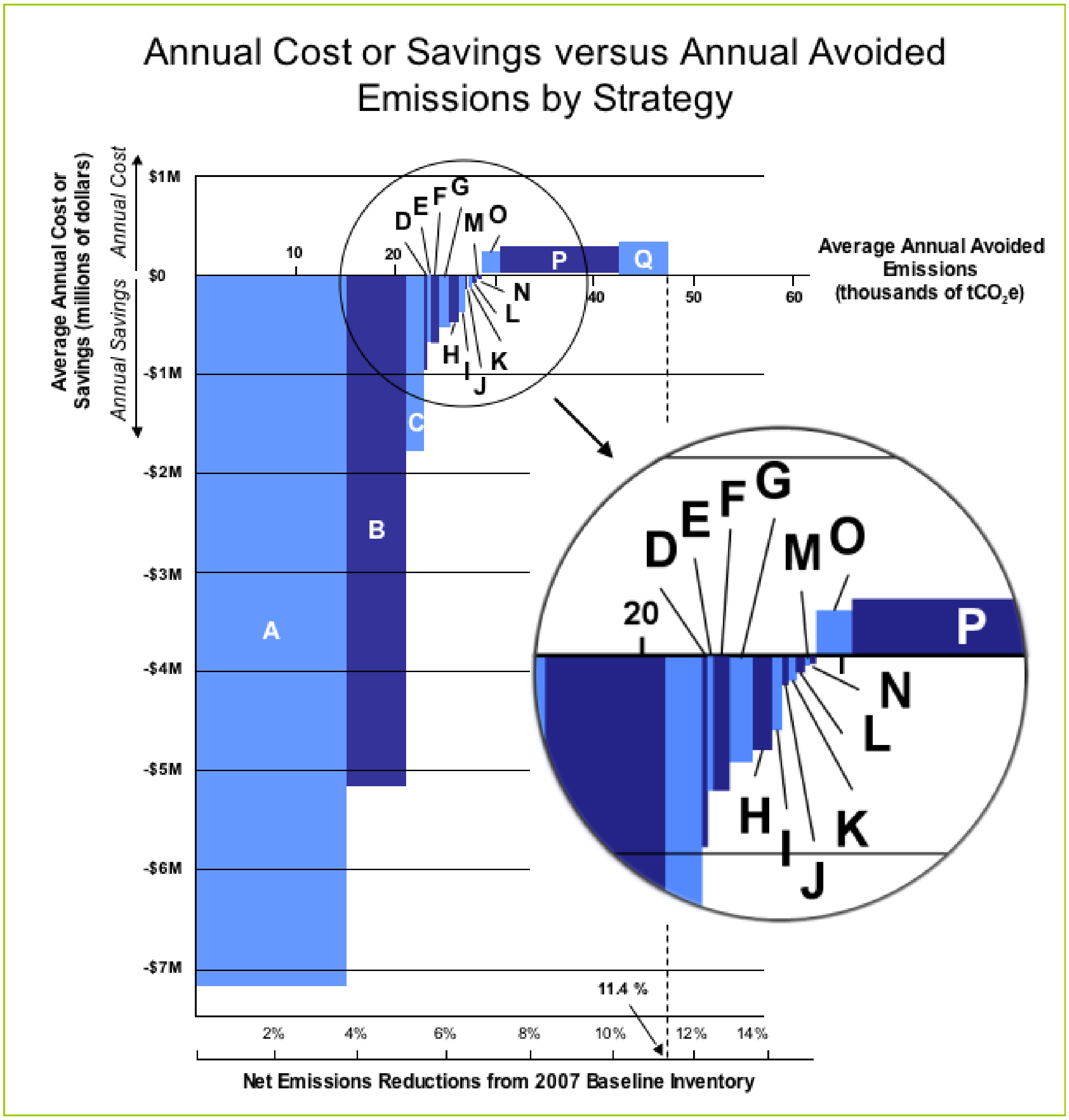
Spring Hill's work for the City of Burlington includes three main tasks: (1) preliminary strategy filtering; (2) cost-carbon-benefit analysis; and (3) final strategy prioritization. Over 200 recommended strategies were sorted into three color-coded categories according to their suitability for further analysis. Information on the preliminary strategy filtering can be found in Appendix A. For the strategies deemed most suitable for further analysis, a cost-carbon-benefit analysis was conducted which focused on their financial characteristics and GHG emissions reduction potential. More information on the strategy cost-carbon-benefit analysis can be found in Appendix B. Finally, the strategies are shown, based directly on results from the strategy analysis, on a cost-carbon abatement curve.

This report summarizes the results of the analysis and its graphical representation, the cost-abatement curve. A discussion of the strategy analysis methodology and an overview of financial and environmental parameters are provided. Each strategy description includes the current status of the measure (if applicable), the proposed changes from business-as-usual, the leading assumptions, and how the strategy performed according to financial and environmental parameters.

3. Results and Discussion

Cost-Carbon Abatement Curve

To most effectively support the selection of actionable carbon reduction strategies and to provide a foundation for the City's CAP, the strategies analyzed are presented in a customized cost-carbon abatement curve in Figure 1 below. This graphical format, based directly on results from the strategy analysis, illustrates the strategies that will reduce GHG emissions most cost-effectively.



*Consistent with climate action planning methodology, our analysis aggregates all costs, savings, and GHG reductions - regardless of who would bear abatement costs or benefit from savings to reflect the society-wide net impact of implementing a given strategy.

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Each column on the graph above represents an analyzed strategy. The width of each column indicates the average annual avoided emissions achieved through implementing a strategy. The height of each column indicates the average annual cost or savings associated with strategy implementation. Columns below the horizontal axis (negative cost) designate strategies that will result in an annual savings or net benefit, and therefore represent the “low-hanging fruit” opportunities that will both save money and avoid emissions. Columns above the horizontal axis (positive cost) designate strategies that will result in an annual cost, and therefore may be considered lower priority. The net emissions reduction scale shows the emissions reductions as a percentage of the City of Burlington’s 2007 baseline inventory.

Of the strategies analyzed, three (Reduce community VMT, Implement POWER program, and Require new commercial construction to follow Core Performance guidelines) offer the greatest potential for annual cost savings. Collectively, these three strategies comprise nearly half of the estimated carbon reductions and will save the City, citizens, and other stakeholders more than $14 million each year. If all of the strategies analyzed were implemented, 47,392 tCO_2e would be avoided. This would be equivalent to an 11.4% reduction from the 2007 baseline inventory.

It is important to note that co-benefits (e.g., the effects of strategy implementation other than carbon emissions and cost) may exist and are not reflected in the analysis or graph, but should be considered when prioritizing the employment of these strategies. Depending on the strategy, co-benefits might include increased water quality, improved soil retention, increased shading, improved human health and safety, enhanced public visibility and marketability, increased local economic activity, and the creation of educational opportunities.

Cost-Carbon-Benefit Analysis

The purpose of the analysis process is to analyze and describe the financial characteristics and GHG reduction potential of the strategies previously deemed suitable for analysis; and to determine which strategies reduce emissions most cost-effectively. The analysis utilized seven assessment parameters for each strategy:

- Initial capital investment
- Total capital investment
- Average annual costs/savings
- Internal rate of return
- Net present value
- Average annual avoided emissions
- Cost per ton of avoided emissions

The overall goal of our methodological approach was to gather and use high-quality, local, and regional data to the extent practicable. Local and regional experts were consulted to obtain data and provide guidance on current practices, reasonable assumptions, and potential for each of the strategies analyzed. This required extensive dialogue and follow-up with these experts. If local data did not exist, regional data was extrapolated from as appropriate. Efforts were made to ensure that the data collected and the assumptions used for each strategy were informed by the experts to ensure transparency, consistency, and accuracy.

The City of Burlington’s CAP is a multi-stakeholder initiative requiring careful and non-conventional financial and GHG accounting. While most of the strategy-related costs and savings will impact all City residents, some will only affect people who participate in a given strategy such as those who change the way they commute to work, or property owners that take advantage of long term financing of energy efficiency improvements. However, the GHG reductions generated by strategy implementation will benefit all stakeholders. The methodology first determined the relevant stakeholders (e.g. taxpayers, ratepayers, City departments, and property owners), costs, savings, and GHG reductions associated with a given strategy. Then, consistent with climate action planning methodology elsewhere, our analysis aggregates all costs, savings, and GHG reductions – regardless of who would bear abatement costs or benefit from abatement savings – to reflect the society-wide net impact of implementing a given strategy.

This analysis addresses the economic, financial, and GHG emissions impacts of each strategy. It does not, however, address all critical information that should be considered when deciding whether to implement these strategies. Most importantly, our analysis does not attempt to consider or quantify the co-benefits associated with strategy implementation. Depending on the strategy, co-benefits might include increased water quality, improved soil retention, increased shading, improved human health and safety, enhanced public visibility and marketability, increased local economic support, and the creation of educational opportunities.

The results of the Cost-Carbon-Benefit Analysis are summarized in Table 1 below, sorted by annual cost or savings per ton of avoided emissions ($/tCO_2e$). Following international standards, we express GHG emissions in metric tons of carbon dioxide equivalent (tCO_2e). This reflects the fact that there is more than one type of GHG considered in this assessment and each has a different climate impact relative to carbon dioxide. Please note that negative numbers and costs are in red and in parenthesis.

Table 1: Cost-Carbon-Benefit Analysis

Strategy	Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)	
Discount Rate 9% Timeframe 25 years									
Implement McNeil district heating project.	Renewable Energy	($4,200,000)	($23,100,000)	$961,272	5%	($5,873,688)	186	4,273	Annual Savings
Reduce government VMT.	Government Transportation	$0	$0	$681,485	Infinite	$5,652,451	167	4,086	
Require new residential construction to be VESH qualified.	Energy Efficiency	($1,714)	($42,857)	$36,924	98%	$207,874	30	1,223	
Implement BED AMI program.	Energy Efficiency	($3,471,966)	($3,471,966)	$676,667	15%	$2,211,948	466	1,154	
Require new commercial construction to follow Core Performance guidelines.	Energy Efficiency	($582,000)	($14,550,000)	$1,780,802	22%	$7,490,927	1,947	903	
Implement POWER program.	Energy Efficiency	($235,175)	($4,525,000)	$5,173,195	29%	$21,832,538	6,161	838	
Implement “Solar on Schools.”	Renewable Energy	($2,144,000)	($2,144,000)	$365,427	29%	$2,199,821	533	525	
Implement residential PAYT program.	Waste Reduction and Recycling	$0	$0	$466,658	Infinite	$4,583,789	943	495	
Reduce community VMT.	Community Transportation	$0	$0	$7,200,583	Infinite	$59,723,917	15,289	471	
Implement government vehicle retirement and replacement program.	Government Transportation	($125,000)	($625,000)	$531, 219	93%	$4,282,645	1,177	447	
Implement government alternative-commuting program.	Government Transportation	$0	$0	$139,346	Infinite	$1,155,776	339	411	
Implement BED “Renewable Energy Resource Rider” program.	Renewable Energy	($857,750)	($4,288,750)	$124,524	3%	($1,586,927)	462	195	
Replace existing streetlights with LEDs.	Energy Efficiency	($156,750)	($1,567,500)	$42,475	5%	($314,437)	293	124	
Implement deep energy efficiency program in government buildings.	Energy Efficiency	($2,027,221)	($20,272,208)	$78,690	1%	($8,577,448)	513	(5)	Annual Cost
Increase the UTC.	Urban Forestry	($132,300)	($3,424,500)	($284,568)	N/A	($2,468,775)	12,087	(24)	
Implement a digester for organic waste.	Renewable Energy	($4,950,000)	($4,950,000)	($334,707)	N/A	($8,237,684)	5,017	(106)	
Implement residential organics collection program.	Waste Reduction and Recycling	($855,000)	($855,000)	($218,313)	N/A	($3,126,170)	1,782	(142)	

*Consistent with climate action planning methodology, our analysis aggregates all costs, savings, and GHG reductions - regardless of who would bear abatement costs or benefit from savings to reflect the society-wide net impact of implementing a given strategy.

Overview of Financial and Environmental Analysis

To better enable the comprehension and interpretation of the table above, an overview of the financial and environmental parameters and language is provided below.

- A 25 year timeframe was used for the analysis. While this is common in the assessment of renewable energy projects, it is important to note that the lifetime of each strategy does not necessarily correspond to the analysis timeframe. Some strategy lifetimes are shorter and many are longer. The length of the timeframe impacts both the financial and environmental performance of the strategy. As the length of the timeframe increases, the results become more uncertain.

- The discount rate is used to discount future cash flows to determine their present value, or value in today's dollars. A 9% discount rate was used for this analysis. Due to the number and variety of stakeholders associated with the City of Burlington's CAP initiative, it is very difficult to determine a discount rate that accurately reflects the average cost of capital. As a result, the discount rate used is typical in climate and environmental planning, and is relatively conservative.

- Some strategies have a $0 initial capital investment. This means that the strategy does not have any upfront capital costs. The total capital investment captures the initial capital plus any phased-in capital costs.

- The average annual cost/savings includes all incremental annual costs related to a strategy over the evaluated timeframe (e.g., O & M), and all incremental annual savings over the same time period (e.g., avoided natural gas purchases).

- The internal rate of return (IRR) is used in capital budgeting to measure and compare the profitability of an investment or project. It is the discount rate that equates the present value of the project's free cash flows with the project's initial capital investment. Strategies with an IRR higher than the discount rate are generally considered sound investments. Strategies with an "infinite" IRR generate positive cash flows every year of the analysis timeframe, while strategies with "N/A" for their IRR generate negative cash flows every year.

- Net present value (NPV) is used in capital budgeting to analyze the profitability of an investment or project. It is equal to the present value of an investment's future annual free cash flows minus the initial capital investment. Strategies with an NPV greater than $0 are generally considered sound investments. A negative NPV means that the present value of a given strategy's future free cash flows is negative or that a strategy will not pay for itself over the analysis timeframe. This occurs when the IRR is either less than the discount rate or "N/A".

- The average annual avoided emissions, stated in terms of tCO_2e, sums the timeframe avoided emissions and divides it by the 25-year timeframe.

- The cost/savings per ton of avoided emissions divides the total costs or savings of the strategy by the total avoided emissions during the analysis timeframe. In this column, numbers in black are savings per ton of avoided emissions and numbers in red and parenthesis are costs per ton of avoided emissions.

More detail on the data, assumptions, and methodologies used for each strategy can be found in Appendix B.

Description of Strategies

Implement McNeil district heating project.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Renewable Energy	($4,200,000)	($23,100,000)	$961,272	5%	($5,873,688)	186	4,273

Currently, the McNeil power plant in Burlington's Intervale burns wood chips to generate electricity at 25% efficiency, meaning only 25% of the energy of the fuel is actually converted into usable electricity. The 75% of the energy that is not being converted to electricity is waste energy that mainly leaves the plant through the smokestack and cooling towers. The plant was originally designed for district heating and has steam extraction ports that can be used to divert some of the energy.

The proposed strategy is to use McNeil as a heat source for a district heating system that would improve McNeil's efficiency, make use of some of its waste heat, and provide heat to consumers at a relatively low and predictable price. The heating network would extend from the plant through the Old North End to downtown. The strategy assumes that approximately 20% of the City of Burlington's heat would eventually be provided by the district heating system, that all heat provided would replace natural gas, and the system would be built incrementally over a 13-year period.

This strategy has the highest savings per ton of avoided emissions and the highest total capital investment. Due to the low GHG emissions content of the displaced fuel, this strategy avoids a relatively small amount of emissions.

Reduce government vehicle miles traveled.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Government Transportation	$0	$0	$681,485	Infinite	$5, 652, 451	167	4,086

The City of Burlington's government vehicle miles traveled (VMT) was 2,219,361 in 2007 comprised of City government's fleet vehicular travel in a variety of vehicle and fuel types.

The proposal is to reduce government VMT by 10% through a combination of travel substitutions (combining trips, video conferencing and conference calling, walking and biking, ridesharing and carpooling, and using mass transit). This strategy is assumed to have no costs because most of the reduction strategies are free or have nominal costs and the savings from avoided vehicle operations and maintenance will offset any VMT reduction costs such as using mass transit. The savings generated as a result of this strategy are a function of avoided fuel consumption. This strategy is not intended to be prescriptive in terms of how the VMT reduction is achieved, but rather show the financial and environmental benefits of a 10% reduction in government VMT.

This strategy requires no capital investment, generates a positive cash flow every year, and has the second highest savings per ton of avoided emissions.

Require new residential construction to be Vermont Energy Star for Homes qualified.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($1,714)	($42,857)	$36,924	98%	$207,874	30	1,223

Currently, new residential construction is subject to the Vermont Residential Building Energy Standard (RBES) which is based on the Council of American Building Officials' Model Energy Code (1995 CABO-MEC) and Vermont amendments to the 2000 IECC. On January 1, 2011, Vermont's Energy Code will be updated to reflect the 2009 IECC, which the DOE estimates will result in a 15% reduction in energy use compared to the 2006 version. This aggressive new code means efforts to improve new building efficiency will be compared against an improving baseline.

The proposed strategy is to require new residential construction to be Vermont Energy Star for Homes (VESH) qualified. Energy Star Homes are designed and built using best practices to save energy by reducing air leaks and thermal bypass, and by requiring high efficiency heating systems and appliances. It is assumed that VESH homes will maintain the same level of performance beyond code compliant buildings as they have in the past even as code becomes stricter. Renovations were not included because of the wide range of possibilities, the reduced effectiveness of efficiency improvements when done piecemeal as opposed to as a system, and the lack of detailed permit records to determine the rate of relevant renovations.

Since 2003, only twenty-five permits have been issued for new residential construction in the City of Burlington. Not only is there a slow rate of new construction, but there is already a high participation rate in the Energy Star program, which is due in part to a coordinated effort by Vermont Gas, BED, and Efficiency Vermont to promote the program. Additionally, in Vermont, the consumer does not pay the program's administration fee and incentives are available.

Designing and building efficiency into new buildings is much simpler than adding it later. While the slow rate of new building limits the overall impact of this strategy, the energy savings for each building are high, giving this strategy the highest, non-infinite IRR and a high savings per ton of avoided emissions.

Implement BED advanced meter infrastructure program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($3,471,966)	($3,471,966)	$676,667	15%	$2,211,948	466	1,154

BED currently uses traditional electrical usage meters that feature no communication capability. Customers receive their usage data in monthly totals that are not useful in determining what demands the most electricity in their homes and businesses or how much electricity is used during peak times when energy is more costly and has higher emissions.

BED is planning to install advanced meter infrastructure (AMI), commonly referred to as "smart meters." AMI would replace all existing meters, provide data to BED and its customers in 15-minute intervals, and offer two-way communication. This better data will be combined with incentive(s) to reduce peak electricity use, cost, and emissions. There are pilot programs going on around the state to determine what type(s) of information and incentives best motivate people to use less peak electricity.

BED estimates 5-10% of peak power consumption will be shifted to off-peak times when emissions are lower and electricity is cheaper. Due to the relatively short amount of time that is considered peak, only 0.55 of BED's total annual energy load is likely to be affected by this strategy. While not considered as part of this analysis, this strategy will reduce miles traveled associated with meter reading.

This strategy has positive financial results and performs well in terms of savings per ton of avoided emissions.

Require new commercial construction to follow Core Performance guidelines.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($582,000)	($14,550,000)	$1,780,802	22%	$7,490,927	1,947	903

New commercial construction is currently subject to the Vermont Commercial Building Energy Standard (CBES), which is based on IECC 2004 and ASHREA 90.1-2004. CBES covers alterations, renovations, and repairs on commercial buildings, in addition to new construction. Twenty-five percent of Burlington's existing commercial buildings meet the CBES, while 95% of new commercial construction meets or exceeds it.

The proposed strategy requires new commercial construction to follow Core Performance guidelines, a program offered by BED, Efficiency Vermont, and Vermont Gas. Core Performance is a prescriptive guide to reduce energy use in commercial buildings by 20-30%. It was developed to avoid the time and expense of modeling the energy use of every new building and was derived using energy modeling of batches of buildings by selecting the features found consistently in high performing buildings.

Only new construction was considered in this analysis because of the wide range of renovation possibilities, the reduced effectiveness of efficiency improvements when done piecemeal as opposed to as a system, and the lack of detailed permit records to determine the rate of relevant renovations. Commercial buildings vary widely in size; 30,000 ft^2, which is the center of the range of building sizes used to develop Core Performance, was used as the average for newly constructed buildings affected by this strategy. Commercial construction was assumed to cost $175/$ft^2$.

This strategy has a high total capital investment, but performs well in terms of its average annual avoided emissions.

Implement Property Owners Win with Efficiency and Renewables program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($235,175)	($4,525,000)	$5,173,195	29%	$21,832,538	6,161	838

Various programs exist to help Burlington property owners save energy. While BED does not currently offer a loan program to finance efficiency projects, they do offer free energy audits, technical assistance, and rebates on efficient appliances, as well as free CFLs and low flow showerheads to landlords. Vermont Gas offers an attractive program for consumers with high gas use, including a free audit, payment of one-third of the cost of recommended improvements for owner occupied buildings and one-half for rental properties, and low interest loans for the remaining cost. Champlain Valley Office of Economic Opportunity's (CVOEO) weatherization program for low income resident performs audits and recommended improvements at no cost to the resident. Both BED and Vermont Gas have agreements with CVOEO where they pay for a portion of the work performed. This allows weatherization to achieve deeper energy savings on the apartments and houses worked on.

The Property Owners Win with Efficiency and Renewables (POWER) program allows property owners to access long term municipal financing to make eligible energy efficiency and renewable energy improvements to their buildings. This concept is known as Property Assessed Clean Energy (PACE) or Clean Energy Assessment District (CEAD) in other places. By opting into a special tax assessment district, property owners pay for these improvements via property taxes over a period up to twenty years. BED will screen and approve projects, and terms will not exceed the useful life of the improvement. The analysis phases-in implementation costs and energy savings over the first ten years of the program, with an estimated total of 400 projects.

As shown by its NPV and average annual avoided emissions, this strategy has the potential for a large reduction of emissions, while also being financially effective and allowing the implementation of projects that may not otherwise be economically feasible from the property owner's perspective.

Implement "Solar on Schools."

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Renewable Energy	($2,144,000)	($2,144,000)	$365,427	29%	$2,199,821	533	525

Currently, the City of Burlington's schools only have small demonstration solar PV generation projects.

"Solar on Schools" is a proposal to put solar PV panels on the City of Burlington schools' roofs. The panels on seven schools will be owned and operated by New Generation Partners, a private third-party development partner who can take advantage of federal and state tax credits, which the City cannot. Lease payments will be made to the school for use of the roof space and electricity will be sold to BED at a contracted rate. Half of the energy output is assumed to occur at peak times and half off-peak.

Due to the creative financing arrangement, as well as the size of proposed project, this strategy is both financially and environmentally effective.

Implement residential Pay as You Throw program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Waste Reduction and Recycling	$0	$0	$466,658	Infinite	$4,583,789	943	495

The City of Burlington currently lacks an incentive-based solid waste collection program. Residents elect to use any one of several private waste haulers to collect their trash. These haulers receive a license from the City of Burlington to operate within city limits and charge their customers based on the size of their collection container and/or frequency of pick-up. Residents also have the option to bring their trash to one of several Drop-Off Centers or Transfer Stations, operated by CSWD. At these locations, residents pay for disposal by the bag.

This proposed strategy would change the current residential collection payment system to a system in which residents pay per unit of trash collected. Programs like these result in a decrease in solid waste, as well as overall cost savings to participants. The current physical collection system would remain the same.

This strategy requires no capital investment, generates a positive cash flow every year, and performs well in terms of average annual avoided emissions.

Reduce community vehicle miles traveled.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Community Transportation	$0	$0	$7,200,583	Infinite	$59,723,917	15,289	471

The City of Burlington's community vehicle miles traveled (VMT) was 257,837,788 in 2007 comprised of vehicular travel in a variety of private vehicles and fuel types.

This proposed strategy would reduce community VMT by 10% through a combination of travel substitutions (combining trips, telecommuting, walking and biking, ridesharing and carpooling, and using mass transit). This strategy is assumed to have no costs because most of the reduction strategies are free or have nominal costs and the savings from avoided vehicle operations and maintenance will offset any VMT reduction costs such as using mass transit. The savings generated as a result of this strategy are a function of avoided fuel consumption. This strategy is not intended to be prescriptive in terms of how the VMT reduction is achieved, but rather show the financial and environmental benefits of a 10% reduction in community VMT.

Due the relatively high amount of vehicle miles traveled by the average Vermont resident, as well as the large number of City residents impacted, this strategy has the greatest emissions reduction potential, the highest average annual savings, and the highest NPV.

Implement government vehicle retirement and replacement program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Government Transportation	($125,000)	($625,000)	$531, 219	93%	$4,282,645	1,177	447

The City of Burlington currently lacks a comprehensive vehicle retirement and replacement program, as well as a city-wide fleet management system.

This strategy will result in retiring 5% of the government's vehicle fleet and replacing 25% of the gasoline-powered vehicles with hybrids. A 5% vehicle retirement rate is assumed to result in a 5% reduction in vehicle miles and a 5% reduction in emissions. The City of Burlington has approximately 250 fleet vehicles. This strategy would retire twelve vehicles and replace 62 gas-powered vehicles with hybrids over a five year period.

This strategy has strong financial performance with a very high return on a low total capital investment. Its average annual avoided emissions are above average.

Implement government alternative-commuting program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Government Transportation	$0	$0	$139,346	Infinite	$1,155,776	339	411

The City of Burlington does not currently have a commuting program or commuting incentives for its employees. In 2007, employees commuted 5,158,036 miles.

This proposed strategy would encourage employees to commute through emissions-free modes (telecommuting, walking, and biking), as well as less impactful modes (car pooling, ridesharing, and mass transit). It would result in a 10% reduction in government employee commuting miles. This strategy is assumed to be cost neutral because most reduction strategies are free or have nominal costs and the savings from avoided vehicle operations and maintenance will offset the VMT reduction costs such as using mass transit. This strategy is not intended to be prescriptive in terms of how the program would operate, but rather show the financial and environmental benefits of a government alternative-commuting program.

This strategy requires no capital investment, generates a positive cash flow every year, and performs below average in terms of average annual avoided emissions.

Implement BED "Renewable Energy Resource Rider" program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Renewable Energy	($857,750)	($4,288,750)	$124,524	3%	($1,586,927)	462	195

Currently, per Vermont Public Service Board rules, BED offers standard 12-month net metering, which does not incentivize electricity generation beyond consumption.

The proposed Renewable Energy Resource Rider (which currently only includes solar and is sometimes called "solar rider") is a program to encourage residents and businesses to install solar PV panels. This is achieved through setting a predictable and stable rate above the retail cost of electricity, and therefore above the rate for standard net metered production. BED calculated the rate based on their avoided cost of electricity during the hours when solar is producing the most. At those times, power is currently purchased from distant peaking power plants. Transmission costs were therefore included in the calculation. Solar PV is the only resource approved at this time and the only one modeled. Most installations are assumed to be residential. Half of the energy output is assumed to occur at peak times and half off-peak. The cap on the program, 2% of BED's 1996 peak, is assumed to be reached during the analysis timeframe, although BED has the option of continuing beyond the cap.

Although this strategy produces savings, the IRR is below the discount rate and therefore – from a purely financial perspective – would be an underperforming investment. Among the considered strategies, it performs at the low end of average annual avoided emissions.

Replace existing streetlights with LEDs.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($156,750)	($1,567,500)	$42,475	5%	($314,437)	293	124

BED currently maintains a mix of high-pressure sodium, metal halide, and mercury vapor streetlights for the City of Burlington. A pilot project is underway on selected streets to test the durability and longevity of LED streetlights in Burlington.

The strategy proposes to replace all existing streetlights (approximately 3,300) in the City of Burlington with LEDs over a 10-year period. The current distribution of existing streetlights is assumed to be 60% high-pressure sodium, 35% metal halide (10% decorative style and 25% standard), and 5% mercury vapor.

Despite producing savings, the IRR is below the discount rate and therefore – from a purely financial perspective – this strategy would be an underperforming investment. This is mainly a function of how expensive LEDs are today, the lack of certainty regarding their longevity, and that savings are not realized within the analysis timeframe.

Implement deep energy efficiency program in government buildings.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Energy Efficiency	($2,027,221)	($20,272,208)	$78,690	N/A	($8,577,448)	513	(5)

The majority of city government buildings in the City of Burlington are inefficient in their use of energy. Energy efficiency upgrades and retrofits have been implemented inconsistently and, with the exception of lighting, generally occur only when replacement is demanded. Many government buildings, including Burlington's schools, have been through a lighting retrofit from T12 to T8 and are now undergoing a retrofit from T8 to super-T8. In contrast, HVAC and mechanical systems are under-performing and many buildings are in need of thermal envelope improvements. The schools have obtained a $9M bond to address the most critical needs which include significant energy efficiency improvements to three schools.

The strategy proposes to perform deep energy efficiency improvements in all government buildings. Deep energy retrofits are extensive renovations to existing structures that use the latest in energy-efficient materials and technologies and result in significant energy reductions. The condition of municipal buildings is assumed to be similar to schools, and renovations planned for Barnes, Smith, and Flynn represent the type and cost of improvements that would be done citywide under this strategy. However, renovations at these schools will also include non-energy related upgrades. Therefore, the cost factor of renovations for other buildings was discounted by 50%. Renovations would be phased in over a 10-year period.

This strategy has the second highest total capital investment required and savings are not realized within the analysis timeframe. This is a result of both the extent of deferred maintenance and the relatively high cost of retrofitting existing buildings for energy efficiency.

Increase the urban tree canopy.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Urban Forestry	($132,300)	($3,424,500)	($284,568)	N/A	($2,468,775)	12,087	(24)

Currently, 43% of the City of Burlington's land area, 2648 acres, is covered by tree canopy. The Trees & Greenways Section of the Department of Parks & Recreation manages the urban forestry program. This program currently includes 8,500 street trees, 3,100 park trees, and 150 acres of forested parkland. Approximately 150-200 new street trees are planted each year. The number of existing trees and annual tree plantings on private property are not documented or monitored.

This proposed strategy would increase the urban tree canopy (UTC) by planting a total of 588 trees per year and by maintaining the existing urban tree canopy. This would be achieved both on public and private property. In conjunction with existing tree maintenance and conservation practices, this rate of tree planting would increase the UTC to 50% in 40 years and would be equal to 125 additional acres planted in trees. This strategy, however, only considers the first 25 years of tree planting. This analysis accounted for the avoided emissions that would occur as a result of sequestration and net carbon storage. While not considered as part of this analysis, this strategy will also result in a reduction of energy usage and emissions due to shading, which directly lowers cooling energy and indirectly lowers cooling energy by reducing the urban heat island effect.

This strategy has a high total capital investment and does not generate a return on investment as it has no direct income and avoids no direct cost. However, it has the second highest average annual avoided emissions.

Implement a digester for organic waste.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Renewable Energy	($4,950,000)	($4,950,000)	($334,707)	N/A	($8,237,684)	5,017	(106)

The City of Burlington does not currently utilize digesters for organic waste.

The proposed digester system would take community organic waste and manure from local farms to process in a strategically located CHP facility. In addition to generating electricity and heat, this project would create a bi-product to be sold as bulk compost/soil amendment. Moreover, it would reduce GHG emissions by producing cleaner electricity and heat and from avoided landfill emissions. The proposed digester and CHP system's capacity would have a capacity of 400 kW and was modeled on the Vermont Technical College's current digester project.

This strategy has a high initial capital investment and the highest average annual costs. However, it performs very well in terms of average annual avoided emissions.

Implement residential organics collection program.

Category	Initial Capital Investment ($)	Total Capital Investment ($)	Average Annual Cost / Savings ($)	Internal Rate of Return (%)	Net Present Value ($)	Average Annual Avoided Emissions (tCO_2e)	Cost / Savings per Ton of Avoided Emissions ($\$/tCO_2e$)
Waste Reduction and Recycling	($855,000)	($855,000)	($218,313)	N/A	($3,126,170)	1,782	(142)

The City of Burlington does not currently have a municipal organic collection program. There are a few stand-alone organic collection services offered by the City of Burlington including a fall leaf pick-up day and the Merry Mulch program. Casella/All Cycle and Gauthiers offer organic collection services to businesses. In addition, Earth Girl Composting offers organic collection services for events, households, and non-food based businesses in Burlington. All existing organic services dispose of their organic material at the Intervale.

This proposed strategy would be modeled after the existing City residential recycling program and have a similar infrastructure and cost profile. The program would collect residential organic food waste (no yard waste) to be composted. Approximately 33% of land filled waste is organic matter, which can be composted and turned into a rich soil amendment. This program would not be mandatory and would be assumed to have a 50% participation rate.

This strategy generates a negative cash flow every year, but performs well in terms of average annual avoided emissions.

4. Conclusions and Next Steps

This report summarizes the results of a cost-carbon-benefit analysis of several GHG mitigation strategies and their graphical representation in a cost-abatement curve. Through providing a detailed description and illustration of the relative "carbon bang for each investment buck" for each strategy analyzed, this report is intended to be a decision-support tool for the City of Burlington in its climate action planning process.

Ultimately, the City of Burlington will consider this analysis, along with other strategies that were not analyzed, to determine which strategies correspond best with their priorities, financial resources, co-benefits, public will, and a range of other factors. To maximize avoided emissions, cost-effectiveness, and operational efficiencies, some strategies may best be implemented in conjunction with others.

Implementing some combination of these and other strategies will enable the City of Burlington to make significant progress towards achieving its GHG emissions reduction goals. Our analysis addressed the economic, financial, and GHG emissions impacts of each strategy. It did not, however, address all critical information that should be considered when deciding whether to implement these strategies. To understand the full impact of a strategy, both in financial and environmental terms, further analysis is needed before implementation occurs.

Appendix A: Task 1 Preliminary Strategy Filtering Report

1. Introduction

Since 2008, the City of Burlington has been in the process of updating its Climate Action Plan (CAP) – first developed and released in 1999. After conducting a comprehensive inventory using the International Council for Local Environmental Initiatives (ICLEI) municipal greenhouse gas (GHG) inventory framework and software, the City facilitated a series of public participatory, multi-stakeholder meetings that yielded over 200 recommended carbon mitigation strategies. With the help of American Recovery and Revitalization Act funds, Spring Hill Solutions, a Burlington-based carbon-management, clean energy, and business sustainability consulting firm, was contracted to filter, analyze, and prioritize these strategies. The goal of this process is to define a set of actionable GHG mitigation strategies that will: (1) form the foundation of the City's CAP; (2) provide the City with a carbon mitigation strategy decision-support framework, and (3) better prepare the City to reach its GHG reduction target of 20% of 2007 emission levels by 2020 and 80% by 2050.

Task 1 of this three-phase project entails a preliminary sort-and-filter process by which over 200 recommended strategies are separated into three color-coded categories according to their suitability for further, more detailed analysis – including financial characteristics and GHG reduction potential. The purpose of this Task 1 report is to:

- Describe the Task 1 methodology and preliminary strategy filtering rationale
- Describe the results of the Task 1 sort-and-filter process

2. Task 1 Strategy Sort-and-Filter Methodology

As an active participant in the public phase of the CAP process, Spring Hill recognizes and values the time and effort that have gone into the development of the proposed action strategies. Whether qualitative or quantitative in nature, these ideas represent powerful public participation and community buy-in from eight workgroups and over 100 volunteers. As such, each strategy was carefully considered as a part of Burlington's CAP process. However, in order to determine which of these opportunities is best suited to a more detailed cost-carbon-benefit analysis that generates meaningful and comparable results, Spring Hill has first undertaken a preliminary sort-and-filter process by which over 200 strategies were separated into three color-coded categories according to their suitability for further analysis:

- **Green-coded strategies** relate directly to the City's GHG emissions inventory, benefit from the availability of applicable data to warrant a detailed and quantifiable analysis, and are likely suited to near- or mid-term implementation that will result in emissions reductions and possible cost savings. Green strategies are deemed to be immediately assessable and quantifiable in terms of their capital investment, annual cost/savings, return on investment, GHG reduction impact, and dollars per ton of carbon reduced.
- **Yellow-coded strategies** relate directly to the City's GHG emissions inventory and may be effective in terms of reducing emissions. However, they will require greater specificity and extensive assumptions prior to being quantified in any rigorous way. Though these yellow strategies may require further development, they will likely be useful in considering as mid-term and long-term GHG reduction options. In addition to being

sorted by color, yellow strategies are further sorted along a 1-3 ranking scale with 1 being the most assessable and 3 being the least assessable.

- **Red-coded strategies** will have no or little impact on the City's GHG emissions inventory, are not easily assessable, may be cost-prohibitive and/or impractical, and/or are not suited to near- or mid-term implementation. Though not immediately useful, red strategies may provide fodder for future GHG reduction ideas and general City sustainability strategy development.

Figure A1 below illustrates the Task 1 sort-and-filter decision tree used during the preliminary strategy filtering process.

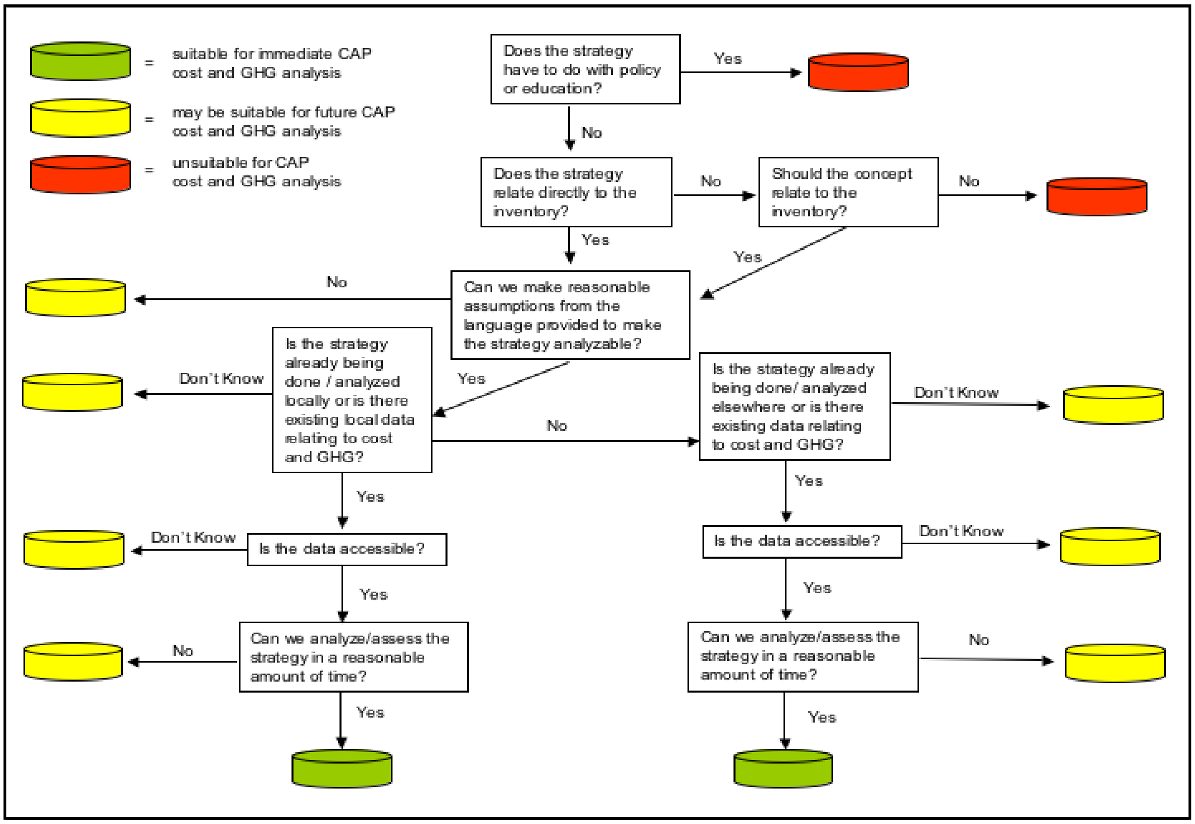

Figure A1: Task 1 Sort-and-Filter Decision Tree

During Task 1, Spring Hill has also drawn upon its experience in developing GHG mitigation strategies for other businesses and communities to: (1) modify scope or language associated with some of the original strategies in order to render them more quantifiable, and (2) suggest carbon mitigation strategies other than those appearing in the initial strategy list provided by the City. In keeping with the CAP goals, any additional suggested strategies will likely have a track record of success in other municipalities, have assessable and quantifiable carbon reduction impacts, and will be suited to near- or mid-term implementation in Burlington. Any strategy additions or edits have been documented and discussed with City staff.

For the purposes of transparency, accountability, and decision reproducibility, Spring Hill has gone to great lengths to document the Task 1 sort-and-filter process. This entailed recording details and key decisions associated with each strategy. Such a level of documentation is intended to allow CAP stakeholders (1) to understand the "how and why" of decisions made during the Task 1 sort-and-filter process and (2) to track information associated with each decision. Full Task 1 documentation is captured in the file *Burlington CAP Task 1 Analysis.xls*, which is available from appropriate City staff upon request.

3. Task 1 Strategy Sort-and-Filter Results

The Task 1 sort-and-filter process yielded 24 green-coded strategies (12%), 43 yellow-coded strategies (21%), and 140 red-coded strategies (68%). Of the 24 green-coded strategies, Spring Hill added nine. These additional strategies were derived from a variety of sources including local experts and organizations, City staff and departments, and other municipal climate action plans. A complete list of the filtered strategies with original language can be found in Appendices A1, A2, and A3.

The green strategies with revised language are listed below. Final strategy language will be determined at the completion of Task 2, the detailed strategy analysis.

Table A1: Green-Coded Strategies with Revised Language

Category	Strategy
1. Policy	None
2. Renewable Energy	Increase McNeil's Capacity Factor.
	Develop methane gas capture and electricity generation at all City wastewater treatment plants.
	Implement a Clean Energy Assessment District.
	Implement a "Solar City" project on city-owned buildings.
	Implement a "Solar on Schools" project.
	Implement a BED Solar Rider program.
	Implement McNeil CHP district energy project.
	Implement centralized digesters for food processing waste and high energy feed stocks.
3. Urban Forestry and Carbon Offsets	Plant an additional 620 acres of tree canopy. *
	Plant some number of trees each year. *
4. City Government Transportation	Retire one inefficient city fleet vehicle per department.
	Purchase hybrids and/or CNG vehicles for all administrative staff city fleet.
	Use a more aggressive biofuel mix for fleet vehicles.
	Implement a comprehensive alternative-commuting program (public transit, walking, biking, carpooling, and ridesharing) for city employees.
	Reduce City employee work miles by 10%.
5. Community Transportation	Reduce VMT by 10%.
6. Energy Efficiency in Buildings	Implement a comprehensive energy efficiency program in City buildings.
	Implement a BED "Smart Metering" program.
	Require all new construction and renovations to be Vermont Energy Star Homes qualified.
	Require all new construction and renovations for commercial buildings to exceed 2007 Commercial Building Energy Standards by 25%.
	Implement a comprehensive lighting retrofit in Burlington Schools.
	Implement a comprehensive streetlight retrofit in Burlington.
7. Local Farms, Gardens and Food Production	None
8. Waste Reduction and	Increase City's diversion rate by 25%.

Recycling	Implement a comprehensive composting program. *

* Some strategies do not relate to the inventory, but are green-coded because of their important carbon sequestration properties.

4. Conclusions

The Task 1 sort-and-filter process yielded 24 green strategies that relate directly to the City's GHG emissions inventory, benefit from the availability of applicable data to warrant a detailed and quantifiable analysis, and are likely suited to near- or mid-term implementation that will result in emissions reductions and possible cost savings. These strategies will (1) form the foundation of the City of Burlington's Climate Action Plan, (2) provide the City with a carbon mitigation strategy decision-making framework, and (3) better prepare the City to reach its GHG reduction target of 20% of 2007 emission levels by 2020 and 80% by 2050. Further refinement, analysis, and characterization of the 24 strategies will occur during the Task 2 and Task 3 project phases.

Appendix A1: Task 1 Green-Coded Strategies

Green-coded strategies relate directly to the City's GHG emissions inventory, benefit from the availability of applicable data to warrant a detailed and quantifiable analysis, and are likely suited to near- or mid-term implementation that will result in emissions reductions and possible cost savings. Green strategies are deemed to be immediately (or nearly so) assessable and quantifiable in terms of their capital investment, annual cost/savings, return on investment, GHG reduction impact, and dollars per ton of carbon reduced. The green-coded strategies in their original language are listed below.

Table A2: Green-Coded Strategies with Original Language

Category	Strategy
1. Policy	None
2. Renewable Energy	Take steps to increase McNeil's Capacity Factor from 65% to 80% (From BED's 2008 IRP).
	Fully develop methane gas capture and electric generation potential at the City's wastewater treatment plants.
	Follow legislative approval and implement use of clean energy financing districts for small-scale renewable energy generation projects (e.g., solar photovoltaics, solar hot water, home-scale geothermal, biomass co-generation, etc.).
	Fund the Solar City Project to minimize the occurrence of peak load by installing solar photovoltaic panels on city-owned buildings to provide 1MW aggregate power.
	Conduct feasibility study of district heating/cooling using waste heat from McNeil Station. Develop limited build out of project.
	Pursue diverse anaerobic digestion opportunities for CHP such as: the City's and UVM's wastewater treatment plants (UVM may be looking at this for combined use with dairy), centralized digesters for food processing waste or other high energy feedstocks, and household and/or other small-scale anaerobic digestion technologies as they become available.
3. Urban Forestry and Carbon Offsets	Plant an additional 620 acres of tree canopy.
	Plant ?? street trees each year (150-250 trees planted each year now).
4. City Government	Retire a minimum of one underused and inefficient city fleet vehicle per department.
	Purchase hybrids and/or CNG vehicles for all administrative staff city fleet.

Transportation	Continue the use of bio-fuels for city fleet with B5 in the winter and B20 in the summer.
5. Community Transportation	Comprehensive strategy to reduce VMT including many of strategy components above and potentially incorporating commuting strategies from City Transportation.
6. Energy Efficiency in Buildings	Work with BED and others to write and implement a policy to improve energy efficiency in existing City facilities by a minimum of 20% total for all energy types.
7. Local Farms, Gardens and Food Production	None
8. Waste Reduction and Recycling	Create a waste reduction challenge or program that will enable city government employee to lead by example. Incorporate a waste management plan with incentives.
	Expand the current organics collections and encourage other haulers to offer the service.

Appendix A2: Task 1 Yellow-Coded Strategies

Yellow-coded strategies relate directly to the City's GHG emissions inventory and may be effective in terms of reducing emissions. However, they will require greater specificity and extensive assumptions prior to being quantified in any rigorous way. Though these yellow strategies may require further development, they will likely be useful in considering as mid-term and long-term GHG reduction options.

In addition to being sorted by color, yellow strategies are further sorted along a 1-3 ranking scale with 1 being the most assessable and 3 being the least assessable. The yellow-coded strategies in their original language are listed below.

Table A3: Yellow-Coded Strategies with Original Language

Category	Strategy	Ranking Scale
1. Policy	None	
2. Renewable Energy	Promote the use of biomass based combined heat-and-power (CHP) for large businesses, organizations, and institutions.	2
3. Urban Forestry and Carbon Offsets	Explore opportunities for creating local carbon offset market options for offsetting personal or corporate greenhouse gas emissions that could be used to support and sustain community tree planting, forest management, and land conservation activities.	3
	Improve development practices to limit destruction of trees and encourage planting of suitable trees.	3
	Plant more trees on private property - near the street and in backyards.	2
4. City Government Transportation	Improve car sharing amongst city fleet vehicles to optimize their use.	2
	Replace additional city fleet vehicles with the use of CarShareVT vehicles.	2
	Implement a police on bicycle fleet for officers working in the downtown area during the summer.	2
	Enforce the anti-idling city policy for all non-emergency fleet vehicles.	2
	Increase the priority transit system indicator to 100%, improving frequency of transit availability.	2
	Avoid growth and even reduce traffic volume by 10% by 2015 (1,650 vehicles in the morning -2,080 vehicles at night) during the morning and evening peak hours.	3
	Avoid growth and even reduce the accumulation of cars in Burlington during the day by 10% by 2015.	3
	Price on-street parking to maintain 85% on-street parking utilization, so that spaces are generally available.	2

	Lead the effort of the establishment of a downtown Transportation Management Agency (TMA) to increase the number of Burlington employees covered.	2
	Continue to implement alternative work schedules for city employees, such as flextime, compressed workweek and/or staggered shifts to reduce and/or facilitate employee commute.	2
	Explore telework options for certain city employees to reduce weekly commute and improve preparedness in case of a disaster.	2
	Develop strategies to encourage city employees to use non-motorized means of transportation.	2
	Develop incentives to increase city employees' use of local and regional public transit by 10% by 2020.	2
	Develop a ridesharing program for city employees with guaranteed ride home provided.	2
	Institute a parking cash-out program to entice city employees to use other means of transportation.	2
5. Community Transportation	Devise and implement strategies to create SOV-free colleges and High School.	2
	Improve non-auto related infrastructure, including those dedicated to bicycle and pedestrian traffic.	2
	Improve the convenience and appeal of alternative transit, with increase bus frequency and service hours, and the promotion of rail service.	2
	Create a downtown Transportation Management Association (TMA).	2
	Support CarShare VT.	2
	Increase frequency of transit in corridors servicing downtown and auto intercept facilities.	2
	Make improvements identified in the North South Bike pedestrian Plan adopted by City Council.	2
	Expand no-idling ordinance to year round coverage.	3
6. Energy Efficiency in Buildings	Require all City construction projects to exceed energy code by 25% on new construction and a minimum of 15% on major renovations and recommissioning.	2
	Put a purchasing policy in place that requires all appropriate products meet ENERGY STAR or LEED (or Green Seal) requirements.	2
	For example, any new printers, copiers or computers must be ENERGY STAR. If carpet is to be replaced, then it must meet the criteria for "green carpet" listed in LEED. We are not suggesting whole – building LEED certification in these cases just use LEED or Green Seal for purchasing guidance.	2
	Require green building and energy-efficiency measures, including Energy Star or equivalent appliances, lighting and heating equipment in city-funded affordable housing and other development projects.	1
	Support a Planning and Zoning ordinance requiring LEED standards, with emphasis on energy efficiency.	1
	Investigate sliding-scale building permit fees, with rebates for high-performance green buildings, and higher fees for conventional buildings.	3
7. Local Farms, Gardens and Food Production	Consider growing fuels (algae, etc.) that can reduce reliance on local power generators.	3
	Public sector purchasing power; schools, city departments, city events.	2
8. Waste Reduction and Recycling	Develop and mandate an Environmentally Preferable Purchasing Policy similar to Rutgers University utilizing the State of Vermont's current EPP as a resource.	2
	Ban bottled water at all city events and facilities. Remove bottled water from vending machines and promote the use of reusable water bottles.	2
	Consolidate trash haulers by neighborhood or district limiting the number of trucks driving through the city.	3
	Develop a pay as you throw away (PAYT) program. Issue large recycling containers and smaller trash receptacles.	1
	Promote backyard composting by making bins, digesters and other mechanism that allows residents to compost at home. Support compost facilities in the area.	2

	Expand the current organics collections and encourage other haulers to offer the service.	2
	Provide incentives for those that bring their own containers for bulk items, salad and soup bars and beverages.	3
	Ban the use of plastic bags in the City of Burlington for purchases.	2

Appendix A3: Task 1 Red-Coded Strategies

Red-coded strategies will have no or little impact on the City's GHG emissions inventory, are not easily assessable, may be cost-prohibitive and/or impractical, and/or are not suited to near- or mid-term implementation. Though not immediately useful, red strategies may provide fodder for future GHG reduction ideas and general City sustainability strategy development. The red-coded strategies in their original language are listed below.

Table A4: Red-Coded Strategies with Original Language

Category	Strategy
1. Policy	Prepare an adaptation plan to determine Burlington's vulnerability to the impacts of climate change.
	Coordinate and include climate change considerations in the city's emergency operations plan so that Burlington is ready for important climatic events.
	Work with regional organizations to prepare for the impacts of climate change on a more regional basis.
	Develop a warning system through the use of radio, television or phone (reverse 911) to caution residents and others in case a severe climate related event occurs.
	Encourage the Burlington Electric Department (BED) to pursue the development of local power generation to reduce the city's vulnerability to climate change and its impacts.
	Take into consideration the effects of climate change when writing stormwater management policies and regulations.
	Review the status of the local economy in relation to its current level of green economic activity.
	Encourage green economic development as a goal of its Community and Economic Development Office, consistent with the goal of promoting the creation of jobs with a livable wage.
	Leverage city policy, purchasing, and regulation, and deepen local university partnerships, to promote local research, development, and production of green technology and products.
	Pursue the development of green technology, the renewable energy industry, and energy efficiency improvements in the Burlington area, with methods such as direct investment, grants and other funding opportunities.
	Support the development of targeted programs to train residents of low and middle-income communities for jobs in the green economy.
	Collaborate with local educational institutions such as universities, community colleges, adult education programs and job training programs to create more curricula that provide students with the skills and knowledge to work for competitive green business.
	Establish a database or other suitable dedicated information source for public use of green builders/contractors and available renewable energy options and other green technology.
	Continually review City zoning ordinances to ensure appropriate encouragement of green building practices.
	Create a climate action stakeholder database that identifies the stakeholders or sectors that are vital to local climate protection strategies (including civic and service organizations, NPAs, faith communities, educational organizations, senior centers, condo and homeowners' associations, etc.).

	Establish community outreach teams to engage and communicate with these stakeholders and sectors.
	Conduct a public education campaign to inform residents, elected officials, community leaders, media, businesses, and non-profit institutions about the causes and impacts of climate change and actions they can take to reduce greenhouse gas (GHG) emissions.
	Develop a Burlington Climate Action website as a tool for households and organizations to learn about the causes and impacts of climate change, estimate their current GHG emissions, identify strategies to reduce GHG emissions, locate resources to support GHG reductions (such as rebates and federal tax credits), take the Climate Action Pledge, report GHG savings, and track the city's progress toward climate protection goals.
	Educate City employees about "Sustainability at Work and at Home," including strategies to reduce GHG emissions, as part of employee orientations and ongoing professional development. Establish GHG reduction targets for city departments and create incentives and recognition for departments and individuals that reduce GHG emissions.
	Use City Hall, schools, and other public buildings as demonstration sites for energy efficiency, renewable energy, and other GHG reduction strategies.
	Support the development of a "green collar jobs" tech program for Burlington High School.
	Work with Burlington schools to expand opportunities to learn about and take action on climate change for administrators, teachers, staff and students, including professional development, teaching resources, events, contests, and demonstrations.
	Promote a Burlington Climate Action Pledge for individuals or organizations to commit to specific reductions of their own emissions through targeted actions.
	Create a "constant contact" system to send updates and resources to those who have pledged.
	Partner with NPAs, PTOs and other neighborhood groups to promote neighborhood initiatives to reduce GHG emissions, such as Eco-Teams and Low Carbon Diet working groups.
	Provide resources for employers to educate their employees about GHG reduction strategies, encourage employees to take the Climate Action Pledge, and create incentives and recognition for employees to reduce GHG emissions.
	Create a Burlington Business Climate Protection group to share expertise, successes, and lessons learned in reducing GHG emissions.
	Launch a "Green Neighborhood Challenge," "Green Household Challenge," and "Green Organization Challenge" program to recognize neighborhoods, households, and organizations who achieve the largest GHG savings.
	Create high profile events to celebrate community progress toward climate protection goals and provide recognition to those in the community who are taking a leadership role.
	Create a Teen Climate Protection Corps, in association with Youth on Boards, to enable youth to play a leadership role in moving Burlington toward its climate protection goals.
	Collaborate with local educational institutions such as universities, colleges, and adult education programs to create more opportunities that provide residents with the skills and knowledge to work for competitive green businesses, including targeted programs to train residents of low and middle-income communities for jobs in the green economy.
	Partner with organizations such as Efficiency Vermont and the Vermont Green Building Network to provide training in energy efficiency, renewable energy, and green building techniques to key players in the residential, commercial, and industrial sector.
	Ensure the implementation of the Climate Action Plan (CAP) through constant coordination with stakeholders and regular annual assessment of the city's progress.
	Dedicate a city position responsible for the management of Burlington's Climate Action Plan. This position will involve assessing progress as well as overseeing the involvement of partner agencies such as the Burlington Sustainability Action Team (BSAT) and the Energy and Environmental Coordinating Committee (E2C2).
	Identify progress assessment metrics for each Climate Action Plan item.
	Create an Implementation Matrix to clarify how action items will be accomplished and how assessment metrics will be used to track progress.
	Develop a progress assessment structure. We recommend: Doing an annual progress report using the Implementation Matrix.

	Develop a progress assessment structure. We recommend: Updating Burlington's greenhouse gas inventory every three years using the ICLEI Clean Air and Climate Action tool to measure progress on reduction targets.
	Develop a progress assessment structure. We recommend: Periodically revisit the action items identified for Burlington's Climate Action Plan to assess relevance.
	Integrate climate protection into all department levels citywide.
2. Renewable Energy	Develop a "green" premium-pricing program to accelerate BED's investments in additional and new renewable energy projects.
	Advocate for the creation of the feed-in tariff model for all distributed, small- or community-scale, on-site renewable energy generation with the PSB.
	Enable business personal property tax exemption for renewable energy projects.
	Create incentives for residents and businesses to switch to renewable energy sources for heating through enabling business personal property tax exemptions for renewable energy projects, clean energy financing districts, and other mechanisms.
	Develop a renewable energy best practices clearinghouse and describe city efforts.
	Encourage renewable energy projects and education in Burlington Schools.
	Create education outreach materials for each public renewable energy site describing the project and benefits.
	Promote green power as a community ethic by encouraging residents and businesses to generate at least 10% of their electricity onsite from new, renewable sources.
	Evaluate city codes and ordinances to determine what revisions are necessary to implement renewable energy projects.
3. Urban Forestry and Carbon Offsets	Use the Urban Tree Canopy (UTC) Study to identify areas of the city with highest "potential" tree canopy. Greatest opportunity to target commercial and industrial areas overall and some residential areas in particular. Large governmental and institutional properties also present significant opportunities.
	Initiate tree-planting plans for all city-owned properties (including schools).
	Identify and promote the planting of tree species to accrue optimum benefits in the areas of carbon offsets, energy conservation, air quality, storm water management, and habitat.
	Update the City Urban Forestry's inventory to determine its current health and identify needs and priorities for future urban forest management.
	Secure increased funding for green infrastructure through partnerships and from businesses, residents, and organizations that benefit, either directly or indirectly, from tree planting.
	Document and, where possible, quantify the multiple benefits associated with Burlington's urban canopy. Use this analysis to inform policy decisions and include this information in adult and child education programs.
	Provide outreach and education regarding proper planting (right tree in the right place), ongoing care and maintenance, and value (direct and indirect ecosystem services) to the community.
	Provide incentives in development regulations to promote green roof technologies to expand possible planting sites (e.g., FAHC).
	Develop tree-planting plans for tax-exempt properties (colleges, other government, religious, non-profits).
	Improve community understanding of the role and value of the urban forest.
	Engage community members to assist with tree inventories and assessments.
	Expand the Branch-Out Burlington! Tree Nursery to provide more trees for public and private planting.
	Forge partnerships with community cooperatives to organize tree-planting and maintenance events.
	Encourage residents, businesses, governments, schools, and institutions to invest in greenhouse gas-reducing projects to offset their personal or corporate greenhouse gas emissions.
	Identify forest fragments, their condition, potential threats, ownership, etc.
	Utilize City Parks, UVM, and WVPD as possible pilot areas for demonstration.
	Develop list of objectives for forest condition and management.

	Consider Urban Forest Effects (UFORE) model as a tool to quantify sequestration. Seek grant funding (USFS), partners (ANR and UVM) and volunteers (BOB!).
	Implement best management practices for City urban landscaped areas and, where appropriate, seek certification.
	Expand the urban forest and improve forest performance by maintaining trees carefully, eradicating invasive vegetation, and promoting trees that will perform well for a long period of time.
	Conserve and preserve existing forests, wetlands, agriculture and other open natural areas of the City.
	Implement the Burlington Open Space Plan.
4. City Government Transportation	Ensure that bio-fuel utilized by the city fleet is responsibly produced.
	Institute a purchasing policy that requires the procurement of low-emissions vehicles whenever new vehicles need to be acquired.
	Increase the CCTA transit system, ridership by 5% per year.
	Pursue the realization of the Downtown Parking Study.
	Pursue the implementation of street design guidelines that will improve pedestrian crossings and signals, as well as add and improve bike lanes.
	Offer tune-ups for bicycles to encourage employees to bike to work instead of driving.
	Research Smart Card technology for employees to use their ID cards for parking or transit. This could eliminate situations where the city pays for both parking and transit for an employee.
5. Community Transportation	Build a Downtown Transit Center.
	Build Park and Ride and Auto Intercept lots to capture cars before they enter City neighborhoods.
	Research, identify and educate the public on the true cost of car ownership (such as air pollution and impacts on public health) and the benefits of alternative modes of transport. Solicit University Transportation Center assistance.
	Assign the true cost of driving through voluntary measures and explore increased fees.
	Launch a public awareness campaign to stimulate behavior change, including slower driving speeds.
	Support and implement the 2007 Transportation Plan.
	Provide parking incentives for fuel-efficient vehicles.
	Provide the necessary infrastructure for fuel-efficient vehicles, such as charging stations.
	Celebrate success of fuel-efficient vehicle use!
	Educate public about greenhouse gas emissions including the emissions associated with traditional landscaping.
	Promote attractive density including identification of living close to work and public transportation.
	Explore new mass transit and capital parking fund with the goal of reducing the amount of unnecessary parking.
6. Energy Efficiency in Buildings	Have BED Energy Services sign-off on any replacement or renovation to a building component covered by the energy code.
	For example, one of the fire stations needs to replace a piece of heating and cooling equipment. BED can provide them with specification upfront before they go out to bid or review the contractor proposal(s) to see if efficiency gains can be made before the PO is signed. Often there will be incentives from BED or VGS to install high efficiency equipment. A lot of HVAC equipment replacement needs to happen quickly after a sudden breakdown so BED will be able to respond quickly. EVT and BED incentives locale HVAC (and lighting) suppliers to have higher efficiency equipment quickly available.
	Inventory City buildings in order to assess current energy performance and develop a priority list for high use buildings and equipment reaching end of life. This could give decision-makers an idea of where limited dollars should be target. This work includes:
	Benchmark all City buildings using the tool on the ENERGY STAR website.
	Rank the buildings by kWh/square foot and CCF/square foot.

	Compile all the energy audit and project completion information (electric and gas) that we have on each building.
	Where needed, inventory the age of all major equipment (HVAC, DHW, lighting ballasts and any control systems).
	List those buildings that have maintenance and service agreements with HVAC firms.
	Find out who makes decisions for the various buildings about how and when major equipment is replaced.
	Develop incentives for property owners to exceed code in weatherization of residential properties at time of sale. The existing Time of Sale ordinance should undergo regular technical review and upgrades to include best available practices, and should be expanded to include owner-occupied dwellings.
	Develop a consortium of local and state support, including BED and EVT, for more stringent federal efficiency standards for furnaces, refrigerators, water heaters, air conditioners, other appliances and lighting products.
	Implement neighborhood-based outreach efforts to combine and promote energy and water conservation, solid waste reduction, safety and livability.
	Improve the efficiency, effectiveness and control of residential outdoor lighting through regional educational efforts and retail promotions.
	Improve the maintenance of residential heating, ventilation and air-conditioning equipment by educating consumers and schoolchildren.
	Provide green building design assistance and technical resources to Burlington residential developers, designers, homebuilders and residents.
	Help small businesses, non-profit organizations and public agencies gain access to energy-efficiency services.
	Promote opportunities to improve operations and maintenance practices in local buildings, including resource-conservation managers.
	Review City Ordinances to remove any barriers to the installation of co-generation and distributed generation systems in order to facilitate low-cost interconnections and to encourage increased efficiencies.
7. Local Farms, Gardens and Food Production	Expand organic farms and community supported agriculture (CSAs).
	Encourage home vegetable gardens.
	Create and enhance community, neighborhood and school gardens across the city of Burlington, especially within walking distance for neighborhood residents.
	Renew public sector support that is clearly reflected in zoning, planning, city policy, economic development priorities and advocacy at state level.
	Weave community gardens into the permitting of all new housing.
	Increase opportunities for grocery shoppers to purchase local foods.
	Promote bee keeping for both honey and pollination.
	Establish provisions for meat production in city neighborhoods and agricultural areas including laying hens, fowl and rabbits.
	Propose a usufruct law (usufruct- "the legal right to use and enjoy the advantages or profits of another person's property"). In an urban situation, this would mean you could harvest from a neighbor's fruit tree if it hangs into your property or if the fruit is on public land-street trees.
	Establish a model Edible Schoolyard Project at Burlington High School.
	Encourage food preservation (canning, freezing, dryer, etc.) through education using community facilities.
	Promote greater use of compost and less use of chemical fertilizers, pesticides and herbicides to reduce carbon footprint and pollution of lakes and streams.
	Public and private ventures: Vermont Land Trust, NOFA, Intervale Center, Friends of Burlington Gardens, Vermont Community Garden Network, Regional Planning Commission; new models (e.g., South Village).
	Plant food-bearing trees and shrubs on public lands and in schoolyards, where appropriate, with harvest rights available to groups caring for the food-bearing trees and/or to the public.
	R & D and application: UVM Extension Service and UVM Extension Master Gardeners, Intervale projects, local businesses.

	Public sector support through zoning and building codes.
	Promote efforts to increase markets for locally produced food at the retail, wholesale, household and institutional levels.
	Private initiative, Food Hub (Intervale) to increase markets for locally produced food at the retail, wholesale, household and institutional levels.
	Public sector incentives to increase markets for locally produced food at the retail, wholesale, household and institutional levels.
	Work with supermarket chains and local markets to distribute locally produced foods.
	Interval Food Enterprise Center; Intervale Food Hub: develop infrastructure for the processing, preserving and long-term storage of locally produced foods to increase year round access.
	Farm-to-School Program: develop infrastructure for the processing, preserving and long-term storage of locally produced foods to increase year round access.
	Local business, entrepreneurial business (think Stonewall Kitchen!): develop infrastructure for the processing, preserving and long-term storage of locally produced foods to increase year round access.
8. Waste Reduction and Recycling	Create/publish a list of products approved by the City that reduce waste and promote reusable items rather than just recyclable items.
	Require all new construction and renovation plans to design for energy efficiency and recycled materials. Create incentives for LEED Certified Projects.
	Require all Construction and Demolition projects to submit a waste management plan that is posted on site in public view and must be approved before the project begins.
	Provide incentives to promote salvaging materials that can be reused and for incorporating salvage materials into constructions projects.
	Prepare all handouts and informational pieces in multiple languages.
	Create an environmental educational outreach position.
	Encourage greater use of the recycling bin. Require recycling bins for all events, business and homes. Provide multiple sizes (e.g., one for the bedroom, one for the bathroom) of recycling bins and place them next to all trash receptacles.
	Plan and execute public educational events on Church Street about waste reduction and recycling.
	Design educational displays that can be located at the Waterfront, Airport and other public facilities.

Appendix B: Task 2 Strategy Analysis Information

Appendix B1: Data, Assumptions, and Methodologies

This section provides data, assumptions, and methodologies used in the analysis of Task 2 strategies.

The following information applies to all strategies:

Strategy analysis timeframe (years)	**25**
Discount Rate	**9%**
Source: Spring Hill Solutions	

Specific information for each strategy and its analysis, including emissions factors and assumptions, are described below.

Implement McNeil CHP district energy project.	Renewable Energy	
McNeil's heat emissions factor (kgCO2e/mmBtu) Source: Spring Hill Solutions		**0**
Floor Area served by district heating system (ft2) Source: BURDES team		**5000000**
Annual Heat Provided (mmBtu/yr) Source: BURDES team		**340000**
Natural gas emissions (kgCO2e/mmBtu) Source: EPA Inventory of Greenhouse Gas Emissions and Sinks		**53.046**
Average natural gas price in 2010 ($/mmBtu) Source: Vermont Fuel Price Report November, 2009		**19.75**
Natural gas price escalation rate Source: Spring Hill Solutions		**4%**
District heating price in 2010 ($/mmBtu) Source: BURDES team		**15.91**
District heat price escalation rate Source: Spring Hill Solutions		**0%**
Annual O&M Cost ($) Source: John Irving, BED, Personal Correspondence, February 18, 2010		**$0**
Capital Cost to Build System ($) Source: Adapted from BURDES consultants report 2/11/2009. At time of CAP, BURDES team was getting a better figure through engineering feasibility study RFP.		**23,100,000**
McNeil retrofit design 2011 ($) Source: Adapted from BURDES consultant report 2/11/2009		**100,000**
Distribution system design 2012 ($) Source: Adapted from BURDES consultant report 2/11/2009		**100,000**
Pipe Trunk 2013 ($)		**4,000,000**

Source: Adapted from BURDES consultant report 2/11/2009

Balance of system ($/yr) **1,890,000**
Assumed to be equally distributed over 10 years 2014-2023

Reduce government VMT.	Government Transportation

Reduction in government VMT **10%**
Source: Spring Hill Solutions

ICLEI Emissions Factor for Biodiesel (tCO_2e/mile)	**0**
ICLEI Emissions Factor for Diesel (tCO_2e/mile)	**0.00133721**
ICLEI Emissions Factor for Gasoline (tCO_2e/mile)	**0.000709155**
ICLEI Emissions Factor for Hybrids (tCO_2e/mile)	**0.00011446**

Source: 2007 ICLEI Inventory

Fuel Escalation Rate **4%**
Source: Spring Hill Solutions

Fuel Efficiency Rates

Biodiesel (B100)	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Diesel	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Gas	**Heavy Duty Trucks**	**8**
	Light Trucks	**15**
	Passenger Cars	**20**
Hybrid	**Light Trucks**	**22**
	Passenger Cars	**37**

Source: <www.fueleconomy.gov>

Cost of Gasoline per Gallon ($)	**$2.75**
Cost of Diesel per Gallon ($)	**$3.00**

Source: Vermont Gas Prices, <www.vermontgasprices.com>

This strategy is assumed to be cost neutral.
Source: Spring Hill Solutions

Require new residential construction to be VESH qualified.	Energy Efficiency

Houses built per year **3.57**
Average number of building permits for new construction since 2003
Source: Jay Appleton, P&Z, Personal Correspondence, February 10, 2010

Share of homes built to Energy Star already **68%**
In Vermont Gas territory Source: Efficiency Vermont and Vermont Gas Systems "Vermont Energy Star Homes," 2003

BED electric emissions factor (kgCO2e/kWh) **0.255**
Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol

Natural gas emissions (kgCO2e/mmBtu) **53.046**
Source: EPA Inventory of Greenhouse Gas Emissions and Sinks.

Average cost per home after rebate ($) Source: Chris Burns, BED, Personal Correspondence, December 1, 2009	**1500**
Average electricity price in 2010 ($/kWh) Source: Ken Nolan, BED, Personal Correspondence, October 23, 2009	**0.13**
Electricity price escalation rate Source: Spring Hill Solutions	**4%**
Average natural gas price in 2010 ($/mmBtu) Source: Vermont Fuel Price Report November, 2009	**19.75**
Natural gas price escalation rate Source: Spring Hill Solutions	**4%**

Implement BED AMI program.	Energy Efficiency	
Forecast residential peak shift (kWh) Source: Ken Nolan, BED, Personal Correspondence June 10, 2010		**538,648**
Forecast commercial peak shift (kWh) Source: Ken Nolan, BED, Personal Correspondence June 10, 2010	**1,402,933**	
Assuming no actual reduction in energy use Source: Ken Nolan, BED, Personal Correspondence June 10, 2010		
Peak emissions (kgCO2e/kWh) Source: ISO-NE 2007 Marginal Emissions Analysis		**0.495**
BED electric emissions factor (kgCO2e/kWh) Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol		**0.255**
Annual operation cost is neutral Source: Ken Nolan, BED, Personal Correspondence, February 1, 2010		

Require new commercial construction to follow Core Performance guidelines.	Energy Efficiency	
Commercial buildings built per year Average number of building permits for new construction and additions since 2003 Source: Jay Appleton, Planning and Zoning, Personal Correspondence, February 10, 2010		**5.71**
Average size of new commercial buildings (ft^2) Source: Spring Hill based on Burlington and the range of buildings modeled for Core Performance		**30000**
Share of commercial buildings currently achieving Core Performance Source: Chris Burns, BED, Personal Correspondence, December 23, 2009		**3%**
Electrical savings (kWh/ft^2*yr) Source: "Streamlining the Small Commercial New Construction Market," 2008		**1.8**
Thermal savings ($mmBtu/ft^2$*yr) Source: "Streamlining the Small Commercial New Construction Market," 2008		**0.00832**
BED electric emissions factor (kgCO2e/kWh) Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol		**0.255**

Natural gas emissions (kgCO2e/mmBtu) Source: EPA Inventory of Greenhouse Gas Emissions and Sinks.	**53.046**

Implement POWER program.	Energy Efficiency	
Pounds of CO_2 per CCF of natural gas Source: EPA Inventory of GHG Emissions and Sinks		**12.012**
Pounds of CO_2 per kWh of BED electricity Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol		**0.561**
Average electricity price in 2010 ($/kWh) Source: Ken Nolan, BED, Personal Correspondence, October 23, 2009		**0.13**
Electricity price escalation rate Source: Spring Hill Solutions		**4%**
Average natural gas price in 2010 ($/mmBtu) Source: Vermont Fuel Price Report November, 2009		**19.75**
Natural gas price escalation rate Source: Spring Hill Solutions		**4%**
Energy savings are phased in over the first 10 years, and remain in place		

Implement "Solar on Schools."	Renewable Energy	
BED electric emissions factor (kgCO2e/kWh) Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol		**0.255**
Peak emissions factor (kgCO2e/kWh) Source: ISO-NE 2007 Marginal Emissions Analysis		**0.495**
Electricity sales price ($/kWh) Source: Ken Nolan, BED, Personal Correspondence, October 23, 2009		**0.20**
Upfront Cost ($) Source: Andrew Broderick, New Generation Partners, Personal Correspondence, February 18, 2010		**6700000**
Annual Operations and Maintenance ($) Source: Andrew Broderick, New Generation Partners, Personal Correspondence, February 18, 2010		**33000**

Implement residential PAYT program.	Waste Reduction and Recycling	
ICLEI's land filled waste (tCO_2e/ton) Source: 2007 ICLEI Inventory		**0.40**
Percentage of waste that is residential Source: Nancy Plunkett, CSWD, Personal Correspondence, January 27, 2010 and Skumatz and Freeman, "Pay As You Throw in the US: 2006 Update and Analyses," December 2006		**55%**
Average annual CSWD household trash (tons) Source: Nancy Plunkett, CSWD, Personal Correspondence, January 27, 2010		**0.83**

Number of Burlington households Source: U.S. Census Bureau, "Burlington City, Vermont," 2006-2008		**14,957**
Decrease in residential MSW with PAYT		**17.00%**
Recycling	**5.00%**	
Yard Waste	**6.00%**	
Source reduction	**6.00%**	
Source: Skumatz and Freeman, "Pay As You Throw in the US: 2006 Update and Analyses," December 2006		
Methane capture and electricity generation emissions (tCO_2e/short ton) Source: CA-CP Calculator V6		**0.16**

Reduce community VMT.	Community Transportation	
ICLEI Emissions Factor for Gasoline (tCO_2e/mile)		**0.000102607**
ICLEI Emissions Factor for Diesel (tCO_2e/mile)		**0.00710768**
Source: 2007 ICLEI Inventory		
Fuel Escalation Rate Source: Spring Hill Solutions		**4%**
Cost of Gasoline per Gallon ($)		**$2.75**
Cost of Diesel per Gallon ($)		**$3.00**
Source: Vermont Gas Prices, <www.vermontgasprices.com>		
This strategy is assumed to be cost neutral. Source: Spring Hill Solutions		

Fuel Efficiency Rates

Biodiesel (B100)	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Diesel	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Gas	**Heavy Duty Trucks**	**8**
	Light Trucks	**15**
	Passenger Cars	**20**
Hybrid	**Light Trucks**	**22**
	Passenger Cars	**37**

Source: <www.fueleconomy.gov>

Implement government vehicle retirement and replacement program.	Government Transportation

Retire 5% of vehicles
Source: City of Philadelphia, <http://www.mayorsinnovation.org/pdf/PhiladelphiaFleetManagement.pdf>

A 5% vehicle retirement rate equals a 5% reduction in vehicle miles and a 5% reduction in emissions
Source: Spring Hill Solutions

Replace 25% of gasoline vehicles with hybrid
Source: Spring Hill Solutions

ICLEI Emissions Factor for Biodiesel (tCO_2e/mile)	**0**
ICLEI Emissions Factor for Diesel (tCO_2e/mile)	**0.00133721**
ICLEI Emissions Factor for Gasoline (tCO_2e/mile)	**0.000709155**
ICLEI Emissions Factor for Hybrids (tCO_2e/mile)	**0.00011446**

Source: 2007 ICLEI Inventory

Fuel Escalation Rate	**4%**

Source: Spring Hill Solutions

Cost of Gasoline per Gallon ($)	**$2.75**
Cost of Diesel per Gallon ($)	**$3.00**

Source: Vermont Gas Prices, <www.vermontgasprices.com>

Number of City Fleet Vehicles	**250**

Source: Adapted from Dan Bradley, DPW, Personal Correspondence, February 26, 2010

Average Insurance for all vehicle types	**$1,300**
Average O & M for all vehicle types	**$450**
Average retirement vehicle cost	**$41,667**

Source: Spring Hill Solutions

Incremental purchase cost of hybrid vehicle	**$10,000**

Source: Spring Hill Solutions

Fuel Efficiency Rates

Biodiesel (B100)	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Diesel	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Gas	**Heavy Duty Trucks**	**8**
	Light Trucks	**15**
	Passenger Cars	**20**
Hybrid	**Light Trucks**	**22**
	Passenger Cars	**37**

Source: <www.fueleconomy.gov>

Implement government alternative-commuting program.	Government Transportation

10% Reduction of Employee Commuting Miles
Source: Spring Hill Solutions

ICLEI Emissions Factor for Diesel (tCO_2e/mile)	**0.001250806**
ICLEI Emissions Factor for Gasoline (tCO_2e/mile)	**0.000776995**
ICLEI Emissions Factor for Hybrids (tCO_2e/mile)	**0.010643016**

Source: 2007 ICLEI Inventory

Fuel Efficiency Rates

Biodiesel (B100)	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Diesel	**Heavy Duty Trucks**	**10**
	Light Trucks	**20**
	Passenger Cars	**28**
Gas	**Heavy Duty Trucks**	**8**

	Light Trucks	**15**
	Passenger Cars	**20**
Hybrid	**Light Trucks**	**22**
	Passenger Cars	**37**

Source: <www.fueleconomy.gov>

Fuel Escalation Rate — **4%**
Source: Spring Hill Solutions

Cost of Gasoline per Gallon ($) — **$2.75**
Cost of Diesel per Gallon ($) — **$3.00**
Source: Vermont Gas Prices, <www.vermontgasprices.com>

This strategy is assumed to be cost neutral.
Source: Spring Hill Solutions

Implement BED "Renewable Energy Resource Rider" program.	Renewable Energy

Maximum capacity under program (kW) — **1175**
2% of BED's 1996 peak demand
Source: Ken Nolan, BED, Personal Correspondence, February 25, 2010

Annual output per capacity (kWh/kW) — **1140**
Source: NREL PVWatts v2

BED electric emissions factor (kgCO2e/kWh) — **0.255**
Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol

Peak emissions factor (kgCO2e/kWh) — **0.495**
Source: ISO-NE 2007 Marginal Emissions Analysis

Electricity sales price ($/kWh) — **0.16**
Source: Adapted from Ken Nolan, BED, Personal Correspondence, February 1, 2010

Upfront cost per capacity ($/W) — **8**
Source: Spring Hill Solutions

Vermont RE Incentive ($/W) — **1.5**
Source: VT Dept of Public Service

Annual O & M per capacity ($/kW) — **27.5**
Source: Adapted from Andrew Broderick, New Generation Partners, Personal Correspondence, February 18, 2010

Replace existing streetlights with LEDs.	Energy Efficiency

Estimate annual electricity savings (kWh) — **1400000**
Source: Chris Burns, BED, Personal Correspondence, December 23, 2009

BED electric emissions factor (kgCO2e/kWh) — **0.255**
Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol

Incremental installed cost of LED streetlight ($) — **$475**
Source: Chris Burns, BED, Personal Correspondence, December 23, 2009

LED streetlights installed per year — **330**
LED streetlights are phased in evenly over 10 years

Source: Spring Hill Solutions

Streetlights in Burlington **3300**
Source: Chris Burns, BED, Personal Correspondence, December 23, 2009

Share of Mercury Vapor (%) **5%**
Source: Adapted from Jake Yanulavich, BED, Personal Correspondence, February 23, 2010

Mercury Vapor average monthly cost: energy and maintenance ($) **$16.22**
Source: Ken Nolan, BED, Personal Correspondence, February 10, 2010

Share of Metal Halide (%) **35%**
Source: Adapted from Jake Yanulavich, BED, Personal Correspondence, February 23, 2010

Metal Halide average monthly cost: energy and maintenance ($) **$18.57**
Source: Ken Nolan, BED, Personal Correspondence, February 10, 2010

Share of High Pressure Sodium **60%**
Source: Adapted from Jake Yanulavich, BED, Personal Correspondence, February 23, 2010

High Pressure Sodium average monthly cost: energy and maintenance ($) **$15.43**
Source: Ken Nolan, BED, Personal Correspondence, February 10, 2010

LED average monthly cost: energy and maintenance ($) **$13.52**
Source: Ken Nolan, BED, Personal Correspondence, February 10, 2010

Implement deep energy efficiency program in government buildings.	Energy Efficiency

For schools: Floor Area is "Existing sq ft + Proposed sq ft" and Annual Cost / Savings is "Probable Saving/yr with proposed Envelope and HVAC upgrades"
Source: L.N. Consulting 9/15/2008 report

Non-school floor areas **As shown in workbook**
Source: City Assessor

Average cost of renovations for Barnes, Smith, and Flynn, used to estimate cost at other buildings (USD/ft2) **66.14**
Source: School's Capital Projects 2010/2011

Discount to reflect that above cost is based on the worst schools and includes renovations that are not energy related (%) **50%**
Source: Spring Hill Solutions

Average Electric Price ($/kWh) **0.13**
Source: Ken Nolan, BED, Personal Correspondence, October 23, 2009

Average Heat Price ($/kWh) **0.06738**
Source: Vermont Fuel Price Report

BED electric emissions factor (kgCO2e/kWh) **0.255**
Source: Spring Hill using BED 2008 fuel mix and TCR-CRIS protocol

Natural gas emissions (kgCO2e/kWh) **0.18**
Source: EPA Inventory of Greenhouse Gas Emissions and Sinks.

Goal heating cost (USD/ft^2) Source: L.N. Consulting 9/15/2008 report	**0.45**
Goal electricity cost (USD/ft^2) Source: Kats, Gregory, Greening America's Schools, 2006	**0.485**
Energy price escalation rate Source: Spring Hill Solutions	**4%**
Renovations and resulting savings are phased in over the first 10 years, and remain in place Source: Spring Hill Solutions	

Increase the UTC.	Urban Forestry	
Burlington's Current Urban Tree Canopy (percentage) Source: Jarlath O'Neil-Dunne, "A Report on the City of Burlington's Existing and Possible Urban Tree Canopy"		**43%**
Burlington's Current Urban Tree Canopy (acres) Source: Jarlath O'Neil-Dunne, "A Report on the City of Burlington's Existing and Possible Urban Tree Canopy"		**2,648**
Trees per acre in an urban setting Source: New York City Department of Parks & Recreation and US Department of Agriculture, "MilliontreesNYC Research"		**190**
Burlington's plantable acres in low-lying settings Source: Jarlath O'Neil-Dunne, "A Report on the City of Burlington's Existing and Possible Urban Tree Canopy"		**1,237**
Percent of low-lying that is assumed can be planted Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010		**10%**
Percent increase in UTC through planting trees Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010		**3.50%**
Percent increase in UTC due to maintenance and annual growth Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010		**3.50%**
Number of tree plantings required each year to increase UTC by 3.5% Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010		**588**
Number of years Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010		**40**
Carbon storage and sequestration assumptions		
Hectares per acre		**0.4046**
Meters squared per hectare		**10,000**
Carbon storage: Kilograms of carbon per square meter		**9.1**
Annual carbon storage: kilogram of carbon per square meter		**0.3**
Kilograms per metric ton		**1,000**

Carbon per carbon dioxide	**3.7**
Carbon dioxide per tCO_2e	**1**
Source: Dave Nowak, Syracuse, and SUNY ESF, "UFORE Model"	

Planting cost per tree	**$225**
Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010	

Maintenance cost per tree per year	**$20**
Source: Warren Spinner, DPW, Jarlath O'Neil-Dunne, UVM, and Danielle Fitzko, VTUCFD, Personal Correspondence, January 13, 2010	

Working capital in year 15:	
One more employee	**$39,000**
Chip Truck and Chipper	**$73,000**
Small equipment	**$5,000**
Source: Warren Spinner, DPW, Personal Correspondence, February 11, 2010	

Implement a digester for organic waste.	Renewable Energy

Proposed Digester (400 kW) is 1.65 times larger than VTC Digester (250 kW)
Source: Spring Hill Solutions

ICLEI's land filled waste emissions (tCO_2e/ton)	**0.40**
Source: 2007 ICLEI Inventory	

Percentage of land filled waste that is organic	**33%**
Source: Chittenden Solid Waste District, "2006 Household Solid Waste Survey Report," 2006	

Manure tons per day using ratio	**16**
Volume Ratio 58:42 (Food: Manure)	
Source: Daniel Hecht, VEC, Joan Richmond-Hall, VTC, Donna Barlow-Casey, CVSWMD, Personal Correspondence, January 28, 2010	

Energy Output Ratio is 75:25 (Food: Manure)
Source: Daniel Hecht, VEC, Joan Richmond-Hall, VTC, Donna Barlow-Casey, CVSWMD, Personal Correspondence, January 28, 2010

Energy (kW) per ton of manure	**6**
Energy (kW) per ton of organic food waste	**15**
Source: Daniel Hecht, VEC, Joan Richmond-Hall, VTC, Donna Barlow-Casey, CVSWMD, Personal Correspondence, January 28, 2010	

VTC 250 kW Digester: Electricity Capacity (kWh)	**2,100,000**
VTC 250 kW Digester: Thermal Capacity (mmBtu)	**9,200**
Source: Joan Richmond-Hall, VTC, Personal Correspondence, January 28, 2010	

Digester generated electricity emissions (tCO_2e/kWh)	**0**
Digester generated thermal emissions (tCO_2e/mmBtu)	**0**
Source: Spring Hill Solutions	

BED emissions for FY09 ($kgCO_2e$/kWh)	**0.255**
Source: CA-CP v6	

Natural gas emissions ($kgCO_2e$/mmBtu)	**53.046**

Source: EPA Inventory of Greenhouse Gas Emissions and Sinks.

KgCO2e/tCO2e	**1000**

Implement residential organics collection program.	Waste Reduction and Recycling

ICLEI's land filled waste (tCO_2e/ton) Source: 2007 ICLEI Inventory	**0.40**
Percentage of waste that is residential Source: Nancy Plunkett, CSWD, Personal Correspondence, January 27, 2010 and EPA	**55%**
Average annual CSWD household trash (tons) Source: Nancy Plunkett, CSWD, Personal Correspondence, January 27, 2010	**0.83**
Number of Burlington households Source: U.S. Census Bureau, "Burlington City, Vermont," 2006-2008	**14,957**
Percentage of land filled waste that is organic Source: Chittenden Solid Waste District, "2006 Household Solid Waste Survey Report," 2006	**33%**
Assumed participation rate, based on City's recycling rate Source: Nancy Plunkett, CSWD, Personal Correspondence, January 27, 2010	**50%**
On-site composting/ton Emissions Factor Source: CA-CP Calculator V6	**-0.38**
Methane capture and electricity generation emissions (tCO_2e/short ton)	0.16

Appendix B2: Eliminated Strategies

The Task 1 sort and filter process determined the strategies suitable for further analysis. This resulted in over 200 strategies being reduced to 24. In Task 2, these 24 strategies were further reduced to 17. An explanation of each eliminated strategy is provided below.

Implement a "Solar City" project on city-owned buildings.	Renewable Energy

We removed this strategy because two other strategies (*Implement a POWER Program* and *Implement a BED "Renewable Energy Resource Rider"*), would be the most feasible tools through which this strategy would be achieved. Not only are the two aforementioned strategies being analyzed, they are also currently being implemented by the City of Burlington.

Increase McNeil's Capacity Factor.	Renewable Energy

We removed this strategy because it was determined that McNeil's Capacity Factor is a function of the market and grid prices and can't be influenced directly.

Develop methane gas capture and electricity generation at all City wastewater treatment plants.	Renewable Energy

After further research and meetings with experts, this strategy is deemed “not technically feasible.” The gas production is below minimum requirement for the smallest turbine currently on the market, the Capstone C-30 (30kW).

Plant an additional 620 acres of tree canopy.	Urban Forestry
Plant some number of trees each year.	

We merged these two strategies into one comprehensive strategy – *Increase the Urban Tree Canopy.*

Retire one inefficient city fleet vehicle per department.	Government Transportation
Purchase hybrids and/or compressed natural gas (CNG) vehicles for all administrative staff city fleet.	
Use a more aggressive biofuel mix for fleet vehicles.	

We merged these three strategies into one comprehensive strategy – *Implement vehicle retirement and replacement program.*

Implement a comprehensive lighting retrofit in Burlington Schools.	Energy Efficiency

We removed this strategy because it is partially being done, and partially being captured in another strategy. Lighting retrofits have already been done and will continue. Day lighting retrofits are happening as part of larger renovations analyzed in another strategy: *Implement a comprehensive energy efficiency program in City buildings*. Additionally, BSD must comply with codes addressing the amount of light in schools and on a per area basis.

None	Local Farms, Gardens and Food Production

We met with experts to determine whether any strategies in this category merit analysis. They deemed that none of the recommended strategies would relate to the inventory, and therefore they would not meet our qualifications for analysis.

Increase City's diversion rate by 25%.	Waste Reduction and Recycling

We replaced this strategy with one that would achieve the same goal in a more specific way – *Implement a residential PAYT program.*