CLIMATE/ENERGY/AIR QUALITY PLANNING BEST PRACTICES REVIEW AND SUMMARY

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ACRONYMS AND ABBREVIATIONS

ADP	Adaptation
AEO	Department of Energy Information Administration's Annual Energy Outlook
AFW	Agriculture, Forestry, and Waste
BTS	Bureau of Transportation Statistics
CACP	Clean Air Climate Protection software produced by the National Associates of Clean Air Agencies and International Council for Local Environmental Initiatives-Local Governments for Sustainability
CARB	California Air Resources Board
CAMD	EPA's Clean Air Markets Division
CCRPC	Chittenden County Regional Planning Commission
CEC	California Energy Commission
CEPA	Comprehensive Energy Plan
CEPA	California Environmental Protection Agency
CH_4	Methane
CFL	Compact fluorescent light bulb
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COLE	National Council for Air and Stream Improvement Carbon On-Line Estimator
CPUC	California Public Utilities Commission
CRA	California Resources Agency
CWNS	Clean Watership Needs Survey
DC	District of Columbia
DEP	Department of Environmental Protection
DEC	Department of Environmental Conservation
DVRPC	Delaware Valley Regional Planning Commission
EDMS	Federal Aviation Administration Emissions and Dispersion Modeling System
EDRAM	Environmental Dynamic Revenue Model, An Economic Model for California created by UC-Berkeley
EIA	US Department of Energy Information Administration
EMFAC	Emissions Factors Model created by ARB
EPA	US Environmental Protection Agency
GHG	Greenhouse gas
GIS	Geographic information system

GREET	Argonne National Laboratory's GHG Regulated Emissions and Energy Use in Transport model
GSP	Gross state product
H&P	Heat and power
ICLEI	International Council for Local Environmental Initiatives-Local Governments for Sustainability
LandGEM	EPA's Landfill Gas Emissions Model
LMOP	EPA Landfill Methane Outreach Program
MCD	Municipal Civil Division
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MOVES	EPA's Motor Vehicle Emission Simulator 2010 model
MPO	Metropolitan Planning Organization
N_2O	Nitrous oxide
NASS	National Agricultural Statistics Service
NIF	National Inventory Format
NJDEP	New Jersey Department of Environmental Protection
NJTPA	North Jersey Transportation Planning Authority
NJTRM-E	North Jersey Regional Transportation Model-Enhanced
NO_x	Oxides of Nitrogen
NYSERDA	New York State Energy Research and Development Authority
PANYNJ	Port Authority of New York and New Jersey
PECO	Philadelphia Electric Company
PM	Particulate matter
PSC	Process Stakeholder Committee
RCI	Residential, Commercial, and Industrial
SCAG	Southern California Association of Governments
SCC	Source Classification Code
SIT	EPA State GHG Inventory Tool
SO_x	Sulfur oxides
TCR GRP	The Climate Registry General Reporting Protocol
TDM	Transportation demand management
TLU	Transportation and Land Use
TSM	Transportation system management
TWG	Technical Working Group
US DOT	US Department of Transportation
USDA	US Department of Agriculture
VMT	Vehicle miles traveled
WARM	EPA's Waste Reduction Model

CHAPTER I. INTRODUCTION

The Chittenden County Regional Planning Commission (CCRPC) is interested in the development of a regional framework for planning in the areas of energy, climate change, and air quality. Like other transportation and land use planning metropolitan planning organizations (MPOs), CCRPC recognizes the unique role that these agencies can serve in fostering local, regional, and state collaboration in addressing these inter-related program areas. Chittenden County, Vermont is a county located in northwestern Vermont. The county includes the greater Burlington metropolitan area and is made up of eighteen municipalities with a population of approximately 150,000.

Chittenden County, as well as the entire state of Vermont, is currently in attainment of all of the National Ambient Air Quality Standards under the federal Clean Air Act. The state has set aggressive greenhouse gas (GHG) reduction goals in statute (2006 Act 168) and state agency climate change planning efforts recognize the need for planning coordination at the regional and municipal levels. The CCRPC has been involved for some time in activities related to climate change, energy and air quality planning. A 2010 report evaluated air quality conditions in Chittenden County and recommended strategies to maintain air quality. (Keeping Our Air Clean: *Local and Regional Strategies to Improve Air Quality in Chittenden County*. http://www.ccmpo.us/library/airquality/). The city of Burlington has completed a climate change action plan and other communities have been preparing greenhouse gas inventories. Finally, CCRPC has been working with many Chittenden County municipalities on energy planning and emissions reductions in association with the Vermont Energy and Climate Action Network.

CCRPC contracted with TranSystems|E.H. Pechan & Associates and the Center for Climate Strategies to assist CCRPC in understanding how these issues are being addressed in other regions and to recommend a strategy for CCRPC to follow in advancing their GHG program. This project encompassed four key components or tasks. The first task involved developing a summary of modeling tools used for conducting GHG inventories that would be appropriate for the CCRPC region. The results of this task are documented in Appendix A. The second task involved undertaking a literature search of climate, energy, and air quality planning in other regions to identify common elements, successful performance indicators, and best practices. Chapter II of this report documents this literature search. Key elements of the individual plans reviewed are summarized in a matrix in Appendix B. Under the third task, a wide range of strategies that could be implemented by regions, municipalities, employers, and individuals to reduce GHG emissions were reviewed and summarized. That effort is documented in Chapter III of this report, and the individual strategies are summarized in Appendix C. Finally, a framework that CCRPC could use to conduct integrated climate, energy, and air quality planning for Chittenden County was developed and is presented in Chapter IV.

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CHAPTER II. LITERATURE SEARCH AND INVENTORY OF CLIMATE, ENERGY, AND AIR QUALITY PLANS

The purpose of this chapter is to provide CCRPC with a summary of planning processes that have taken place across the country dealing with climate change, energy, and air quality. The focus of this summary is on a selected set of state, regional, and local planning processes that can provide CCRPC with information on best practices in these processes and on ways that these processes, or the data underlying them, can be combined. A matrix summarizing key characteristics in each of the selected processes is presented and discussed. In addition, the key elements of these processes and plans and their applicability to CCRPC are also discussed.

A. KEY INFORMATION REVIEWED

A matrix was developed to summarize the key attributes of each plan that was reviewed. Each of the data elements of the matrix are listed below, with discussion where applicable.

- *Name of Plan*
- *Type of Planning Process.* This could be informational, plan without goals, or action plan. The type of planning process will generally have an impact on many of the data elements in the matrix.
- *Area Covered.* The geographic area represented in the process; generally municipal, county, regional, or statewide.
- *Stakeholders Involved.* A representative sampling of the agencies or organizations that were involved if a stakeholder process was used.
- *Was an inventory conducted, and if so, how?* This data element provides information on the primary methodology or model used in developing a GHG emission inventory, if one was developed in the process.
- *Emission Data Used.* This provides key sources and types of data used. It will indicate where significant amounts of default data were used to calculate the GHG inventory or the key agencies that provided data to replace the defaults.
- *GHGs Included.* The pollutants that were included in the GHG inventory are listed here.
- *Models Used.* The key models that were used in developing source sector emission estimates for the GHG inventory are listed here.
- *How was a reduction target determined? Were they adopted by the governing body?* This data element provides information on the reduction target either developed through the process or adopted by the process, if applicable. If a target was developed in the planning process and later adopted by the relevant body (e.g., mayor's office, governor's office, etc.), that is also indicated.
- *Were strategies developed for reducing GHGs?* Yes or no.
- *Are the reductions measurable?* Yes or no.
- *Was an action plan developed?* Yes or no.
- *Process Completed?* If the process has been completed, the year of completion is generally provided.
- *Level of inventory detail.* In most cases, the level of inventory detail is listed as sector or subsector. An indication of subsector typically indicates that the data developed can be used to quantify potential emission reductions from proposed GHG mitigation measures. The sector level of detail is broader and more general, and normally does not provide information needed

to quantify emission reductions from GHG mitigation measures. As an example, at the sector level of detail, the Montgomery County plan breaks emissions down by four major sectors: residential building energy, commercial building energy, transportation, and solid waste management. An inventory at the subsector level of detail might further break the energy emissions by fuel type and transportation emissions by onroad emissions vs. the various nonroad subsectors (air, rail, commercial marine).

- *Geographic resolution.* This indicates the level of refinement of the inventory geographically. If emissions are only developed statewide, then counties or municipalities within that state would not necessarily have the information they would need to begin a climate action process. On the other hand, in the example of the NJTPA inventory, emissions were allocated to the county and municipal civil division (MCD) level of detail, thus providing a number of entities within the region with the data needed to proceed with their own climate action plans.
- *Timeframe of analysis.* This indicates both whether the analysis was seasonal or annual and the year or years included. This also indicates the time horizon used in the planning or inventory process as well as the historical year or year used for a baseline.
- *Direct or alternative accounting methods?* Most inventories use direct accounting methods. In cases where other types of accounting are used, such as consumption-based accounting, this is indicated.
- *Unique Elements.* Elements of the plan or process that may be of interest to CCRPC or that might be considered best practice are listed here.
- *Interaction between climate and air quality?* If the plan includes information on air quality or other types of environmental benefits, that information is provided.
- *Web Page*. A link is provided to the referenced plan.

B. SELECTION OF PLANS TO REVIEW

Plans were selected in an attempt to provide a broad representation of inventories and climate action plans which have been undertaken across the country. These focused on five different areas: New England (3 plans), New York (2 plans), New Jersey/Philadelphia (4 plans), DC/Maryland (4 plans) and California (2 plans). This was meant to provide a diversity of geographic areas while still being relevant to Vermont. It was also important to include policies at various levels of government. Action plans are included from the municipal/MPO level (6 plans), the county level (1 plan), the substate/regional level (3 plans) and the state level (5 plans). Plans at different levels of government can have a very different focus, since differing policy approaches are relevant at a state versus regional or municipal level. For example, state governments generally have little influence over local land use, transportation planning, and waste management. Plans were also considered based on their range of source coverage and the tools used. Many MPOs used ICLEI software in their climate planning, so it was important to include plans which did and did not use this tool.

C. SUMMARY OF PLANS

1. Matrix

The matrix used to present key information about each Climate Plan under consideration can be found in the tables in Appendix B. This matrix summarizes the basic information from each plan, as described above, such as the area covered in the process, what stakeholders were involved, and the timeframe. The matrix also includes information about what models were used in each analysis, and what unique features each plan may have for CCRPC's consideration. Particular attention is paid to integration between climate and air quality planning, as well as information on climate change adaptation.

2. Discussion

Key stakeholders involved in several of the various climate plans reviewed were contacted in order to get feedback on their experience once the process was complete. Two sets of comments raised important issues not already captured in the matrix.

Rhett Lamb, the planning director in Keene, NH had several comments based on his experience with Keene's climate action plan. He indicated that mitigation planning can often be tied with energy and cost savings. Energy efficiency investments in particular often have a relatively short payback period, and once these energy expenditures are tracked, savings can be found. Adaptation planning on the other hand is more difficult for smaller cities such as Keene, because cost effective adaptation investments are difficult to find. In addition, most climate modeling is done at no lower than the multi-state regional level, and adaptation planning requires detailed information at the local level. Integrating long term adaptation planning with other long terms plans has proven problematic for Keene. He also indicated that a city such as Keene has difficulty measuring the success and impact of mitigation and adaptation actions given the limited available resources of the local government.

Eric Coffman, a senior energy planner in Montgomery County, MD, and Brian Hug, deputy program manager for Maryland's Department of the Environment, also provided information on their processes. They indicated that it was essential to get a diverse group of stakeholders and officials from various government agencies to buy into the planning process. A diverse stakeholder group is needed to represent the views of different groups, and establish the legitimacy of the process. In addition, the process will go much more smoothly if it is clearly laid out how the various government agencies will need to work together, and what the responsibilities of each agency will be.

D. CONSIDERATIONS FOR CCRPC

1. Common Elements

Commonalities can be observed among the plans undertaken by agencies at comparable levels. For example, many of the municipal and county-based plans rely on ICLEI for preparing GHG emission inventories. State-level inventories are generally prepared at the subsector level of detail, but without further allocation of the emissions below the state level. In many cases, these inventories are prepared using EPA's State Inventory Tool (SIT) model to some degree. In contrast, the regional plans from Delaware Valley Regional Planning Commission (DVRPC), North Jersey Transportation Planning Authority (NJTPA), and Southern California Association of Governments (SCAG) all either allocated emissions to the county or municipal level or developed the emissions estimates at the county or municipal level of detail. Having the inventories for the counties and municipalities within a region all prepared in a consistent manner along with reporting of the inventories at the municipal or county level of detail allows the municipalities or counties to then develop their own climate action plans with a firm baseline and a knowledge of the primary contributors to GHG emissions in their areas.

2. Successful Performance Indicators

Plans that are most likely to be successful are those that provide sufficient detail on the objectives of the recommended measures, goals for implementation of these measures, details on how the programs should be implemented, and ways in which the results could be measured.

3. Best Practices and Innovative Programs

The NJTPA plan shows a number of best practices in developing a GHG inventory that should be considered when CCRPC moves forward in developing a climate action plan. First, although the plan covers a broad region, over approximately half of the state, the data were allocated to the both the county and municipal level of detail. In doing this, it provides these counties and municipalities with an inventory that can be used as a starting point that is consistent with others being used in the state. Given the current budget limitations of most local governments, an MPO that takes on the lead role in developing the community inventories for each of the counties and municipalities in its region has removed a significant amount of work needed by these local governments to begin and maintain climate action planning processes. In addition, by using both direct and consumption-based emissions accounting, the government agencies are provided a better indication of the emissions that might actually be able to be impacted by measures under the control of their jurisdiction (including emissions beyond their own geographic boundaries). The DVRPC regional inventory provides another example of where a regional emissions inventory was allocated to both the county and municipal level of detail, where applicable.

The California Climate Action Team report includes significant modeling of the impacts of their plan, not just for the individual measures, but an economic impact modeling of the entire set of selected strategies. They have also estimated environmental justice impacts of their selected measures. This report also has a focus on measures that can be implemented in the very short term-over the next two years. In addition, the report examines a variety of implementation options that can be used to achieve GHG emission reductions.

The Montgomery County Climate Protection Plan recommends a number of actions that can be undertaken in the county. Although the GHG emission reductions expected to result from these actions are not quantified, the plan provides the specific sequential steps that should be undertaken to fully implement the recommended actions. Such specificity should simplify future evaluations of the status of these measures. In addition, one of the appendices to this plan contains a detailed energy analysis of planned county energy management programs.

4. Discussion of the US EPA Multi-Pollutant Pilot Project for Iowa

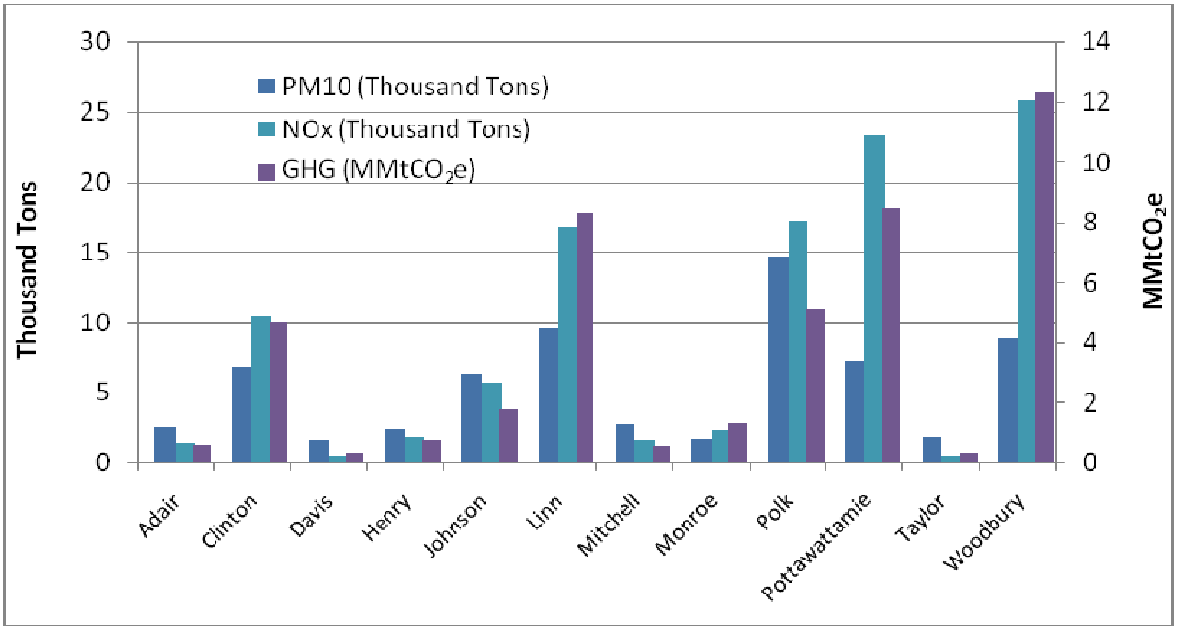
The focus of the review of climate action plans was limited to GHG emissions. Some of the climate action plans that were reviewed make reference to environmental co-benefits, including air pollutant reductions; however, for the most part, these are only explored qualitatively. ICLEI's Clean Air Climate Protection (CACP) model calculates air pollutant reductions from certain mitigation actions that reduce energy consumption; however, these estimates should be viewed as rough approximations that would likely not be of high enough quality to support air quality modeling (e.g., as part of an ozone state implementation plan). This is because the "coefficients" that are applied by CACP are at a higher level of aggregation than used in a SIP inventory, which is down to an EPA source classification code (SCC) level (capturing sufficient detail of the source, including fuel, technology, and local influences on emissions).

Due to the lack of examples of truly integrated approaches to climate action and air quality planning, we are including a discussion below of a recent pilot project for the US EPA, where a multi-pollutant inventory was developed for the State of Iowa within the EPA national inventory format (NIF). The objective of this pilot project was to develop a combined statewide emissions inventory covering criteria air pollutants, toxic air pollutants, and GHGs at the county level. The inventory covered a 2005 base year and was designed to be used within a data framework that is capable of projecting inventory data for use in a wide variety of policy analyses. Both emission sources and sinks were covered and data files developed in NIF version 3.0).

The work involved integrating Iowa's 2005 GHG inventory with existing criteria and toxics air pollutant inventory data. Detailed documentation of the procedures used to integrate the inventory data on a sector by sector basis was developed for future use by Iowa, other states, and the EPA. Among the integration procedures/issues addressed: new source classification codes for GHG sources that do not have a direct analog in the criteria and toxics NIF inventory structure; state to county-level allocation of GHG emissions for the nonpoint sectors; accounting for both emissions and sinks (including negative emissions) within the existing NIF data structure. The final report for the project presented results in the form of summary tables and graphs of GHG/criteria/toxics emissions, as well as lessons learned from the integration process.[1]

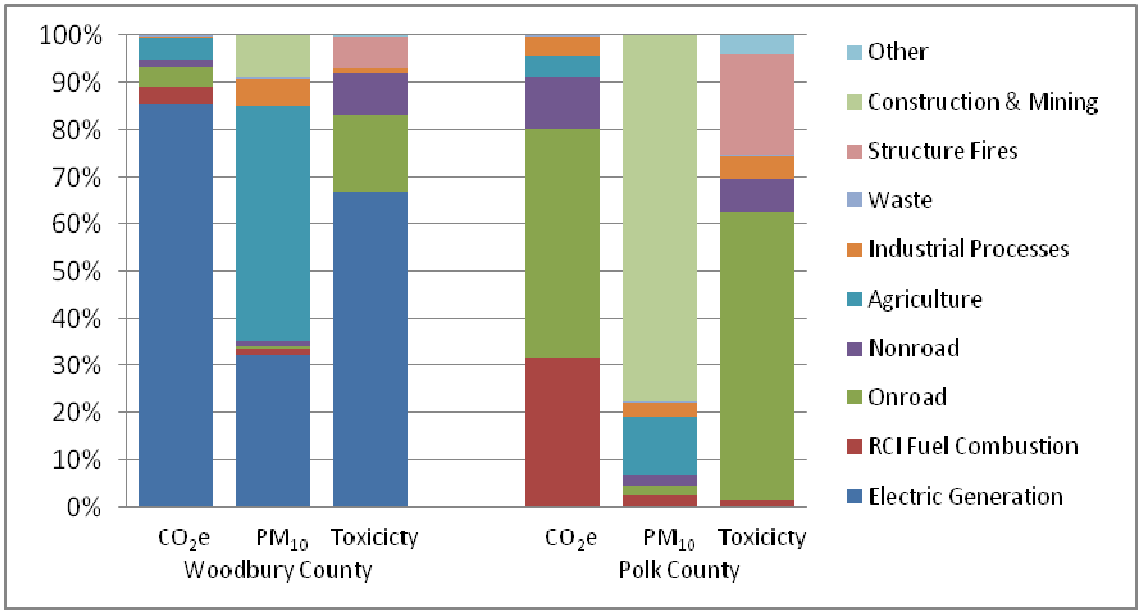
Figures II-1 and II-2 are examples of the type of emission summaries that can be generated from a multi-pollutant inventory. Since the emissions are all derived from the same set of activity data, the air pollutant co-benefits of policy options directed at GHGs can be readily derived (and vice versa). The same inventory is also provided at the level of detail needed to support regional air quality modeling.

Figure II-1. 2005 PM_{10}, NO_x, and GHG Emissions for Selected Iowa Counties



[1] A summary of the project results can also be found in this recent EPA conference paper: http://www.epa.gov/ttn/chief/conference/ei19/session3/lindquist.pdf.

Figure II-2. Sector Contributions for GHG, PM_{10}, and Toxicity-Weighted Emissions



CHAPTER III. STRATEGIES FOR ENERGY AND GHG REDUCTIONS

The purpose of this chapter is to provide CCRPC with a summary of strategies that could be implemented at the individual, employer, utility, municipal, or state/regional level to mitigate the impacts of climate change, reduce GHG emissions, and reduce energy consumption. State and regional implementation are grouped together since many of the strategies that might be applicable at the geographical regional level would need to be implemented by a state agency since CCRPC and the county do not have the authority to implement these policies. A matrix listing the compilation of strategies is presented, including information on the potential level(s) of implementation of each strategy, an indication of the cost per ton of GHG emissions reduced, and information on whether reductions in fossil-based energy consumption are expected with the strategy. This report section also discusses how reductions of GHG emissions and/or energy use resulting from these strategies might be measured and monitored, where applicable.

A. KEY INFORMATION REVIEWED

In compiling the matrix of GHG mitigation options that could be considered by CCRPC, the GHG mitigation strategies that have been included in the climate action plans of over 20 states were first reviewed. These strategies cover all GHG-emitting sectors and include actions implementable at a variety of levels. In addition, these strategies have the additional impetus of being recommended for inclusion in the climate action plan by a majority of diverse stakeholders involved in the development of these state climate action plans.

Additional options specified in CCRPC's "Keeping our Air Clean" report were added to the matrix. These options classified the strategies by implementation level--individual, employer, municipal or regional. Additional strategies included in ICLEI's Climate Air Pollutant Planning Assistant software were also reviewed for inclusion in the strategy matrix. Finally, a set of transportation control measures from EPA's Local Government Climate and Energy Strategy Series were evaluated and added, where not already captured.

B. SUMMARY OF STRATEGIES

The resulting strategies are summarized in Table C-1 of Appendix C. This table lists the major emission sector affected by the strategy, the strategy or option name, a description of the strategy, the potential implementing authority, an estimate of the cost per ton of GHG reduced by the measure, an indication of whether the strategy will result in reduced fossil fuel consumption, and the data source.

Control options that are included in CCRPC's "Keeping our Air Clean" report identified the expected level of implementation for each strategy. Some information on level of implementation was also available from the strategies from the state climate action plans. In cases where this information was not explicitly provided, professional judgment was used to determine the potential level(s) of implementation for each policy. This judgment was primarily based on the resources each policy requires. Strategies that involve immediate behavior change are typically implemented at the level of an individual or an employer. If the costs or authority required to implement a policy are beyond the ability of an individual or employer, then it would need to be implemented at the municipal or state level. Note that state level implementation would be necessary for many of the strategies that might be adapted

only at the regional level since CCRPC and the county do not have the authority to implement most of these types of policies. A policy would be labeled "All" levels if it could be implemented at the individual level, but could also be improved through a larger government effort.

Three potential ratings were used to indicate the relative cost per ton of an option. A rating of "Neg," or negative, indicates that an option is likely to have a net societal cost savings (e.g., from accumulated energy savings over time).[2] Options rated as "Low" are estimated to have costs less than $50/ton, whereas options estimated to cost more than $50/ton are considered "High" cost. For most of the strategies extracted from state climate action plans, this information had been quantified and is simply reported here, using the selected rating scale. The other data sources reviewed did not always provide information on the cost per ton of GHGs reduced. In these cases, professional judgment was used to estimate the cost per ton rating. In such cases, the estimate is based primarily on whether the option has the potential to save money, primarily through reduced energy costs. This would be weighed against an estimate of what sort of costs would be incurred in implementation of this policy, including capital investment, startup costs and recurring operation and maintenance costs.

C. DISCUSSION

The matrix includes some overlap in the strategies in order to assure that we captured potentially differing implementation approaches of similar strategies. For example, a number of the strategies were obtained from state climate action plans that designate a specific implementation approach. In many of these cases we also included similar strategies from CCRPC's work that could be designed with a different implementation approach.

It should be noted that many of the strategies included in the matrix are broad strategies that could encompass a number of more specific and targeted strategies. For example, the strategy labeled Energy Efficiency-Lighting could include programs to incentivize consumers to replace standard light bulbs with compact fluorescent light bulbs (CFLs), a government or employer program to replace all light bulbs in their buildings with efficient light bulbs, or even a program aimed at replacing street lights with LED street lights. Thus, such a program could be implemented at a number of different levels, each targeting a different subset of GHG emissions, and with potentially different costs per ton. An advantage to an area selecting such a broad strategy to include in a climate action plan is that the plan could then include sub-strategies targeted at each of these levels of implementation, thus potentially involving the entire community in initiating parallel strategies.

The strategies provided in the matrix are heavily weighted toward those likely to be implemented geographically at the municipal to regional levels. However, variations of these strategies could be designed to target employers or individuals. Where this is possible, those have been indicated in the matrix. For example, a strategy like Distributed Renewables, which refers to programs to incentivize small power projects, like wind and solar, is most likely to be implemented at a municipal to regional level by the local utility. However, employers with appropriate facilities (e.g., rooftop solar space) could also be involved in the implementation. Similarly, Renewable Energy Generation programs are typically implemented by regional or municipal electricity providers; however, individual home owners and businesses where the projects would be sited are also involved in the implementation of the strategy.

[2] Societal cost, in economics, is the total of all the costs associated with an economic activity. It includes both costs borne by the economic agent and also all costs borne by society at large. It includes the costs reflected in the organization's production function (called private costs) and the costs external to the firm's private costs (called externalities or external costs).

An important consideration when selecting among a variety of strategies might be the ability to track the progress made during implementation toward the total expected coverage of the strategy (e.g., total energy efficiency projects completed); as well as to measure the progress towards the intended energy or GHG reduction targets (e.g., total kilowatt-hours saved; total metric tons of GHG reduced). The types of strategies that lend themselves to direct measurement and monitoring are actions involving the consumption of fossil fuels and electricity. Total reductions due to energy efficiency actions, for example, can be measured by tracking changes in an organization's monthly utility bills or even the changes over time of electricity delivered by the utility to a class of customers within a municipality. If multiple strategies have been undertaken that all result in reduced electricity usage and/or increased energy efficiency (for example replacing drafty windows, inefficient light bulbs, and distributed renewable, like solar electric or hot water systems), it would be difficult to break out the reductions attributable to each individual strategy.

Actions that do not directly involve fossil fuel consumption may be harder to track. Many of the transportation-oriented options fall into this category. For example, options that should lead to mode shifts, such as transit oriented development, would be difficult to directly track. In a case like this, transit ridership could be monitored, and periodic surveys could be conducted to determine the mode of transportation that would have been used without the specific transit oriented development, but the resultant change in emissions or reduced fuel consumption could only be estimated based on this information and not directly monitored.

Implementation progress for many strategies can't be measured and monitored directly. In another set of examples for the transportation and land use sector, strategies aimed at reducing vehicle-miles traveled (VMT) will need to be modeled. Over time, the region's transportation model should indicate reductions in VMT; and while these estimates might be related to measurements contained within the model (traffic counts), the "measured" VMT reductions should still be considered indirect measurements. Also, these indirect measurements would likely not be apparent in the near-term (1 to 3 years) like direct measurements; but probably more likely noticed over a longer period of time (e.g., 3 to 10 years).

There are many similar examples in other GHG sectors, including the non-energy sectors. In theory, urban forestry programs could be directly measured and monitored using inventories of urban trees (tree counts); however, a much more cost effective approach would be to use aerial photography or satellite imagery within a geographic information system (GIS) to measure canopy cover and its changes (growth) over time. From tree canopy cover, an increase in biomass (and carbon sequestration) can be modeled to provide indirect measurements of GHG benefits.

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CHAPTER IV. FRAMEWORK FOR INTEGRATED PLANNING

This chapter outlines a proposed process by which CCRPC can develop a comprehensive strategy and analysis for achieving local and county-wide climate, energy, air quality and economic goals. The process described here will produce a final report that identifies a comprehensive and integrated set of policy options to meet these goals. The planning framework will ideally support the development and analysis of mitigation and adaptation actions taken at the local, regional, state, and national levels and be capable of monitoring the progress of the region and municipalities toward their own energy and emission reduction goals. The framework will then capture energy and emissions data at an appropriate level of detail and based on applicable accounting methods to support planners at each jurisdictional level. Given the limited authority of Vermont RPCs to implement policies, it is critical that the county-wide process effectively engage municipal leaders, state officials, and key private and institutional organizations.

A. PURPOSE AND GOALS OF THE PROCESS

The purpose of the proposed process is to identify, analyze, and recommend a set of policies that, when implemented, will lead to or contribute toward the attainment of climate, energy and air quality goals at the municipal, regional, and state levels. The process must also identify the relevant regional goals for air quality attainment, energy security, and GHG reduction. Policies to be considered would include all economic sectors, all implementation mechanisms and potentially require action by all levels of government, the private sector, institutions, and individuals. As a result, successful implementation will require the cooperation and support of a diverse group of stakeholders. The process must engage the participation and support of these key stakeholders to effectively address their concerns and earn their commitment toward implementation of the recommended policies.

B. FINAL REPORT AND END PRODUCT

This final report documenting this process will be presented to the CCRPC and made available to Chittenden County municipalities, the State of Vermont, key institutional and private sector organizations and the general public. Additional presentations to municipal and state bodies with opportunity for questions may also be desirable.

The outline of the final report and supporting materials is proposed as follows:

1. Executive Summary
2. Chapter 1: Introduction and Background of the Process
3. Chapter 2: Chittenden County Inventory and Forecast of Energy Production & Consumption, GHG Emissions and Air Pollution
4. Chapter 3: Existing and Planned Policies Related to Energy, Climate and Air Quality
5. Chapter 4: Development of Goals for Process
6. Chapter 5: Transportation and Land Use (TLU) Technical Working Group (TWG) Policy Recommendations
7. Chapter 6: Heat and Power (H&P) TWG Policy Recommendations

8. Chapter 7: Residential, Commercial and Industrial (RCI) TWG Policy Recommendations
9. Chapter 8: Agriculture, Forestry and Waste Management (AFW) TWG Policy Recommendations
10. Chapter 9: Integration and Implementation of Multiple Goals and Policies for Energy, Climate, Air Quality, and Economic Benefits
11. Chapter 10: Near-term Policy Recommendations to Address the Challenges of Unavoidable Climate Change
12. Appendices:
    a. Meeting Schedule, Members, and Attendance
    b. Quantification Methods Guidance Memos for Cost Effectiveness, Macroeconomic and Distributional Impacts, and Co-benefits Assessments
    c. Regional Energy, GHG and Air Quality Inventory and Forecast Details
    d. Policy Options Templates, Analyses, and References for Process Stakeholder Committee (PSC) Recommendations by sector including:
        i. TLU Policy Recommendations
        ii. H&P Policy Recommendations
        iii. RCI Policy Recommendations
        iv. AFW Policy Recommendations
    e. Adaptation Analyses and Mid- and Long-term Adaptation Plan
    f. Other Technical Materials As Needed

The final report and the process itself need to integrate the multiple goals and programs undertaken by Chittenden County, its municipalities and institutions, state agencies, and any others that might measurably affect efforts or outcomes relative to air quality, GHG emissions or future energy production and use and economic activity. For example, Vermont's new Comprehensive Energy Plan (CEP) issued by the Department of Public Service in December 2011 calls for the use of renewable energy resources to meet 90% of Vermont's energy needs by 2050. The Vermont Legislature has adopted GHG emission reductions goals of 25% below 1990 levels by January 2012[3] and 50% below 2012 by January 2050. The City of Burlington has adopted a near-term GHG reduction goal of 20% below 2007 levels by 2020 and a long-term goal of 80% below 2007 levels by 2050. In 2010, the University of Vermont issued its Climate Action Plan, calling for campus wide climate neutrality by 2025.

Sandrine Thibault, comprehensive planner with the City of Burlington Department of Planning and Zoning, indicated that Burlington has commissioned the development of an Excel-based workbook to support current and future GHG emissions inventories. The workbook will replace and customize prior inventories (2000, 2007), the most recent of which was constructed using ICLEI software. Ms. Thibault indicated that the Burlington workbook could be made available and customized to serve other Chittenden County communities interested in tracking emissions at the municipal level. The CCRPC should review the workbook to determine if the data sources, assumptions and methodology are

[3] This goal will not be met, but the CEP lays out a strategy to attain the 2050 goal.

consistent with the county inventory and forecast, and whether this tool could support similar efforts by other county municipalities as proposed by Ms. Thibault.

All Vermont municipal plans include an energy plan. The City of Burlington's Energy Plan vision statement envisions

> "*. . . Burlington is a leader in the development and implementation of energy efficiency and renewable energy measures that reduce energy costs, enhance environmental quality, improve security and sustainability, and enhance economic vitality. Key elements of this success are a broad range of energy efficiency programs, public education in resource conservation, publicly-owned alternatively-fueled electric generation, biomass-fueled district energy technologies, energy efficient green building technologies, and climate-friendly transportation solutions, which includes support for alternative fueled vehicles*."

Chittenden municipalities, the county itself, and VTrans all have comprehensive transportation plans and most include programs, projects and policies that will reduce the demand for transportation or otherwise reduce the use of energy to provide it.

How will these and other goals, plans and programs contribute to future climate, air quality and energy progress in the county? To what degree will the overall CCRPC Plan contribute to the accomplishment of state, local and institutional goals? Will any of these goals or programs conflict with county objectives (i.e., will significant increases in the use of biomass as called for in the CEP exacerbate Chittenden County air quality concerns)?

To answer these questions the process must include an integrated analysis not only of the policies proposed by the process but also those planned by others. This analysis should begin prior to the development of proposed policies to provide guidance on necessary levels of effort, possible synergies and potential conflicts. As proposed policies are developed and analyzed the integrated analysis should be repeated to demonstrate how the components of the county plan perform within the larger framework.

Policy analysis for key target years (2020, 2030, and if possible 2050) and the planning period (2012-2030 and if possible 2012-2050) should include, where possible:

- Projected net GHG emissions reductions
- Projected impacts on emissions of criteria pollutants (SO_x, NO_x, PM_{10}, $PM_{2.5}$, CO)
- Projected direct societal cost or savings (net present value during the policy period and/or during the life of the applied technology or practice)
- Cost effectiveness ($/ton CO_2e)
- Projected changes in units of energy/fuel consumption (oil, coal, natural gas, gasoline, diesel, aviation fuel, marine fuel, electricity) and production (including renewables)
- Projected changes in imported oil
- Projected changes in fuel mix diversity
- Projected changes in electricity fuel source diversity
- Energy intensity (per unit economic output)
- Capital investment requirements
- Impact on net employment
- Impact on gross state product (GSP)

C. DESIGN OF THE PROCESS

The proposed planning process will rely on intensive use of information and interaction, and require substantial organization and integrated communications among facilitators, participants, and technical analysts. The proposed process will bring together a broadly representative group of stakeholders and technical experts in a transparent, stepwise and fact-based effort. The process proposed here uses formal consensus building to meet the goals and deliverables of the initiative.

This proposed process assumes that CCRPC will assume responsibility for overall process management and much of the technical analysis. The services of a consultant are assumed to offer CCRPC process advice, review and comment on technical analyses, and perform the following functions in partnership with CCRPC:

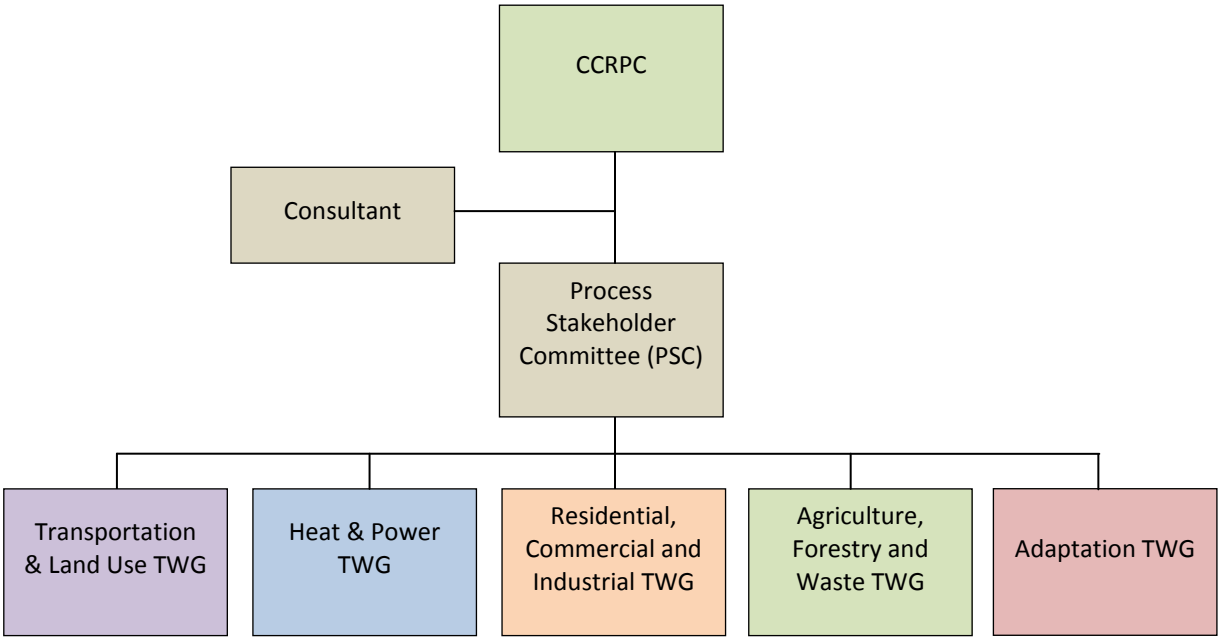
- Meeting Facilitation: Expert and impartial facilitation of stakeholder deliberations and assist in the preparation of meeting agendas, supporting documents and summaries.
- Technical Analysis: For those sectors requiring expertise beyond the in-house capabilities of CCRPC; expert analysis of inventory and forecast projections, policy recommendations and integrated policy analysis. If desired, macroeconomic analysis of policy impacts on employment and economic growth could be included.

The level of analysis envisioned for the process is for planning purposes and not regulation. Air quality analyses may utilize regional or state regulatory data, but forecasts and policy projections are assumed to be appropriate for planning and policy development only and not at the level of precision required for regulation.

D. PROCESS STRUCTURE

The proposed process would involve the creation of several bodies with distinct roles and responsibilities, which are laid out below. The basic organizational structure is shown in Figure IV-1.

Figure IV-1. Proposed Process Organizational Structure



The proposed process includes the following key *principles and guidelines*:

- The process is fully transparent – All materials considered by the CCRPC and TWGs, are posted to the project website, and all meetings are open to the public. The transparency of technical analyses, the design of response policies and participant viewpoints is critical to the identification and resolution of potential conflicts.
- The process is inclusive – A diverse group of CCRPC and TWG members are chosen to represent a broad spectrum of interests and expertise in the Chittenden region. A ground rule for participation is to be supportive of the process, but members are free to disagree on specific decisions within the process. The public also is invited to provide meaningful review of and input to decisions.
- The process will seek but not mandate consensus – Votes will be taken at key milestones in the process in order to advance to next steps as indicated in meeting agendas. Alternatives that address barriers to consensus will be developed by the PSC and TWGs as needed. Voting is conducted by simple request or objection at the point of decision (by hand), followed by resolution of conflicts with the development of alternatives, as needed, to proceed. Final votes by the PSC, and the TWGs where appropriate, include support at three levels, including: unanimous consent (no objection), super majority (less than 25% of members object), and majority (less than half object). The final report will document PSC recommendations and views on each response measure, including alternative views as needed.
- The process is implementation-oriented – The goal of the process is ultimate adoption of specific policies based on the recommendations of the PSC and any subsequent, more-detailed analyses, as needed.

The process is stepwise – Each step of the process builds incrementally on the former step toward a final solution. Sufficient time, information, and interaction are provided between steps to ensure comfort with decisions and quality of results. Figure IV-2 illustrates the steps envisioned for this process.

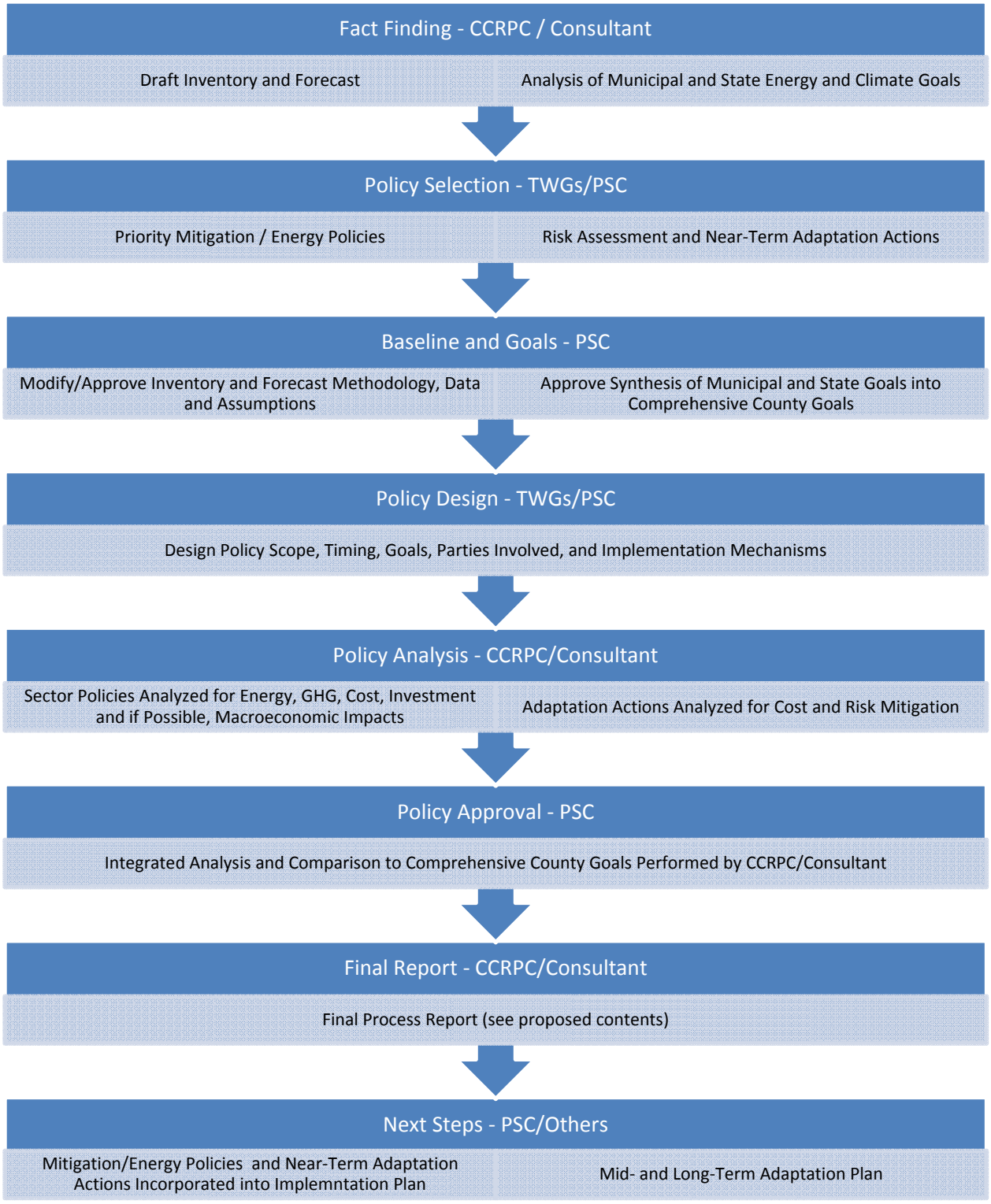
E. ROLES AND RESPONSIBILITIES

The structure of the advisory process, including the roles and responsibilities of the convener, committees, panels and public participants are as follows:

1. CCRPC

CCRPC will serve as the convener of the process and in that role provide: oversight, agency coordination and funding; appoint PSC and TWG members; provide a project website; provide much of the technical analysis in connection with the inventory and forecast and policy analyses and produce a comprehensive final report that describes the process, findings, and results of the project, and continued monitoring and reporting of the process' implementation successes and subsequent results. The CCRPC will appoint a PSC Chair from among its members who will work in partnership with CCRPC staff and the consultant to support timely and orderly completion of tasks, good-faith participation, resolution of issues by PSC members, enforce ground rules, and open and close PSC meetings.

Figure IV-2. Proposed Process Steps



2. Consultant

The consultant will report to CCRPC and the Chair and provide facilitation, capacity building, supplemental technical analysis, and communications support to the PSC and TWGs, and cost share development (if any). The consultant is a neutral party and will not take positions on issues before the PSC or TWGs.

3. Process Stakeholder Committee (PSC)

The PSC will make non-binding recommendations to CCRPC with advice and assistance of the TWGs. The PSC will be composed of local and regional representatives with expertise and interest in the project. The PSC will provide local and regional perspectives important to addressing project objectives and carrying out policy implementation. CCRPC will appoint the members of the PSC.

The PSC will be comprised of members who represent key interests and competencies in the region. PSC members must be able to provide continuity, competence, decision-making, and effective participation. The members should be locally based and reside in the region. Organizations that can directly represent themselves are preferred. PSC membership may include CCRPC representatives but should also include individuals representing critical public, private and institutional entities. Examples might include key officials from municipal bodies and offices not represented on the CCRPC board, the management of Vermont Agency of Natural Resources, the Public Service Department, VTRANS, IBM, Fletcher Allen, UVM, the Lake Champlain Regional Chamber of Commerce, the Lake Champlain Basin Program and others.

Due to the focused and time-sensitive nature of this process, all PSC members should endeavor to attend every meeting. PSC members should commit at least one full day for each meeting. PSC meetings will be approximately 6 hours in duration. No proxies should be allowed. In the case that any PSC member must miss a meeting, a personal representative of that member may attend to gather information.

The PSC must be supportive of the process and ground rules, including:

i. Objective criticisms accompanied by constructive alternatives

ii. No backsliding or returning to issues on which decisions have previously been made through the process

iii. No representation of CCRPC or the process to the media

iv. Supportive of the process

v. Must represent *themselves* in the process, as opposed to their organization, and be able to make decisions without delayed conferrals with their organization; this requirement implies that PSC members must be relatively high level individuals in each organization and either be or directly report to the organization's chief executive officer.

4. Technical Work Groups (TWGs)

The TWGs will make non-binding recommendations to the PSC with technical and facilitative assistance by the consultant. The TWGs will be composed of PSC members, their key advisors, and other subject matter experts who will support and augment the PSC's activities and deliberations. The TWGs will focus on specific topics related to the project objectives, including review and comment on the draft inventory and forecast of emissions, the development of a comprehensive set of potential policy actions, suggested priorities for policy development and analysis, draft policy designs, and review and comment on process analytical methods, data sources and assumptions. TWGs will meet primarily by

teleconference between PSC meetings. TWG teleconferences will be approximately 90 minutes in duration. CCRPC will appoint the members of the TWGs.

a. Scope of the TWGs

i. *Transportation and Land Use (TLU)* – transportation investment in infrastructure, transportation planning and operational policies and practices that fall under the categories of Transportation Demand Management (TDM) and Transportation System Management (TSM), development patterns and distribution of population, business/commercial and employment, housing.

ii. *Heat and Power (H&P)* – generation, transmission and distribution of electricity, natural gas processing, transmission and distribution; dealing principally with the supply of energy resources (including biomass and other renewables), including full fuel-cycle (upstream) energy/emissions issues.

iii. *Residential, Commercial and Industrial (RCI)* – energy use by buildings and industrial processes; dealing principally with the use of energy resources at stationary facilities (including full fuel-cycle energy/emissions issues); non-energy industrial process emissions.

iv. *Agriculture, Forestry and Waste Management (AFW)*– energy use and supply associated with agricultural, silvicultural, and waste management operations; non-energy emissions sources associated with these activities; carbon sinks associated with these activities; upstream (fuel-cycle) emissions associated with solid waste management activities.

v. *Adaptation (ADP)*—actionable measures to address near-term challenges and opportunities associated with unavoidable climate change; scope may include public infrastructure and resources, agriculture, silviculture, water resources, ecosystem health, human health, commerce and industry, air quality, and others as needed; the TWG may also make a series of recommendations for mid and long term studies to anticipate less-certain, longer-term adaptation challenges and opportunities.

b. Composition

Each of the TWGs will include active members from the PSC or their proxies, plus additional active members representing key local interests and competencies that match the scope of each TWG. Members must provide continuity, competence, and effective participation. Each TWG should include experts with local knowledge about the sector for which the TWG is responsible. A mix of interests and expertise is encouraged with balanced consideration of academics, business interests, NGOs, and state and local regulators and officials. If they are a proxy for the PSC representative, both the PSC and TWG representatives must be fully coordinated and able at all times to represent their work jointly (proxies are not preferred). The TWG members will be locally based and reside in the region. TWG members must be supportive of process and other ground rules.

5. The Public

The public will be able to fully monitor the proceedings of the initiative and provide input at regular, scheduled points during PSC and TWG meetings, at special public events, as well as through other means. All materials for the PSC and TWG meetings will be posted to a public website. The proposed process also will work to develop and provide appropriate communications strategies for target audiences and the general public including workshops, a website and webinars, briefings, and publications.

F. TIMING, MILESTONES, AND MEETINGS

The first in-person meeting of the PSC is proposed to be held on Day 1. A series of four or more additional meetings are proposed during the following 3 months. The final report of the PSC to CCRPC will be delivered within 60 days following its final meeting. For each of the TWGs, one or more conference calls or meetings are proposed between each of the PSC meetings.

The following draft schedule is suggested for planning purposes:

Month	Meeting/Action
0	1st PSC Meeting
1	2nd PSC Meeting
3	3rd PSC Meeting
4	4th PSC Meeting
6	Final Report
6+	Implementation Plan, Mid- and Long-Term Adaptation Plan

The objectives and agendas for each of the PSC and interim TWG teleconference meetings are listed below, with notes regarding each of the sequential decisions of the PSC.

PSC Meeting One

1. Objectives:
   a. Introduction to the process.
   b. Presentation of preliminary fact-finding
   c. Presentation of conceptual inventory and forecast
   d. Presentation of county-level synthesis of municipal and state energy and climate goals
2. Agenda:
   a. Introductions
   b. Purpose and goals
   c. Review of the process
   d. Review of Vermont's 2012 Energy Plan and its implications for regional planning
   e. Review of Chittenden County municipal climate plans, goals and town energy plans
   f. Seek PSC volunteers (temporary subcommittee) to work with CCRPC staff on synthesizing state and municipal goals into comprehensive county goals for future consideration by the PSC

g. Review of the regional inventory and forecast of GHG emissions
h. Review compendium of categories of potential response actions
i. Next meeting agenda, time, location, date
j. Public input

3. Interim Sector TWG meetings will:
   a. review and suggest additions to the draft compilation of potential policies and action;
   b. propose priority policies for development and analysis; and
   c. review the GHG inventory and forecast and identify potential modifications.

   Interim Adaptation TWG meetings will assess climate change risks and priority areas for action.[4]

   CCRPC staff and PSC volunteers will synthesize state and municipal energy and climate goals into draft comprehensive county goals.

PSC Meeting Two

1. Objectives:
   a. Approve or modify the selection of identified priority policies for further analysis
   b. Approve or modify Adaptation assessment of risks and selection of priority areas for action
   c. Approve or modify draft comprehensive county goals[5]
2. Agenda:
   a. Review and approve priority policies for TWG development and analysis
   b. Review and approve Adaptation of risks and selection of priority areas for TWG policy development
   c. Review and approve comprehensive county goals for energy and climate action
   d. Public input

   Interim Sector TWG meetings will cover policy design including scope, timing, parties involved, and implementation mechanisms, as well as offer final input on draft inventory and forecast.

   Follow-up Adaptation meetings will select a short list of near-term priority actions that:
   a. are PSC approved priorities;
   b. will address near-term risks and do not require significant additional study, and,
   c. are feasibly implementable by the responsible jurisdiction or entity.

[4] This process for adaptation planning will generally follow the "CCS Adaptation Guidebook". Refer to the guidebook for more information. http://www.climatestrategies.us/library/library/view/908

[5] This process design assumes that the county goals reflect and support both municipal and state goals. It is not envisioned that the CCRPC or the PSC will craft new goals independent of those adopted by the state or member municipalities.

PSC Meeting Three

1. Objectives:
    a. Review development and analysis of priority policies
    b. Review and approve updates to the regional GHG inventory and forecast
    c. Review and approve list of near-term Adaptation priority actions
2. Agenda:
    a. Review development and analysis of priority policies; request redesign and reanalysis as needed
    b. Review and approve proposed updates to the regional GHG inventory and forecast
    c. Review and approve list of near-term Adaptation priority actions
    d. Public input
3. Follow-up sector TWG meetings will cover redesign, reanalysis and finalization of priority policies.

    CCRPC staff and the consultant will integrate the analysis of individual mitigation policies into a comprehensive analysis to eliminate overlaps and double counting and take into consideration policy interactions.

    CCRPC staff and the consultant will compare the integrated results to the comprehensive county goals to determine whether the proposed policies achieve the desired results.

    Interim Adaptation meetings will:

    a. prepare analysis of near-term adaptation priority actions,
    b. prepare lists of medium and long-term priority concerns, and
    c. propose follow-up studies, plans or actions necessary to support the development of medium and long-term actions in response to the identified concerns.

PSC Meeting Four

1. Objectives:
    a. Final approval of policy recommendations and analysis
    b. Discussion of comprehensive county goal attainment, additional follow-up efforts (if needed), and development of a county implementation plan
    c. Final approval of near-term Adaptation actions and analysis, and mid-and long-term Adaptation plan
    d. Approval of final report process
2. Agenda:
    a. Review and approval of final policy recommendations, including final votes
    b. Approve near-term adaptation actions analysis and review and approve mid- and long-term adaptation plan process
    c. Discuss follow-up process or plan to communicate results, promote implementation and monitor progress

d. Summarize the final report drafting process, review next steps, and transmittal/ distribution of the final report.

e. Public input

G. PROPOSED APPROACH TO DEVELOPING INVENTORY AND FORECAST

Table IV-1 provides a summary of suggested data and approaches for developing the baseline energy and emissions inventory and forecast. As shown in the table, there are a mixture of top-down and bottom-up methods. Our suggestions are based on the likely importance of a given sector within the region, as well as the importance of the sector in local energy, air quality, and climate action planning (i.e., the authority of CCRPC and municipalities to affect change).

Previous sections of the final report provide background on the use of direct versus consumption-based accounting methods. We suggest developing a full direct inventory and forecast that is consistent with Vermont Department of Environmental Conservation's (DEC) inventory for criteria and toxic air pollutants. The latest DEC inventory covers 2008, which we feel is a good base year for CCRPC to use in its initial planning. By building consistency with DEC at the outset, future updates to the inventory and forecast will require less effort.

For consumption-based emission estimates, we suggest that these cover, at a minimum: all fuel combustion sources, electricity consumption, and waste management. A full consumption-based inventory should be something considered by CCRPC for future planning purposes.

Table IV-1. Suggested Inventory & Forecast Data Sources and Methods

Sector	Direct Energy & Emissions (GHG/CAP/TAP)		Consumption-Based Energy & Emissions (GHG only)	
	Historic	Forecast	Historic	Forecast
Electricity	2008 DEC CAP/TAP Inventory[a]; add GHGs based on plant-level fuel combustion.	Apply plant-level growth & control factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Surveys of regional electricity providers on annual consumption for residential, commercial, institutional, and industrial customers at the zip code or finer spatial scale (e.g., census tract). Apply utility-specific delivered electricity emission factors (preferred) or US EPA eGRID regional factor. Add in upstream fuel cycle estimates using US DOE Argonne National Labs GREET Model or other source[c].	Local planning studies on growth of building space for the RCII sectors (preferred); or DEC statewide forecast data[b].
Residential/Commercial/ Institutional Fuel Combustion	Preferred: surveys of regional fuel providers on sales of each fuel at the zip code or finer spatial scale. Apply GHG emission factors from The Climate Registry (TCR) and CAP/TAP emission factors from US EPA. Alternative: 2008 DEC county-level CAP/TAP data allocated to municipalities/census tracts with population, employment, or other surrogate. Add in GHGs using TCR emission factors.	Preferred: apply growth factors based on local planning studies of growth in building space for the RCI sectors. Alternative: Apply state-level DEC growth factors for each sector.	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Industrial Fuel Combustion	2008 DEC CAP/TAP plant-level (assumes energy consumption data are available); add in GHGs using TCR emission factors.	Apply plant-level growth & control factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Industrial Processes	2008 DEC CAP/TAP plant-level; add-in GHGs using plant-level activity data.	Apply plant-level growth & control factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Upstream emissions associated with the use of imported high GHG content materials (e.g., iron, steel, cement, glass) are potentially significant; however, consumption data are difficult to obtain. Consider	Based on local planning studies for growth in buildings, roadways, and other infrastructure.

Sector	Direct Energy & Emissions (GHG/CAP/TAP)		Consumption-Based Energy & Emissions (GHG only)	
	Historic	Forecast	Historic	Forecast
			adding in these emissions if consumption data for these materials can be estimated using local data.	
Transportation – Onroad	Link-Level CCRPC regional transportation model VMT allocated to each municipality. EPA MOVES model uses VMT to estimate emissions.	Forecasted regional VMT growth by municipality, adjusted to account for growth in fleet fuel economy and fuels changes (e.g., biofuels).	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Transportation – Aircraft	2008 DEC CAP/TAP facility-level; add-in GHGs using facility-level activity data.	Preferred: apply facility-level growth factors based on airport surveys of LTO growth; Alternative: apply growth factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Transportation – Rail	2008 DEC CAP/TAP county-level allocated to municipalities using track-miles or other surrogate; add-in GHGs using allocated energy data. If this is an important sector for the region, survey rail carriers for data on local fuel use (e.g., at switch yards) and activity data for regional tracks (ton/passenger miles)	Apply growth factors consistent with DEC forecasts (for air quality or regional haze planning purposes). If an important sector: use survey data from rail carriers on expected passenger and freight rail growth for the region.	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Transportation – Commercial Marine Vessels (CMV)	2008 DEC CAP/TAP county-level allocated to municipalities using port activity data or other surrogate; add-in GHGs using allocated energy data. If this is an important sector for the region, survey CMV operators for data on local fuel use (e.g., at switch yards) and activity data for regional tracks (ton/passenger miles)	Apply growth factors consistent with DEC forecasts (for air quality or regional haze planning purposes). If an important sector: use survey data from CMV operators on expected passenger and freight transport growth for the region.	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.

Sector	Direct Energy & Emissions (GHG/CAP/TAP)		Consumption-Based Energy & Emissions (GHG only)	
	Historic	Forecast	Historic	Forecast
Transportation – Other Nonroad	2008 DEC CAP/TAP county-level allocated to each municipality using appropriate surrogate (e.g., employment); add in GHGs using allocated energy data.	Apply growth factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Same as direct, except for the addition of upstream fuel cycle emissions from GREET or other source.	Same as direct.
Agriculture (non-fuel combustion)	2008 DEC CAP/TAP county-level allocated to each municipality using appropriate surrogate (e.g., crop area, livestock population); allocate state-level GHG estimates based on municipal surrogates. See the US EPA citation below[d] for details on merging GHG estimates with CAP/TAP emissions. Note that although this sector typically is devoted to non-fuel combustion emissions, those estimates can be extracted from the 2008 DEC data for the Transportation – Other Nonroad sector	Consult with DEC on appropriate selection of growth factors: either from air quality planning or state-level GHG forecasts.	Add-in upstream emissions from commercial fertilizers and other soil amendments.	Same as direct.
Forestry	Forested lands: Allocate state-level sequestration to each municipality based on local land use data. If this sector is likely to be an area of focus during the planning process, better estimates could be developed from the bottom-up using municipal-level land use change data and county-level carbon sequestration estimates from US Forest Service modeling tools. Urban forest: state-level estimates of carbon sequestration allocated to each municipality based urban area (and canopy cover, if available).	Forested lands: based on municipal level change in forest area and county- or state-level average carbon stocks. Urban forests: local urban area growth estimates and expected change in urban canopy cover.	Forested lands: These estimates would be based on forest products consumption other than for energy purposes which is captured under the fuel combustion categories above (paper, lumber, fiber, other wood products). As with Industrial Processes, these activity data would be difficult to obtain and are partially captured within the consumption based estimates for the Waste Management sector. For initial planning purposes, we suggest holding off on these estimates. Urban forestry: there is no relevant consumption-based accounting for this sub-sector.	Based on local/state growth of forest products consumption or a relevant surrogate (e.g., population).

Sector	Direct Energy & Emissions (GHG/CAP/TAP)		Consumption-Based Energy & Emissions (GHG only)	
	Historic	Forecast	Historic	Forecast
Waste Management	2008 DEC CAP/TAP emissions for landfills and possibly other waste sector sources (e.g., waste combustion, composting operations, wastewater treatment plants). Landfill methane estimates should also be available from the same modeling data. Fill in missing GHG data using activity data consistent with the 2008 DEC data.	Apply growth factors consistent with DEC forecasts (for air quality or regional haze planning purposes).	Municipal solid waste: Capture upstream GHG emissions using estimates of municipal (or county) level waste generation, recycling, combustion, & composting and EPA's WARM model. See the analysis done for the NJTPA I&F for an example[e]. Wastewater treatment: direct emissions plus treatment plant energy use emissions are allocated to wastewater generators. The NJTPA study provides an example.	Municipal solid waste: based on county-level forecasts of waste generation, recycling and waste management. Wastewater treatment: forecast based on population and any anticipated changes to treatment plant operations.

[a] The data for VT are available here: http://www.epa.gov/ttnchie1/net/2008inventory.html.
[b] Data/graphs of the emissions/forecast summaries are available here: http://www.vtenergyplan.vermont.gov/sites/cep/files/u6/CEP-CR_Presentation.pdf.
[c] http://greet.es.anl.gov/.
[d] http://www.climatestrategies.us/library/library/view/930.
[e] http://www.climatestrategies.us/library/library/view/931.
Notes: CAP – criteria air pollutant; CMV – commercial marine vessel; EPA – US Environmental Protection Agency; GHG – greenhouse gas; LTO – landing & take-off cycle; TAP – toxic air pollutant; TCR – The Climate Registry; VMT – vehicle-miles travelled.

APPENDIX A
SUMMARY OF DATA TOOLS AND STRUCTURES FOR GREENHOUSE GAS EMISSION INVENTORIES

To: Chittenden County Metropolitan Planning Organization

From: Steve Roe, Maureen Mullen, Jackson Schreiber, TranSystems

Date: June 10, 2011

Subject: Climate/Energy/Air Quality Planning Best Practices Review and Summary Contract, Task 1 Data Tools and Structures for Greenhouse Gas Emission Inventories

The purpose of this memo is to provide Chittenden County Regional Planning Commission/ Chittenden County Metropolitan Planning Organization (CCRPC/CCMPO) with a summary of data tools and structures that could be used for preparing greenhouse gas (GHG) emission inventories and forecasts for the Chittenden County region. This memo also provides a recommendation for the data tools/structures that we feel would be most appropriate for the region to consider based on the inventory needs of the region in addressing GHGs, ambient air quality, and energy planning.

1.1 Inventory Types and Characteristics

1.1.1 Organizational Inventories vs. Planning Inventories

When determining the best data tools and structures for an organization to use, it is important to keep in mind the needs of the organization and the purpose of the inventory. For the purposes of reporting to a climate registry, an organization would want to prepare an *organizational inventory*. Such an inventory would represent the GHG emissions resulting from the direct operations of the organization, such as the GHG emissions resulting from the fuel used to heat the organization's facilities and the electricity for air conditioning the facilities, and emissions from vehicles owned by the organization.

Inventories developed for climate action planning (CAP) processes covering the GHG emissions that occur within a jurisdiction's geographic boundaries are quite different and require different models and data structures. We refer to these as *planning inventories*, given that they are used for planning purposes, such as to check progress towards meeting a GHG reduction goal or evaluating the future emissions path of planning decisions made in that area. Planning inventories are broader in scope, encompassing emissions from stationary source fuel combustion, fuel combustion from transportation sources, waste management, industrial sources, agriculture, forestry, and land use (another term often applied to these inventories at the municipal level is community inventories). In addition, while in some cases an inventory for a single recent historical year may be useful, inventories are often needed for multiple years, starting with a year from which inventory targets are based (baseline year), along with projections to the future based on expected or business as usual (BAU) conditions. Our focus in this memo is on planning inventories, and not organizational inventories, consistent with the stated needs of CCMPO.

1.1.2 Direct vs. Consumption-Based Accounting Procedures

When developing planning inventories, it is also useful to keep in mind the potential needs of planners in evaluating various climate change mitigation strategies. An important need of planners is the ability to measure GHG benefits of actions that reduce emissions both locally and outside of the jurisdiction. A mitigation action implemented within the jurisdiction can result in reductions both within and outside of the area's boundaries. Common examples include: Energy efficiency approaches to reducing building

electricity use: GHG reductions occur within the power generating fleet supplying electricity to the grid, usually not within the jurisdiction;

- Energy efficiency approaches to reducing fossil fuel use: whether in stationary or mobile sources, reductions in fossil fuel use result in reductions at the point of use (within the jurisdiction), as well as in the upstream energy cycle (e.g., petroleum production, refining, distribution); and
- Waste reduction, reuse, or recycling: most of the reductions occur upstream of the final place of waste generation/management (e.g., extraction of virgin raw materials, transport, manufacturing, etc.).

In order for a planning inventory to be able to adequately capture and communicate the importance of these emissions, differing accounting procedures need to be employed. A planning inventory based on *direct emissions accounting* methods will provide only the emissions that occur within the geographic boundaries of the jurisdiction. We call an inventory designed to capture the emissions associated with the full energy cycle of each source a *consumption-based inventory*. Most climate action planning inventories are a combination of direct and consumption-based accounting. Commonly, the inventories are direct emissions based with the exception of the electricity sector, which is consumption-based (to best show the benefits of electricity efficiency measures). In the recommendations section at the end of this memo, we provide some illustrations of why it is important to consider consumption-based emissions for other sectors within a CAP process.

1.1.3 GHG Inventory Data Tools and Structures

This memo provides a general description of several different data tools and structures that could be used for GHG inventory purposes by CCRPC/CCMPO. Where appropriate, the advantages and disadvantages associated with using each of these tools/structures are also discussed. Finally, the data needs of each tool/structure are described. Summary information on the tools/structures included below is provided in Table 1 at the end of this memo. Our recommendations for CCRPC/CCMPO, based on our understanding of CCRPC/CCMPO's needs, follow the discussion of available tools/structures. This includes addressing needs for tracking criteria air pollutants (CAPs), toxic air pollutants (TAPs), and energy use.

1.2 Key Models for Emissions Inventories and Forecasting

1.2.1 State Inventory Tool

Description - EPA's State Greenhouse Gas Inventory and Projection Tools are a set of interactive spreadsheet models designed to help states develop GHG emissions inventories. The tool has two components: the state inventory tool and the projection tool. The State Inventory Tool (SIT) gives users the option of applying their own state-specific data or using default data pre-loaded for each state. The default data include data published by a variety of federal agencies and cover activity in the fossil fuel, transportation, agriculture, forestry, waste management, and industrial sectors. SIT allows policy planners to update an existing inventory or complete a new inventory, with historical inventories

calculated back to 1990 through the most recent year of available data, usually about two years prior to the current calendar year. The Projection Tool allows users to create a simple forecast of emissions through 2030 based on historical emissions and projections of future energy consumption, population, and economic factors. The U.S. Department of Energy's Annual Energy Outlook (AEO) projection data are frequently used to estimate changes in future energy consumption and economic growth with this tool. SIT is designed to be used at the state level and has been used for many GHG inventories and forecasts developed for state climate action planning processes. While not the intended purpose of the model, and not a supported function, with careful and knowledgeable user-supplied inputs, the tool could be used to estimate emissions at either a smaller geographic level of detail, such as the county level, or for a group of counties. One module of the SIT estimates only CO_2 emissions from fossil fuel consumption. This module estimates CO_2 emissions based on fossil fuel consumption data, and as a result, these CO_2 emissions are not separated by subsector, but only by fuel type and major sector (e.g., commercial, residential, industrial, transportation, and electric power).[6] For example, highway vehicle carbon dioxide (CO_2) emissions are not broken out separately from total transportation emissions. The transportation estimate of diesel CO_2 from the SIT includes diesel used by highway vehicles, locomotives, and commercial marine vessels. TranSystems analysts have applied and refined methods for allocating the transportation fuel consumption and emissions by transportation category, for use with the SIT. Such methods could also be applied by CCRPC/CCMPO, if desired.

Use for CCRPC/CCMPO - Because SIT can only be completed at the state level, this tool may be of limited use to CCMPO for many sectors. Currently, the State's Department of Environmental Conservation (VT DEC) uses SIT for many of the sectors in the state inventory and forecast. Data for CCRPC/CCMPO would need to be adjusted to the county level based on some useful indicator (State vs. county population or VMT or agricultural land, for example). Alternatively, if input data are available at the county or CCRPC/CCMPO regional level, careful use of the SIT could provide GHG emissions at that same level of detail. However, this would require user-input data to replace all SIT default state-level data.

Data Needs - SIT contains state-specific defaults, but more recent or localized data will improve SIT estimates. In addition, there are some subcategories of emissions for which the SIT does not include default data, and the user must input data if emissions are to be calculated for that category. Again, to calculate emissions at the county or CCRPC/CCMPO level of detail, all of the Vermont default state-level data would need to be replaced with local data, or the output emissions data adjusted to the desired geographic level of detail.

1.2.2 U.S. Environmental Protection Agency's (EPA's) MOVES Model

Description - EPA's Motor Vehicle Emission Simulator 2010 (MOVES2010) model was released in December 2010 and is designed to model a broad range of pollutant emissions from on-road vehicles. MOVES2010 is used to model criteria air pollutants for non-attainment areas and to model GHG emissions. On March 2, 2010, EPA provided notice in the Federal Register that MOVES2010 is officially approved for use in State Implementation Plans (SIPs) and for transportation conformity analyses outside of California. Although there is a grace period allowed for the transition from MOBILE6 to MOVES for SIPs and transportation conformity, states and metropolitan planning organizations should now be moving

[6] It should be noted that additional modules of the SIT include CH_4 and N_2O emitted from fossil fuel combustion for stationary and transportation sources, as well as other sources of GHG emissions, such as from the waste and agriculture sectors.

towards the use of MOVES in their official submittals to EPA. As agencies become familiar with this model and develop the local inputs needed for SIP and conformity analyses, it also becomes a more feasible tool for estimating GHG emissions. EPA has stated that "MOVES2010 is currently the best tool EPA has for estimating emissions from the transportation sector" and that "States and local agencies estimating GHG emissions in the transportation process should consider using MOVES2010 for GHG emissions analyses in the future."[7] MOVES 2010 currently has the capability to estimate GHG emissions of CO_2, methane (CH_4), and nitrous oxide (N_2O) from highway vehicles using gasoline or diesel. This includes gasoline blends, such as various levels of ethanol, and biodiesel. Compressed natural gas (CNG) is also included and available for transit buses. MOVES2010 provides the transportation planner with the ability to model GHG emissions from the project level to the regional level, and in a manner consistent with the way their emissions of other pollutants would be calculated using MOVES2010 for SIP or transportation conformity analyses. Once the transportation data (such as vehicle miles traveled (VMT)), fleet data (such as vehicle age distribution), and other local data have been gathered for use in official EPA submittals, these same inputs can be used to calculate GHG emissions in MOVES2010. GHG emissions are calculated in MOVES2010 based on the actual fuel consumed under the local driving conditions (i.e., speed distributions) and vehicle fleet. Thus, the evaluations of projects that include changes in vehicle speeds can be analyzed with MOVES, as can projects or policies that result in changes in vehicle activity or a shift in vehicle types. Emissions can be projected to any year through 2050 with MOVES.

Use for CCRPC/CCMPO - This is a useful tool to CCRPC/CCMPO for estimating onroad emissions if the data needs can be met. By appropriately adjusting the inputs, MOVES emissions can be calculated at a municipal, sub-county, or link-level of detail, if needed. Some of the advantages of using MOVES over a fuel-based approach include:

- The ability to estimate CO_2, CH_4, and N_2O emissions simultaneously from the same activity data (as well as ozone precursors and other criteria pollutants, if needed);
- Emissions represent the geographic area of the input VMT and vehicle population;
- Most of the inputs would already be developed for SIP, conformity, or other transportation planning purposes;
- Since the type of travel (speed distribution, road types, driving cycles) in an area will impact fuel economy, MOVES emissions will be more representative of an area (assuming appropriate inputs are used) than simply allocating fuel use to a sub-state area;
- Many mitigation strategies could also be modeled with MOVES, providing a consistent approach estimating emissions for inventories, forecasts, and mitigation measures. In addition, emissions can be output by vehicle type, to allow for the development of focused mitigation strategies.

Data Needs - Transportation data (such as VMT), fleet data (such as vehicle age distribution), and other local data. As discussed above, most of these would need to be developed for other purposes, so the additional resources needed to develop a MOVES-based GHG inventory should be small. However, MOVES run times can be significant, depending on how the runs are structured. The MOVES outputs are database tables that can easily be exported to a number of different formats. Some data manipulation and/or queries are likely to be needed to get the data in a useable format.

[7] "EPA Releases MOVES2010 Mobile Source Emissions Model: Questions and Answers," EPA-420-F-09-073, U.S. EPA, Office of Transportation and Air Quality, December 2009.

1.2.3 U.S. Environmental Protection Agency NONROAD Model

Description - The NONROAD model calculates past, present, and future emission inventories (i.e., tons of pollutant) for all nonroad equipment categories[8] except commercial marine, locomotives, and aircraft. Fuel types included in the model are: gasoline, diesel, compressed natural gas, and liquefied petroleum gas. The model estimates exhaust and evaporative hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM), sulfur dioxide (SO_2), and CO_2[9]. The user may select a specific geographic area (i.e., national, state, or county) and time period (i.e., annual, monthly, seasonal, or daily) for analysis.

Use for CCRPC/CCMPO –Use of this model would allow CCRPC/CCMPO to calculate detailed emissions from the nonroad sector, providing a lot more detail as compared to the sector-level output of a model like SIT (i.e., detail of nonroad fuel end use by source type). Note that CH_4 and N_2O emissions are not output by this model. Emissions could be estimated at the county level or lower, depending on CCMPO needs. This model can provide a consistent framework for both historical and projected nonroad emission inventories.

Data Needs - Requires information on the number of and specification of nonroad equipment and vehicles, vehicle power and load factors, as well as activity data. These data have likely already been gathered for use by VT DEC in calculating criteria pollutant emission inventories at the county-level, but would need further work to disaggregate them to the municipal level.

1.2.4 U.S. Environmental Protection Agency's Waste Reduction Model

Description - EPA created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report greenhouse gas (GHG) emissions reductions from several different waste management practices. The WARM spreadsheet calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon equivalent (MTCE), metric tons of carbon dioxide equivalent ($MTCO_2E$), and energy units (million BTU) across a wide range of material types commonly found in municipal solid waste (MSW).

Use for CCMPO - Can be used to estimate the effectiveness of waste management goals/scenarios for CCMPO. This model should be used for any source reduction/reuse/recycling/waste management planning CCMPO wants to do on the county level. It also serves as a data source for the development of a consumption-based inventory for the solid waste management sector.

[8] The nonroad categories include offroad vehicle and equipment activity from sources such as agricultural vehicles and equipment (e.g., tractors, combines), construction equipment (e.g., backhoes, cranes), lawn and garden equipment (e.g., lawnmowers, snowblowers), industrial equipment (e.g., forklifts, general industrial equipment), and recreation vehicles (e.g., snowmobiles, outboard engines). Emissions from aircraft, locomotives, and commercial marine vessels are also included in the nonroad category; however emissions from these sources are not included in EPA's NONROAD model, although ground support equipment for these categories are included in NONROAD.

[9] CO_2 is the only GHG included in NONROAD. This model does not calculate emissions of CH_4 or N_2O.

Data Needs - Information on waste recycled, waste composted and waste landfilled by material type.

1.2.5 EPA's LandGEM

Description - The Landfill Gas Emissions Model (LandGEM) is an automated estimation tool with a Microsoft Excel interface that can be used to estimate emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds, and individual air pollutants from active municipal solid waste landfills. LandGEM can use either site-specific data to estimate emissions or default parameters if no site-specific data are available. The model contains two sets of default parameters, Clean Air Act (CAA) defaults and inventory defaults. The CAA defaults are based on federal regulations for MSW landfills laid out by the CAA and can be used for determining whether a landfill is subject to the control requirements of these regulations. The inventory defaults are based on emission factors in EPA's *Compilation of Air Pollutant Emission Factors (AP-42)* and can be used to generate emission estimates for use in emission inventories and air permits in the absence of site-specific test data.

Use for CCRPC/CCMPO - Can be used to assess the impact of active landfills at the county level. Chittenden County has several old closed landfills but no active landfills. A regional landfill is planned in the future.

Data Needs – Annual solid waste emplacement data and use of landfill gas controls at each site are the primary inputs into the model. Additional site-specific data improves LandGEM outputs (e.g., methane content of landfill gas), but default data can be used.

1.2.6 U.S. Forest (USFS) Carbon Calculation Tool (CCT)

Description - The Carbon Calculation Tool is a computer application that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of carbon stocks on forest land based on the USFS FORCARB2 model estimators. Estimates can be recalculated as new inventory data become available. The input set of FIA data files available on the Internet (as well as some older inventory files used to fill in gaps) are summarized by the application, converted to carbon stocks, and saved as part of a state or substate level "survey summary" file. This is used to produce state-level and national tables with annualized carbon stocks and flux (or net stock change) beginning with the year 1990.

Use for CCRPC/CCMPO - Can only be used at the state level, so all results would need to be adjusted to be useful for CCMPO. However, CCT outputs may be relatively scalable from the state to the county level based on acres of forestland, and therefore this model may still be useful for any forestry planning CCMPO requires.

Data Needs - Requires FIA data files, which can be found online.

1.2.7 The Climate Registry's Local Government Operations Protocol

Description - The Climate Registry's Local Government Operations (LGO) Protocol is designed to provide a standardized set of guidelines to assist local governments in quantifying and reporting GHG emissions associated with their government operations. The LGO Protocol provides the principles,

approach, methodology, and procedures needed to develop a local government operations GHG emissions inventory. It is designed to support the complete, transparent, and accurate reporting of a local government's GHG emissions. The Protocol guides participants through emissions calculation methodologies and reporting guidance applicable to all U.S. local governments. The Protocol is a tool for accounting and reporting GHG emissions across a local government's operations. Reductions in emissions are calculated by comparing changes in a local government's emissions over time. By tracking emissions over time, local governments should be able to measure the GHG reduction benefits from policies and programs put in place to reduce emissions within their operations.

Use for CCRPC/CCMPO – Useful for CCRPC/CCMPO or municipalities in development of their organizational inventories; however, it is less useful for developing a planning inventory. Some methods within the protocol (e.g., landfill emissions, wastewater treatment) could be employed within a planning inventory.

Data Needs - Data requirements will vary depending on what CCRPC/CCMPO intends to use the Protocol for.

1.2.8 ICLEI's Clean Air and Climate Protection (CACP) Software

Description - CACP 2009 is an emissions management tool that calculates and tracks emissions and reductions of GHGs (carbon dioxide, methane, nitrous oxide) and criteria air pollutants (NO_x, SO_x, carbon monoxide, volatile organic compounds, PM_{10}, $PM_{2.5}$) associated with electricity, fuel use, and waste disposal. CACP 2009 was created to support emissions inventorying and climate action planning based on the principles and methods of the Local Government Operations Protocol. It allows local planners to create emissions inventories for the community as a whole or for the government's internal operations. This enables local governments to quantify the effect of existing and proposed emissions reduction measures, predict future emissions levels, set reduction targets and track progress towards meeting those goals.

Use for CCRPC/CCMPO - This tool can be used to estimate GHG and CAP emissions in a certain municipality or project, as well as any emissions reductions associated with mitigation actions. Some of the limitations of this model for CCMPO are related to data quality/detail of the CACP model. The model displays output information primarily in terms of GHG/CAP savings of each fuel type as well as cost savings. If any additional information is needed to further subdivide emissions data, based on the emissions reporting method (direct vs. consumption based reporting) or the vehicle type for example, then those data are not going to be available.

Data Needs - Need information on fuel and electricity consumption in all sectors of the analysis. Also information on fuel savings of any mitigation actions

1.3 Other Emissions Estimation Tools

1.3.1 GREET

Argonne National Laboratory's GREET model is used to estimate the full life-cycle emissions of various fuels and technologies. The GREET model allows analysis for any year between 1990 and 2020. GREET

can be used to estimate GHG and CAP emissions, as well as total energy use. Different feedstocks for certain fuels can also be considered, such as potential cellulosic ethanol feedstocks, or Fischer-Tropsch diesel. The GREET Model is valuable for estimating the life cycle emissions (on a per mile basis) of various combinations of vehicles and fuel technologies, although typical GREET outputs in emissions/mile can be converted into another metric, such as emission/gallon, etc.

1.3.2 Annual Energy Outlook/National Energy Modeling System

The AEO is an annual publication from the Department of Energy to estimate total energy consumption by technology type and region. To create this estimate, the DOE uses the National Energy Modeling System (NEMS). NEMS creates an estimate of total energy consumption by analyzing the supply side (oil, natural gas, coal production and costs), and the demand side (residential, commercial, industrial and transportation demand), as well as where they interact (macroeconomic activity, international impacts, etc). The model typically predicts between 20 and 25 years in the future; AEO 2010 is the first year that the model went out to 2035. The model's emphasis is on energy supply and demand, and while GHG emissions are calculated in the model, it is only a small part of the AEO estimate and would not typically be used to estimate GHG emissions.

The AEO is typically considered to be the most reliable estimate of baseline national and regional energy consumption, fuel prices and efficiency improvements in this country. Due to the complexity of NEMS, it cannot be easily modified for specific policy scenarios, although new policies are incorporated into the AEO as soon as possible (such as the strengthening of Corporate Average Fuel Economy standards and the federal stimulus package). The AEO forecasts are updated every year, so they try to capture effects of recent changes in individual behavior and economic activity, such as the recession of 2008-09. In order to make energy forecasts for the entire country, AEO also calculates regional growth indicators for each sector, which can be valuable to transportation planners.

1.3.3 VISION

The VISION model was developed by Argonne National Laboratory to provide estimates of the potential energy use, oil use and carbon emission impacts of various light and heavy-duty vehicle technologies and alternative fuels through the year 2100. This model compares the penetration of various advanced technologies to a baseline scenario, where these technologies have not been implemented. The VISION model is updated annually to reflect changes in energy consumption according to the most recent Annual Energy Outlook. Growth factors are estimated in the VISION model through 2100 to make long term projections, using AEO growth rates, and additional factors such as predicted population and GDP growth. Growth assumptions can be modified by the user to show the sensitivity of various assumptions. The VISION model works exclusively with highway vehicles on ten year increments. VISION is not meant to serve as a replacement for NEMS, because that model provides greater detail on market penetration of various technologies. VISION instead complements NEMS with its relative "user-friendliness", faster modeling turnaround time, and by extending the time frame of potential analysis to 2100.

1.3.4 GreenSTEP/STEEP-AT

The Oregon Department of Transportation (ODOT) developed the GreenSTEP (Greenhouse gas State Transportation Emission Planning) model to provide modeling support for the development of a statewide strategy for reducing transportation sector greenhouse gas emissions. This tool is useful for high level analysis of transportation mitigation options. It is not sufficiently detailed for detailed emissions analysis at a municipal or MPO scale; a MOVES run would be required in that case. It is also not for project level GHG reduction planning, but rather for analyses at the county/state level.

1.3.5 EDMS

The Federal Aviation Administration (FAA) currently requires that agencies performing air quality analyses of airport emissions use the Emissions and Dispersion Modeling System (EDMS) model to estimate emissions from aircraft, auxiliary power units, and ground support equipment. For the purpose of developing GHG emission inventories, the latest version of EDMS (currently EDMS version 5.1) includes CO_2 emissions from aircraft engine activities associated with landing and takeoffs (LTOs). The model is airport-specific and estimates emissions by aircraft engine type. Some default data are available, but the model can also estimate emissions based on specific LTO schedules for an individual airport. Within the next year or two, FAA plans to replace EDMS with the Aviation Environmental Design Tool (AEDT), which is a comprehensive software compliance tool for evaluating the interdependencies between noise, criteria/toxic/GHG emissions, and fuel consumption from the aviation sector. When completed, MOVES and NONROAD capabilities will be included in AEDT for estimating emissions from ground-support equipment and airport-related onroad emissions.

1.4 Available Data Structures for Inventory Development/Storage

1.4.1 EPA's National Emissions Inventory System Format

Description – The National Emissions Inventory System (previously referred to as the NIF) has been in use for 15 years or more. It is the data format required by EPA that states use to report their state inventories for criteria and toxic air pollutants; however, it can also be used to store GHG data as well. EPA uses the national inventory to support national planning assessments and regional to national air quality modeling. Emissions data in this format is also often the first input to local air quality models used in State Implementation Planning for air quality attainment or maintenance.

We are introducing this data format here to initiate thinking around the best way to store and share data among all of the interested stakeholders in VT (i.e., not just the CCRPC/CCMPO, but municipalities and the state). The format could serve the needs of climate mitigation planning, air pollutant planning, and energy planning. Potentially the only limitation related to emissions inventories is that the format was only designed to address direct emissions. However, a related system could easily be developed to address consumption-based emissions, if the CCRPC/CCMPO decides that both are needed.

Use for CCRPC/CCMPO – Lot's of background on the data formats can be found on EPA's website (http://www.epa.gov/ttn/chief/net/neip/index.html). Most applicable to the CCRPC/CCMPO's needs is the documentation on nonpoint emissions (stationary sources not attributed to a point on the map); onroad and nonroad sources, and aircraft/locomotives/commercial marine vessels. We don't suggest

that project stakeholders immerse themselves at this stage of the project in the details of these data formats. In all likelihood, if the CCRPC/CCMPO elects to develop an inventory based on this EPA format, the data elements involved at the regional and municipal levels would be a small subset of those shown in the detailed EPA instructions to state users of the inventory system. We believe that by working with VT DEC, an NEI-compatible data framework could be developed that would allow for top-down and bottom-up sharing of data between municipalities, CCRPC/CCMPO, and the state.

Data Needs – There are no data needs associated with this item, as it is just a data format.

1.5 RECOMMENDATIONS

Lessons from TranSystem's work with the North Jersey Transportation Planning Authority (NJTPA) illustrate some of the considerations in selecting emission inventory tools and accounting methodologies. Figure A-1 shows the common inventory approach to GHG emissions inventories, where direct emissions are used, except in the case of electricity, which is consumption-based. Emissions for the region in 2006 were 86 million metric tons of CO_2 equivalent ($MMtCO_2e$). In Figure A-2, all of the emissions are on a consumption-basis and include the emissions associated with the full energy-cycle of the source (i.e., upstream GHG). At 107 $MMtCO_2e$, the emissions are 24% higher than those using a standard inventory approach (note that in the NJTPA project, consumption-based emissions for the agriculture and forestry sectors were not addressed due to availability and lack of project resources).

Importantly, electricity, transportation, and residential/commercial/industrial (RCI) fuel use are still large contributors in a consumption-based system, but are not the dominant sectors commonly highlighted in standard approaches. Solid waste management and industrial processes become much more important. We feel that the agriculture sector would also be an important contributor in a consumption-based system (embedded GHGs in food consumed within the region). Capturing emissions in a consumption-based provides two clear advantages:

- Full attribution of GHG emissions to each source are achieved and provide a more comprehensive picture of a region's full carbon footprint: full energy-cycle emissions are attributed to the point of fuel use, waste generation, trip origin/destination, etc. rather than just the emissions occurring at a single point on the map; stakeholders can better appreciate actions that need to be taken across all sectors, not just the primary energy use sectors;

- A consumption-based inventory and forecast allows for measurement of the full benefit of GHG actions against a baseline that also captures these emissions: in most CAP processes, a direct emissions based inventory and forecast is used to construct a baseline upon which goals are set and reductions are charted; mitigation analysis will often calculate GHG reductions associated with the full energy-cycle, which creates a disconnect (i.e., should GHG reductions occurring outside of the jurisdiction be counted against a baseline that only includes emissions within the jurisdiction?). Important example mitigation actions include low carbon fuels, waste reduction/reuse/recycling, and reductions in water consumption.

Drawbacks with consumption-based accounting include:

- Potential for double-counting: while a lot of this can be minimized, one needs to understand that there will be at least a small amount of this going on within a consumption-based accounting

scheme. For example, consider emissions from solid waste generation and its subsequent management.

Figure A-1. Direct NJTPA Regional Emissions, 2006 (86 MMtCO$_2$e)

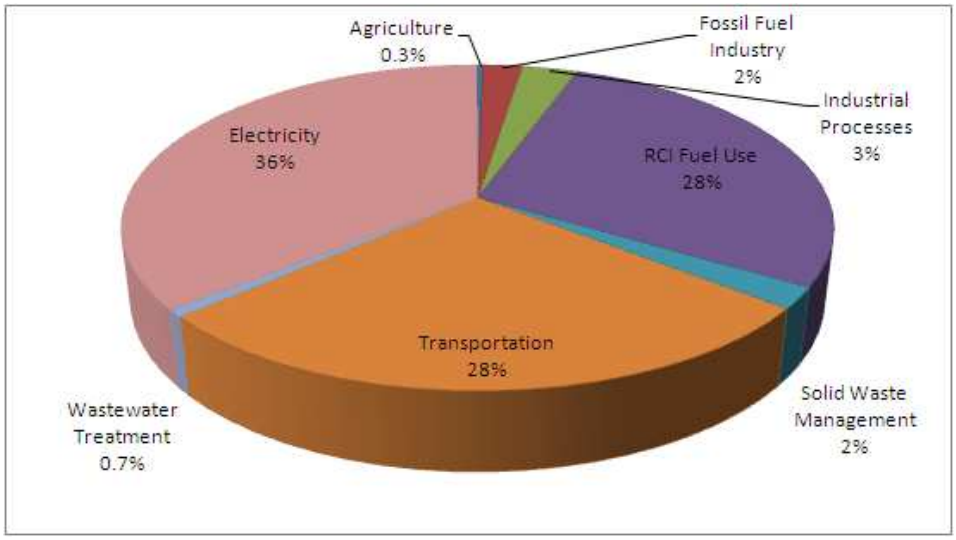
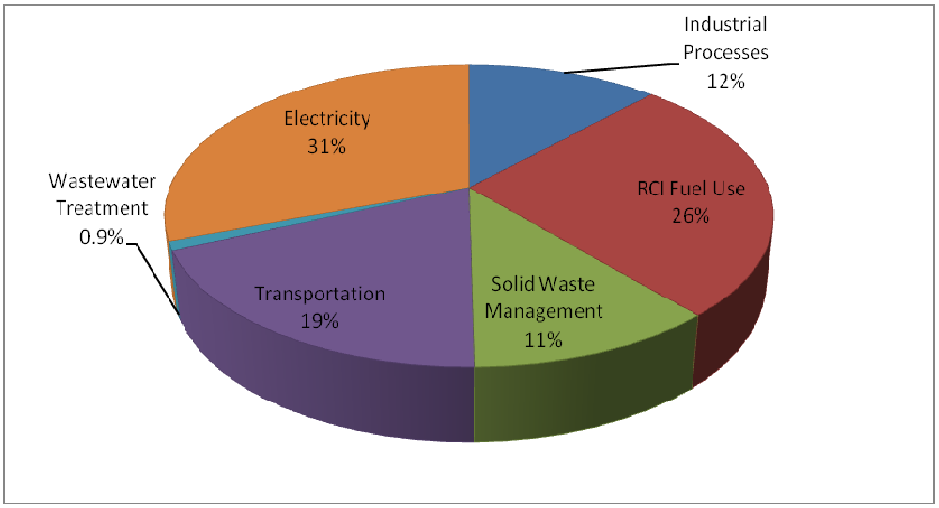


Figure A-2. Consumption-Based NJTPA Regional Emissions, 2006 (107 MMtCO$_2$e)



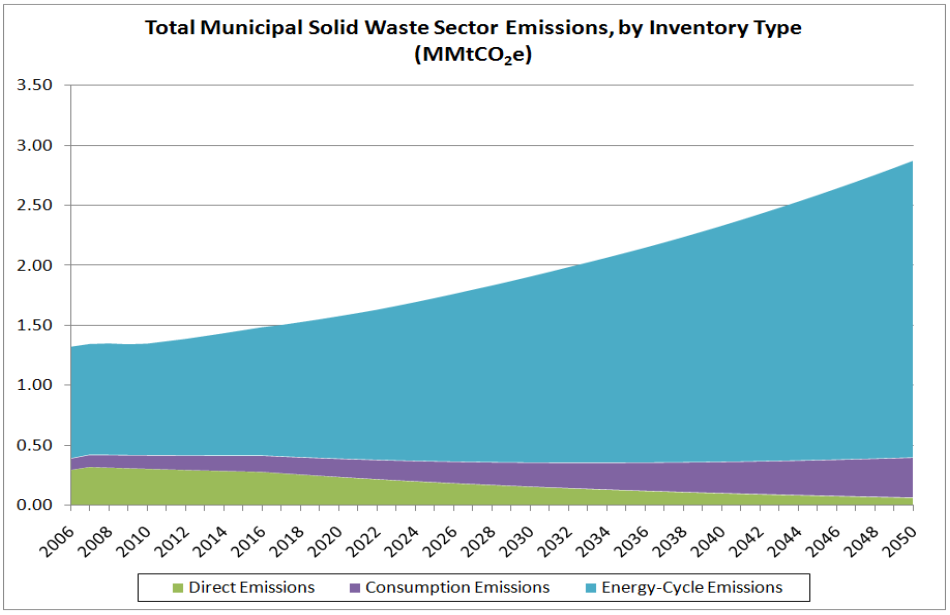
Fully capturing these emissions requires modeling the upstream emissions from the production of each waste component (e.g., paper, steel, glass, etc.) and the downstream emissions at the landfill, waste combustor, compost facility, etc. Included within this is the transportation of these components, at least on the upstream side. Most of those emissions are likely well outside of the jurisdiction, so there would be no double-counting with emissions in the transportation sector; however, there is certainly going to be some double-counting involved.

The advantage of direct emissions accounting is that it excludes the potential for double-counting.

- Lack of compatibility with air quality and area energy use inventories: air pollution inventories of criteria and toxic air pollutants are based on direct emissions accounting; so there would be no direct correlation of a consumption-based GHG inventory with the local criteria and toxic air pollutants inventory used in air quality attainment planning or other purposes.

Figure A-3 provides a very good example of why consumption-based accounting is useful for local climate planning efforts. Ocean County, NJ has a single closed landfill and exports its waste for management (mostly landfilled outside of the county). On a direct emissions basis, the closed landfill produces small amounts of emissions, which are declining over time. Consumption-based accounting corrects for this by capturing the waste management emissions regardless of where they are managed (they are attributed to the point of generation). Finally, capturing the energy-cycle emissions of waste generated in the county shows the magnitude of the embedded GHGs and points to opportunities for significant reductions associated with waste reduction/reuse/recycling (note that often we will combine the consumption-based emissions with the energy-cycle emissions to capture a full picture on a consumption-basis).

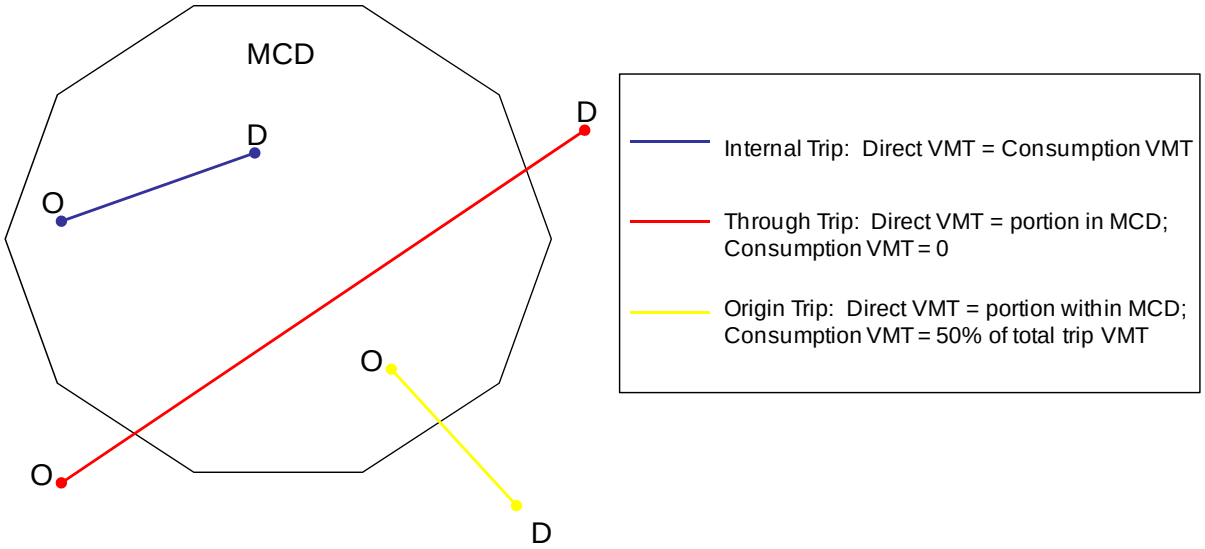
Figure A-3. Ocean County, NJ Municipal Solid Waste Sector Emissions by Accounting Method



Consumption-based approaches can be applied to the onroad transportation sector. On a direct emissions basis, all of the GHG emissions occurring within the jurisdiction's boundaries would be captured regardless of the origin and destination of a trip. Figure A-4 shows a boundary for a given jurisdiction and how different vehicle trips are treated depending on the origin and destination within a consumption-based approach. For a trip occurring within the boundaries consumption based VMT and

direct VMT are the same. For a through trip, the direct VMT is the portion occurring within the boundaries, while consumption based VMT is zero. For a trip where the origin or destination is outside of the boundaries, the direct VMT is again the portion occurring within the boundaries, while the consumption-based VMT is 50% of the total trip (the 50%:50% allocation assumes responsibility for trip generation is equally shared between the origin and destination).

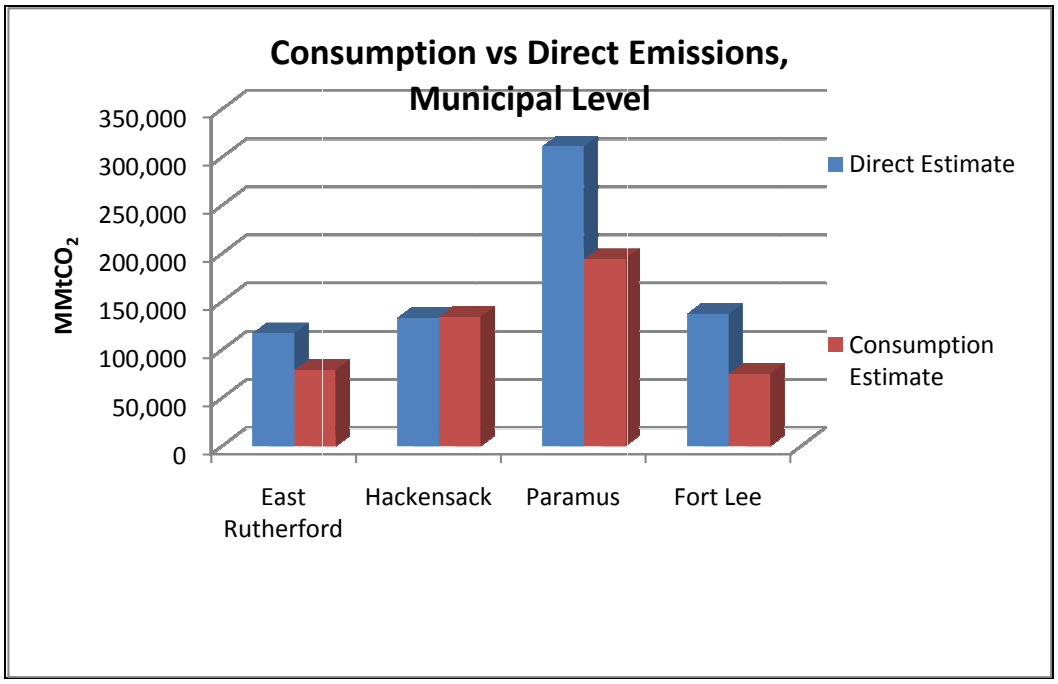
Figure A-4. Allocation of Onroad VMT by Accounting Method



As shown in Figure A-5, the concept of consumption-based accounting in the onroad sector becomes more important as the scale of the analysis shrinks (e.g., state to region to city). These municipal scale results show that for some municipalities, like Paramus, there is a great deal of pass-through traffic which can't be addressed through most types of actions implemented by that city (e.g., any action directed at trip reduction or mode shift).

The importance of consumption-based accounting becomes more and more important as the scale of the jurisdiction decreases. Consider the level of a household, where nearly all GHG mitigation actions involve some type of reduction in consumptive behavior.

Figure A-5. Comparison of 2006 Onroad GHG by Accounting Method



Our recommendations at this stage of the project regarding models and data frameworks are fairly broad; however, we intend to put more detail to these as we continue to get feedback from project stakeholders. As part of our work under Task 3 and documented in the final report, we will provide a more detailed assessment of models and data sources to use for both inventory and forecast development as well as mitigation analysis, a data framework, and responsible parties (capturing the relevant contributions from VT DEC, CCRPC/CCMPO, and the municipalities). Our recommendations at this stage are as follows:

- Consider developing and maintaining a detailed direct emissions inventory covering GHGs and criteria air pollutants. We see this involving primarily VT DEC and CCRPC/CCMPO. Consider using the EPA National Emissions Inventory format to store these data (i.e., build off of the work that VT DEC is currently doing). Consider using methods outlined in a U.S. EPA pilot project that TranSystems/E.H. Pechan completed covering Iowa. Maintenance of these inventories over time will assure that a common comprehensive set of data are available for both GHG and air quality planning going forward;[10]
- Consider developing and maintaining a consumption-based inventory for GHGs in a slightly less detailed (sector-level) format. The geographic resolution of both the direct and consumption-based inventories should be at the municipality-level (e.g., municipal civil division). Data at this level of resolution should provide for both energy and GHG planning going forward;

[10] *Development of a Multipollutant Emission Inventory for the State of Iowa,* Final Report, prepared for U.S. EPA, OAQPS, prepared by E.H. Pechan & Associates, Inc., June 30, 2009.

- Engage stakeholders at the state and municipal levels and determine whether specific responsibilities for inventory development and maintenance can be achieved and maintained over time (we plan to assist in that by identifying likely responsibilities by each organization);
- GHG inventories prepared for climate action planning at the sub-state level have generally been based on either:
    - CACP: for city or county inventories;
        - pros are: ease of use for both inventory development and planning;
        - cons are: lack of detail and transparency; lack of usefulness in sharing with regional organizations or states to improve their GHG or air pollution inventories; lack of full treatment of consumption-based accounting and full energy-cycle emissions.
    - Series of source sector-based worksheets:
        - pros are: transparency; flexibility to handle constantly evolving methods and data sources:
        - cons are: lower ease of use (especially if not well designed); higher need for experienced staff to maintain these over time.

  Consider the pros and cons above and, if ease of use is not the driving consideration, adopt a linked-spreadsheet based approach. Regarding specific models and data sources, we will provide some additional recommendations on those issues, as we continue to learn more about the potential for differentiated responsibilities from all stakeholders (to be documented in the final report). Our initial discussions with VT DEC indicated a strong willingness to move forward in a coordinated fashion. Additional discussions are still needed with municipal stakeholders, however.

Table A-1. Summary Information on GHG Tools and Models

Tool/ Data Source	Emissions Sectors	Geographic Level	Emissions Type	Applicability for Planning	Potential Use by CCRPC/CCMPO	Data Needs	Data Availability	Weblink
State Inventory Tool	fossil fuel combustion, fossil fuel production, transportation, agriculture, forestry and land use, waste management, and industrial sectors	State	Direct	Inventory, Forecast	Because SIT can only be completed at the state level, it is of limited use to CCMPO for many sectors.	SIT contains state-specific defaults, but more recent data can improve SIT estimates	Default data available	http://www.epa.gov/statelocalclimate/resources/tool.html
MOVES	Transportation - Onroad	National/ State/ County/ Project	Direct	Inventory and Forecast	This is a useful tool to CCRPC/CCMPO for estimating onroad emissions if the data needs can be met.	Transportation data (such as VMT), fleet data (such as vehicle age distribution), and other local data.	Default county-level data can be used, but most needed local inputs should have been developed for other emission purposes	http://www.epa.gov/otaq/models/moves/index.htm
NONROAD	Transportation - Offroad	National/ State/ County	Direct	Inventory and Forecast	If CCRPC/CCMPO wants to estimate emissions from nonroad sources, this model allows that to be done, and is easily scalable CCRPC/CCMPO needs.	Requires information on the number of and specification of vehicles, the vehicle power and load factor, as well as hours used	CCRPC/ CCMPO will need to track this information themselves or have an approximation available in order to use NONROAD	http://www.epa.gov/oms/nonrdmdl.htm
Waste Reduction Model	Waste Management	Any	Consumption & Energy Cycle	Inventory, Mitigation	Can be used to estimate the effectiveness of waste management	Information on waste recycled, waste composted and waste	Need local data on waste management (e.g. via	http://www.epa.gov/climatechange/wycd/waste/calculators/

Tool/ Data Source	Emissions Sectors	Geographic Level	Emissions Type	Applicability for Planning	Potential Use by CCRPC/CCMPO	Data Needs	Data Availability	Weblink
					goals/scenarios for CCRPC/CCMPO	landfilled	surveys)	Warm_home.html
Landfill Gas Emissions Model	Waste Management	Any	Direct	Inventory	Can be used to assess the impact of landfills at the county level. It is possible CCRPC/CCMPO has no landfills within its borders.	Site-specific data improves LandGEM outputs, but default data can be used.	Default data available	http://www.epa.gov/ttn/catc/dir1/landgem-v302.xls
Carbon Calculation Tool	Forestry	State/ National	Direct	Inventory	Can only be used at the state level, so all results would need to be adjusted to be useful for CCRPC/CCMPO.	Requires FIA data files	FIA data files are available for download online	http://nrs.fs.fed.us/carbon/tools/#cct
The Climate Registry's Local Government Operations Protocol	Energy Supply, RCI, Transportation	Municipal	Direct	Inventory	Provides a framework for CCRPC/CCMPO to quantify its emissions and emissions reductions over time.	Data requirements will vary depending on what CCMPO intends to use the Protocol for.	Local input data required; varies by source	http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/
ICLEI Clean Air and Climate Protection Software	Electricity Supply, Residential/Commercial/Industrial, Transportation, and Waste Management	Municipal/ Project	Direct	Inventory, Mitigation and Forecast	This tool can be used to estimate GHG and CAP emissions in a certain municipality or project, as well as any emissions reductions associated with mitigation actions.	Need information on fuel and electricity consumption in all sectors of the analysis. Also information on fuel savings of any mitigation actions	Information will need to be collected and monitored by CCRPC/CCMPO	http://www.icleiusa.org/action-center/tools/cacp-software

Tool/ Data Source	Emissions Sectors	Geographic Level	Emissions Type	Applicability for Planning	Potential Use by CCRPC/CCMPO	Data Needs	Data Availability	Weblink
EDMS	Transportation - Aircraft	Airport-specific	Direct	Inventory and Forecast	If CCRPC/CCMPO wants to estimate aircraft emissions, this is the primary data source to do so	LTOs by aircraft engine type	Some default data are available	http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/

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APPENDIX B
SUMMARY OF CLIMATE CHANGE, ENERGY, AND AIR QUALITY PLANS REVIEWED

TABLE B-1. VERMONT

Name of Plan	Final Report and Recommendations of the Governor's Commission on Climate Change	*Type of Planning Process*	Action Plan
Area Covered	State of Vermont	*Stakeholders Involved*	Stakeholders represented legislators, agriculture, forestry, energy, business, industry, transportation, education, public interest groups, and four state agencies.
Was an inventory conducted, and if so, how?	An inventory was conducted using EPA's SIT model for all GHG sectors (electricity supply, RCI, agriculture, forestry, waste, transportation, industrial processes, fossil fuel production). SIT defaults were used unless better data was available for VT.		
Emission Data Used	Data from sources such as NASS, VT Agency of Transportation, LMOP, US DOT, and VT agency projections of population, employment, electricity use, vehicle mileage, and AEO fuel consumption projections	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	SIT		
How was reduction target determined? Were they adopted by the governing body?	Vermont's legislature, in 10 V.S.A 578, set GHG reduction goals of 25% below 1990 levels by 1/1/2012, 50% below 1990 levels by 1/1/2028, and if practicable using reasonable efforts, 75% below 1990 levels by 1/1/2050.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes, for most strategies.
Was an action plan developed?	Yes	*Process Completed?*	Yes, 2007
Level of inventory detail	Subsector	*Geographic resolution*	State level
Timeframe of analysis	1990-2030	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Direct accounting for all sectors. Provides action plan for reducing GHGs over the next 20 years. Includes a strong emphasis on continuing existing demand-side management efforts for the electricity sector.		
Interaction between climate and air quality?	Provides GHG emissions data only. Provides some information on local environmental benefits		
Web Page	http://www.anr.state.vt.us/anr/climatechange/Library.html		

TABLE B-2. CITY OF BURLINGTON

Name of Plan	City of Burlington Climate Action Plan--Final Report: Cost-Carbon-Benefit Analysis	*Type of Planning Process*	2010 update to 2000 Action Plan
Area Covered	City of Burlington	*Stakeholders Involved*	Public stakeholder meetings including representatives from various City of Burlington agencies, local and state agencies, universities, environmental organizations
Was an inventory conducted, and if so, how?	2007 GHG inventory conducted using CACP Software, covers both the government operations inventory and the community-wide inventory; city has also developed a detailed guide for agencies to follow when updating their inventories		
Emission Data Used	The Legacy Project and Planning & Zoning department worked with city departments and several other organizations to gather energy use data.	*GHGs included*	Carbon dioxide, methane, nitrous oxide
Models Used	CACP Software		
How was reduction target determined? Were they adopted by the governing body?	The city of Burlington has established the following emission reduction targets: reduction of 20% below 2007 levels by 2020 and reduction of 80% below 2007 levels by 2050.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes
Was an action plan developed?	Yes	*Process Completed?*	Cost-carbon benefit analysis of Burlington Climate Action Plan completed in 2010.
Level of inventory detail	Agency-level detail by fuel type	*Geographic resolution*	All of Burlington
Timeframe of analysis	2007 baseline, with strategy analyses performed through a 25 year timeframe	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Provides GHG emissions using CACP Software, which was collected from various municipal and state agencies. Second climate action plan included an extensive public citizen stakeholder process. Climate action plan analysis of measures includes cost-carbon abatement curve.		
Interaction between climate and air quality?	Provides GHG emissions data only		
Web Page	http://www.ci.burlington.vt.us/cap/		

TABLE B-3. CITY OF KEENE, NH

Name of Plan	City of Keene, New Hampshire Cities for Climate Protection Campaign Local Action Plan; Keene, New Hampshire Adapting to Climate Change: Planning a Climate Resilient Community	*Type of Planning Process*	Action Plan (2004) and Adaptation Plan (2007)
Area Covered	Municipal	*Stakeholders Involved*	City of Keene
Was an inventory conducted, and if so, how?	Inventory was conducted in 2000 for years 1995 and projection to 2015, and used to inform the stakeholders in creating the action plan. Covers the residential, commercial/industrial, waste, and transportation sectors. Community and local government inventories were developed. An update to the 2000 inventory is now underway.		
Emission Data Used	City data for 1995	*GHGs included*	CO_2 only plus CH_4 from landfills
Models Used	Used Cities for Climate Protection (CCP) software developed for ICLEI for the CCP campaign.		
How was reduction target determined? Were they adopted by the governing body?	Target of 10% below 1995 levels by 2015 included in Local Action Plan for community actions. A target of 20% reduction from 1995 emissions by 2015 was established by the Keene City Council for municipal emissions. City plans to periodically update targets and consider aligning targets with State targets.		
Were strategies developed for reducing GHGs?	yes	*Are the reductions measurable?*	yes
Was an action plan developed?	yes	*Process Completed?*	Yes, in 2004. Adaptation plan completed in 2007.
Level of inventory detail	Subsector	*Geographic resolution*	All of Keene
Timeframe of analysis	1995, 2015	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Energy savings quantified for many measures. Also, full adaptation plan developed.		
Interaction between climate and air quality?	Provides GHG emissions data only; however, some measures include quantification of certain criteria pollutants		
Web Page	http://www.ci.keene.nh.us/sites/default/files/2004_CAP_FINAL.pdf		

TABLE B-4. NEW YORK STATE

Name of Plan	New York State Climate Action Council Climate Action Plan Interim Report	*Type of Planning Process*	Action Plan
Area Covered	State	*Stakeholders Involved*	NY State Department of Environment Conservation and NY State Energy Research and Development Authority (NYSERDA) led effort; with stakeholders from among business, academic and government organizations.
Was an inventory conducted, and if so, how?	An inventory was conducted using EPA's SIT model for all GHG sectors (electricity supply, RCI, agriculture, forestry, waste, transportation, industrial processes, fossil fuel production). State data were used to replace SIT defaults wherever possible.		
Emission Data Used	Data sources include NY utilities, AEO, and NYSERDA, University contacts	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	SIT, WARM, LandGEM		
How was reduction target determined? Were they adopted by the governing body?	Governor's Executive Order in 2009 established a goal of reducing GHG emissions 80% below 1990 levels by 2050		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes, for most strategies.
Was an action plan developed?	Yes	*Process Completed?*	Interim process completed in 2010.
Level of inventory detail	Subsector	*Geographic resolution*	State level
Timeframe of analysis	1990-2030; with sectoral 'visions' through 2050 (not quantified)	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Interim Report includes adaptation planning and also the 2050 Visioning effort for an 80% reduction in GHG emissions by 2050 provides detailed information on possible scenarios that would be needed to reach this target.		
Interaction between climate and air quality?	Provides GHG emissions data only; also significant focus on energy.		
Web Page	http://www.nyclimatechange.us/ewebeditpro/items/O109F24147.pdf		

TABLE B-5. NEW YORK CITY

Name of Plan	PlaNYC: A Greener, Greater New York; Update April 2011	*Type of Planning Process*	City Sustainability Planning
Area Covered	Municipal	*Stakeholders Involved*	City government and agencies, community organizations, and individuals
Was an inventory conducted, and if so, how?	Citywide and City Government inventories prepared, with most recent version published September 2011. (Since 2008, City Council law requires an annual update to the citywide and city government inventories.) The City government inventory is completed in compliance with the Local Government Operations Protocol (LGOP), and citywide calculations were also made using the LGOP, where applicable, as no citywide protocol exists at this time.		
Emission Data Used	Utility data on electricity and fuel consumption, on-road VMT data, public transit energy consumption data, NY DEP data on wastewater treatment, landfill data, and refrigerant data; city government data from City agencies or fuel vendors. Electricity, natural gas, and steam usage for the City's buildings, facilities, and streetlights, heating and vehicle usage data	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	Emissions calculated using LGOP coefficients; EPA's WARM model for waste disposal		
How was reduction target determined? Were they adopted by the governing body?	Reduction target of 30% below 2005 GHG emission levels by 2030. Mayor Bloomberg signed Executive Order 109 in October2007, which mandated even more aggressive greenhouse gas reductions for City government facilities and operations of 30 percent below FY 2006 levels by 2017.		
Were strategies developed for reducing GHGs?	no	*Are the reductions measurable?*	N/A
Was an action plan developed?	no	*Process Completed?*	yes, in 2010

Level of inventory detail	Subsector--The citywide inventory includes energy used by buildings, on-road transportation, and public transit; fugitive emissions from wastewater treatment, solid waste disposal, and electricity and natural gas distribution within New York City; and emissions associated with solid waste exported outside of the city.	*Geographic resolution*	All of NYC
Timeframe of analysis	Inventory year 2010; focus through 2030 for initiatives	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Overall sustainability plan, ties together all aspects of city planning--environment, infrastructure, transportation, energy, climate change mitigation and adaptation.		
Interaction between climate and air quality?	In addition to climate change plans and goals, plan includes air quality goals (to achieve the cleanest air quality of any big city in the US) as well as water, energy, and adaptation plans/goals.		
Web Page	http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/planyc_2011_planyc_full_report.pdf		

TABLE B-6. METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

Name of Plan	National Capital Region Climate Change Report	*Type of Planning Process*	Action Plan
Area Covered	Regional--Washington, DC greater metropolitan area, including all of DC and portions of Maryland and Virginia (8 counties and 14 additional jurisdictions)	*Stakeholders Involved*	DC, Maryland, and Virginia state, county, and city governing agencies, air and transportation agencies, transit, and trade agencies
Was an inventory conducted, and if so, how?	Used and emission factor-based approach. Sectors included in the estimate are electricity, RCI combustion, transportation, and other. Inventory base year is 2005 with projections through 2050. Projections used AEO 2007 grow factors and MWCOG forecasts.		
Emission Data Used	Local utilities provided consumption data; CO_2 emissions from EPA's CAMD reports from local power plants; state-level fuel consumption scaled to region; transportation demand from MWCOG plans; landfill data from MDE	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	EPA's SIT; local transportation model; EPA's MOBILE6.2 model		
How was reduction target determined? Were they adopted by the governing body?	Targets developed based on scientific evidence from IPCC and similar to comparable goals adopted by Washington region jurisdictions. Targets: 2012 emissions 10 percent below business as usual; 2020 emissions 20 percent below 2005 levels; 2050 emissions 80 percent below 2005 levels.		
Were strategies developed for reducing GHGs?	yes	*Are the reductions measurable?*	Yes, acknowledges need to quantitatively track progress towards goals
Was an action plan developed?	yes	*Process Completed?*	Yes, adopted in 2008.
Level of inventory detail	Sector	*Geographic resolution*	DC metropolitan area
Timeframe of analysis	2005 through 2050, with targets for 2012, 2020, and 2050	*Direct or alternative accounting methods?*	Direct
Unique Elements	Focuses on recommendations where local governments can lead by example. Also looks at potential for green jobs in the region. Shows steps for beginning planning for adaptation.		
Interaction between climate and air quality?	Provides GHG emissions data only.		
Web Page	http://www.mwcog.org/environment/climate/about.asp		

TABLE B-7. MARYLAND

Name of Plan	Maryland Commission on Climate Change Climate Action Plan (August 2008)	*Type of Planning Process*	Action Plan
Area Covered	State	*Stakeholders Involved*	The Commission included members representing academia, business, industry, environmental groups and many levels of government.
Was an inventory conducted, and if so, how?	An inventory was conducted using EPA's SIT model for all GHG sectors (electricity supply, RCI, agriculture, forestry, waste, transportation, industrial processes, fossil fuel production). SIT defaults were used unless better data was available for MD.		
Emission Data Used	Data sources include MDOT, MDE and the Maryland Public Service Commission. Local data were supplemented by SIT default data for Maryland, where needed.	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	SIT, with external sector-specific projection methodologies; US Forest Carbon Calculation Tool		
How was reduction target determined? Were they adopted by the governing body?	The Commission for Climate Change set several GHG reduction goals based on input from stakeholders on what level of reductions can and should be achieved, as well as a historical perspective of similar goals in other states. Final goal is 90% below 2006 GHG levels by 2050, with intermediate goals leading to this.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes, for most strategies.
Was an action plan developed?	Yes	*Process Completed?*	Yes, 2008; Process to achieve further reductions and build upon 2008 work is currently underway in Maryland.
Level of inventory detail	Subsector	*Geographic resolution*	State level
Timeframe of analysis	1990-2020	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Direct accounting for all sectors. Provides action plan for reducing GHGs over the next 15 years. Also includes adaptation planning, and some additional information on local environmental impacts, particularly on the Chesapeake Bay.		
Interaction between climate and air quality?	Provides GHG emissions data only. Provides some information on local environmental benefits		
Web Page	http://www.mdclimatechange.us/MCCC.cfm		

TABLE B-8. DISTRICT OF COLUMBIA

Name of Plan	Climate of Opportunity: A Climate Action Plan for the District of Columbia (Draft for Public Discussion September 2010)	*Type of Planning Process*	Action Plan
Area Covered	Municipal	*Stakeholders Involved*	District Department of the Environment and other district agencies; Metropolitan Washington Council of Governments provided significant input on community sector measures; seeking public input and response to proposed plan
Was an inventory conducted, and if so, how?	Government operations and community inventories were prepared. Sectors included in the estimate are buildings (residential, non-residential, and Federal), vehicles, transit, and waste for the community inventory; building and other facilities, wastewater facilities, streetlights and traffic signals, vehicle fleet, employee commute, and solid waste for the government operations inventory.		
Emission Data Used	Data from a variety of DC agencies	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	Government Operations inventory follows the Local Government Operations Protocol developed and adopted by CARB, ICLEI, the California Climate Action Registry, and The Climate Registry. Community inventory based on ICLEI guidance.		
How was reduction target determined? Were they adopted by the governing body?	The plan sets targets for reductions in emissions from government operations of 20% below 2006 levels by 2012, 30% below 2006 levels by 2020, and 80% below 2006 levels by 2050. Targets were set to be aggressive but achievable based on measures the District Government has implemented, planned, or proposed.		
Were strategies developed for reducing GHGs?	yes	*Are the reductions measurable?*	Yes.
Was an action plan developed?	yes	*Process Completed?*	Draft plan completed in 2010; seeks public input.
Level of inventory detail	Sector	*Geographic resolution*	All of DC
Timeframe of analysis	2006, 2012, 2020, 2050	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Emphasizes opportunities for energy efficiency and cost savings; includes some information on adaptation.		
Interaction between climate and air quality?	Provides GHG emissions data only.		
Web Page	http://rrc.dc.gov/green/lib/green/pdfs/ClimateOfOpportunity_web.pdf		

TABLE B-9. MONTGOMERY COUNTY, MARYLAND

Name of Plan	Montgomery County, Maryland Climate Protection Plan	*Type of Planning Process*	Action Plan
Area Covered	Montgomery County, Maryland	*Stakeholders Involved*	Montgomery County Sustainability Working Group, including various state agencies, citizen groups and business leaders
Was an inventory conducted, and if so, how?	Inventory conducted using ICLEI software, from both the community analysis and government analysis approaches. Sectors included in inventory are onroad vehicles, electricity consumption, RCI fuel combustion and solid waste. Other sectors were not included in this analysis.		
Emission Data Used	Various Montgomery County Agencies were contacted for activity data. Building energy use data is from county's energy tax data and is expected to be very good quality.	*GHGs included*	Carbon dioxide, methane, nitrous oxide
Models Used	CACP Software		
How was reduction target determined? Were they adopted by the governing body?	Montgomery County has the goal of an 80% reduction in GHG emissions from 2005 levels by 2050. This was adopted as a goal in County Bill 32-07		
Were strategies developed for reducing GHGs?	yes	*Are the reductions measurable?*	Yes, the Sustainability Working Group reports annually on progress towards meeting targets.
Was an action plan developed?	yes	*Process Completed?*	yes, in 2009
Level of inventory detail	Sector	*Geographic resolution*	County Level
Timeframe of analysis	2005-2050	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Plan includes a full Energy Analysis of Montgomery County Facilities, recognizing the importance of measures that reduce energy consumption. Plan notes issues of climate change adaption and lays out first steps for this. Also notes co-benefits of air and water quality.		
Interaction between climate and air quality?	Plan notes important air quality co-benefits of climate change measures, but does not include criteria pollutant emissions. Also includes strong linkage to energy.		
Web Page	http://www.montgomerycountymd.gov/dectmpl.asp?url=/Content/dep/climatechange/climateL2.asp		

TABLE B-10. DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Name of Plan	Delaware Valley Regional Planning Commission Regional Greenhouse Gas Emissions Inventory, revised December 2010	*Type of Planning Process*	Informational
Area Covered	Regional (9 Counties)	*Stakeholders Involved*	DVRPC, municipal and county agencies, EPA, state agencies, universities, environmental groups, ICLEI-Local Governments for Sustainability, and other interested parties
Was an inventory conducted, and if so, how?	Inventory was conducted for all GHG emissions sectors: Stationary Energy Consumption, Mobile Energy Consumption, Agriculture, Waste, Industrial Processes, Fugitive Emissions from Fuel Systems, and Land Use, Land Use Change, and Forestry. This was done using a combination of a top-down approach (where fuel combustion data was available) and a bottom up approach (using utility data). This mix was determined by data and resource limitations as well as existing protocols.		
Emission Data Used	Data from PA/NJ Utilities, SIT, Bureau of Transportation Statistics, National Transit Database, Army Corps of Engineers Data, USDA	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	SIT methodologies, DVRPC Travel Demand Model, MOBILE6, current Best Practices, NONROAD		
How was reduction target determined? Were they adopted by the governing body?	DRVPC has identified a regional goal of reducing greenhouse gas emissions by 50% by 2035 and 80% by 2050 while building an energy efficient economy in its July 2009 Long Range Plan.		
Were strategies developed for reducing GHGs?	N/A	*Are the reductions measurable?*	N/A
Was an action plan developed?	N/A	*Process Completed?*	yes, 2010
Level of inventory detail	Subsector	*Geographic resolution*	regional, county, and municipal
Timeframe of analysis	Annual, 2005 (most recent inventory)	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption

Unique Elements	This inventory is a mix of top-down and bottom-up emission estimates. The inventory allocates top-down emissions to the each of the nine counties and 352 municipalities in the region. This regional allocation excludes several emissions categories which were not feasible to allocate with available data, including emissions from aircraft, through highway traffic, some industrial fuel use, and livestock. Electricity and natural gas use information was collected at either the municipal or ZIP code level by customer class (residential, commercial, industrial) from each of the dozen or so utilities that serve the region. Vehicle miles traveled (VMT) in the region was allocated to municipalities by assigning half of each trip to the municipality of origin and half to the destination municipality. For aviation, accounts for half of the national flight miles arriving at or departing from major airports (Philadelphia International and Trenton).
Interaction between climate and air quality?	Provides GHG emissions data only (does not estimate criteria pollutant emissions).
Web Page	http://www.dvrpc.org/reports/09038A.pdf

TABLE B-11. CITY OF PHILADELPHIA

Name of Plan	Local Action Plan for Climate Change: City of Philadelphia	*Type of Planning Process*	Action Plan
Area Covered	Municipal	*Stakeholders Involved*	Sustainability Working Group--included numerous Philadelphia City Agencies
Was an inventory conducted, and if so, how?	Inventory conducted using CACP software, from both the community analysis and government analysis approaches. Inventory covered point, area, highway, and nonroad sources in both the government and community inventories. Inventory includes the following years: 1990, 1997, 2006, and 2010.		
Emission Data Used	Various Philadelphia Agencies were contacted for activity data, such as the Municipal Energy Office, PA Dept Labor and Energy, Philadelphia Maritime Exchange, Philadelphia Streets, DVRPC. Data was also provided by the EIA, PECO and Amtrak.	*GHGs included*	carbon dioxide, methane, nitrous oxide
Models Used	CACP Software, EDMS		
How was reduction target determined? Were they adopted by the governing body?	Philadelphia had the goal of a 10% reduction in GHG emissions from 1990 levels. This goal was adopted by the City of Philadelphia in 1999.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes
Was an action plan developed?	Yes	*Process Completed?*	Local Climate Action Plan completed in 2007; updated through Greenworks Philadelphia
Level of inventory detail	Subsector	*Geographic resolution*	All of Philadelphia
Timeframe of analysis	Through 2010	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	The continuation of the climate action process through the Greenworks Philadelphia process shows specific initiatives already underway or proposed to meet goals and shows the renewable energy generated, energy/electricity reduced, VMT reduced, and waste reduced, along with GHG reductions for specific initiatives.		
Interaction between climate and air quality?	Provides GHG emissions data only (some criteria pollutant emissions estimated for airports). However, reductions in energy consumption could be used to estimate criteria pollutant emission reductions.		
Web Page	http://www.phila.gov/green/		

TABLE B-12. NEW JERSEY

Name of Plan	Meeting New Jersey's 2020 Greenhouse Gas Limit: New Jersey's Global Warming Response Act Recommendations Report, December 2009	*Type of Planning Process*	Action Plan
Area Covered	State	*Stakeholders Involved*	State agencies: Board of Public Utilities, Departments of Treasury, Transportation, Agriculture, Community Affairs, Banking and Insurance, the Motor Vehicle Commission, the Economic Development Authority, New Jersey Transit, the Port Authority of New York and New Jersey, the New Jersey Turnpike Authority, the Housing Mortgage Finance Agency, and the Division of Consumer Affairs; and other stakeholders
Was an inventory conducted, and if so, how?	An inventory was conducted using EPA's SIT model for all GHG sectors (electricity supply, RCI, agriculture, forestry, waste, transportation, industrial processes, fossil fuel production). SIT defaults were used unless better data was available for NJ.		
Emission Data Used	Data primarily comes from SIT defaults. Other data sources include NJ utilities, NJDEP, EPA CWNS, AEO, and NJDOT.	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	SIT, WARM, VISION		
How was reduction target determined? Were they adopted by the governing body?	The reduction target was established in the state's Global Warming Response Act.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes, for most strategies.
Was an action plan developed?	Yes	*Process Completed?*	Yes, 2009
Level of inventory detail	Subsector	*Geographic resolution*	State level
Timeframe of analysis	1990-2020	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Direct accounting for all sectors. Provides action plan for reducing GHGs over the next 15 years. Many actions arise from the State Energy Plan and the Regional Greenhouse Gas Initiative.		

Interaction between climate and air quality?	Provides GHG emissions data only. Acknowledges co-benefits of criteria pollutants as well as GHG co-benefits from controls measures designed to meet ozone and PM air quality goals.
Web Page	http://www.nj.gov/globalwarming/home/gwra_report.html

TABLE B-13. NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY

Name of Plan	North Jersey Transportation Planning Authority Regional Greenhouse Gas Emission Inventory and Forecast, Final Report, June 2011	*Type of Planning Process*	Inventory and Forecast is Phase I of a multi-phase process
Area Covered	Regional (13 counties and 388 municipalities)	*Stakeholders Involved*	NJTPA staff and a Technical Advisory Committee (included NJDEP, US EPA, Non-Government Associations, and County Planners)
Was an inventory conducted, and if so, how?	Inventory was conducted for all GHG emissions sectors: Electricity; Residential/Commercial/Industrial Fuel Use; Transportation; Agriculture; Forestry; and Waste Management. A combination of primarily bottom-up and some top-down inventory methods were used depending on the sector's importance in the region and available data. Emissions were allocated to the MCD-level, so that each city/town has its own I&F.		
Emission Data Used	Data from NJDEP, NJTPA, NJ Utilities, PANYNJ, EPA Clean Air Markets Division, US Forest Service	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	TCR GRP, GREET, MOVES, regional transportation model (NJTRM-E, PPSUITE), EDMS, NONROAD, SIT, COLE, LandGEM, WARM		
How was reduction target determined? Were they adopted by the governing body?	N/A; TBD during Phase II.		
Were strategies developed for reducing GHGs?	N/A	*Are the reductions measurable?*	N/A
Was an action plan developed?	N/A	*Process Completed?*	Inventory and Forecast phase was completed in 2011
Level of inventory detail	Subsector	*Geographic resolution*	Municipal level
Timeframe of analysis	Annual, 2006, 2020, 2035, 2050	*Direct or alternative accounting methods?*	Direct and Consumption Based Accounting
Unique Elements	Direct accounting for all sector and consumption-based accounting for most sectors; Inventory data provided at the MCD, county, and NJTPA regional levels.		
Interaction between climate and air quality?	Provides GHG emissions data only (does not estimate criteria pollutant emissions); economic/environmental benefits would be addressed under Phase II.		
Web Page	http://www.njtpa.org/Plan/Element/Climate/RegionalGreenhouseGasInventory.aspx		

TABLE B-14. CALIFORNIA

Name of Plan	Climate Change Scoping Plan: a Framework for Change, December 2008	*Type of Planning Process*	Action Plan
Area Covered	State	*Stakeholders Involved*	Scoping Plan developed by CARB in coordination with CA Climate Action Team. Action Team consisted of leaders in various state agencies. Also included extensive outreach through workgroups, workshops, and webcasts throughout state.
Was an inventory conducted, and if so, how?	CARB conducted an emissions inventory for California for the years 2000-2008, and a forecast to 2020. This included all emissions sectors, and could be organized by IPCC sector or economic sector.		
Emission Data Used	State data was provided by a variety of state agencies, including IWMB, CEC, CARB, CPUC, CEPA, CRA, and various California utilities.	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	Uses an economic model of CGE called EDRAM.		
How was reduction target determined? Were they adopted by the governing body?	California's state law AB 32 requires reductions in GHG emissions to1990 levels by 2020.		
Were strategies developed for reducing GHGs?	Yes	*Are the reductions measurable?*	Yes--Mandatory reporting will assist in tracking actual reductions.
Was an action plan developed?	Yes	*Process Completed?*	Yes, but ongoing.
Level of inventory detail	Subsector	*Geographic resolution*	State level
Timeframe of analysis	1990-2020	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Many of the models used in the State Plan and the CARB inventory are tailored specifically to California and offer additional accuracy. Sophisticated economic modeling used. Includes significant analysis of public health and environmental benefits and energy diversification.		
Interaction between climate and air quality?	Quantified reduction of NO_x and $PM_{2.5}$ from implementation of the Plan's recommendations.		
Web Page	http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm		

TABLE B-15. SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

Name of Plan	Draft Southern California Association of Governments Regional GHG Emissions Inventory and Reference Case Projections, 1990-2035	*Type of Planning Process*	Inventory being finalized, Action Plan is underway
Area Covered	Regional	*Stakeholders Involved*	SCAG, CARB, CEC
Was an inventory conducted, and if so, how?	Covers all sectors in the SCAG region using the CARB GHG inventory for all of California as a guideline. This allocated GHG emissions to various SCCs, and these emissions were scaled based on SCAG's some indicator, such as fuel combustion, animal populations, VMT, etc.		
Emission Data Used	Local utilities as well as various CA agencies provided data, as well as AEO, NASS, BTS data, FAA Air Traffic Activity Data System, and SIT.	*GHGs included*	All Kyoto GHGs (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons)
Models Used	ARB's EMFAC2007, OFFROAD2007, SIT		
How was reduction target determined? Were they adopted by the governing body?	Target not yet established by SCAG		
Were strategies developed for reducing GHGs?	In progress	*Are the reductions measurable?*	TBD
Was an action plan developed?	In progress	*Process Completed?*	No, GHG Mitigation Planning is ongoing
Level of inventory detail	SCC level	*Geographic resolution*	County Level
Timeframe of analysis	1990-2035	*Direct or alternative accounting methods?*	Direct Accounting + Electricity Consumption
Unique Elements	Provides a GHG emissions estimate at the SCC level for the SCAG region.		
Interaction between climate and air quality?	Provides GHG emissions data only.		
Web Page	http://cedp.scag.ca.gov/Inventory_Forecast.cfm		

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APPENDIX C
POTENTIAL GHG REDUCTION STRATEGIES

Table C-1. Matrix of Potential GHG Reduction Strategies

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
ES	Distributed Renewables	This option is focused on renewable energy located on-site at consumer facilities, i.e., on the "customer side of the meter." Policies to increase distributed renewables include improved interconnection policies, improved rates and fees policies, streamlined permitting, recognition of the emission reduction value, financing packages and bonding programs, power procurement policies, education and outreach, and incentive payments provided by electric utilities to customers generating renewable energy (i.e., solar, wind) on their property.	Yes	Yes			Yes	Low	Yes	IA, MT, VT
ES	Renewable Energy Generation	Policies can be developed to help overcome barriers and increase incentives for renewable energy development. Financial incentives can include property tax exemptions, exclusions, and credits; personal income tax credits or deductions to cover the expense of purchasing and installing renewable energy equipment; loan programs to aid in financing the purchase of renewable energy equipment; and grant programs designed for R&D or to help a project achieve commercialization. Regulatory policies can include solar or wind easements of access rights, development guidelines at the local level to enhance renewable energy generation (e.g., requiring proper street orientation), and requirements that utilities provide information and utility leasing programs for renewable energy production to customers in remote regions.	Yes	Yes	Yes	Yes	Yes	Low	Yes	CT, IA, VT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
ES	Energy Efficiency at Power Plants	Efficiency improvements refer to increasing generation efficiency at power stations through incremental improvements at existing plants (e.g., more efficient boilers and turbines, improved control systems) and/or repowering. Repowering existing plants refers to switching to lower- or zero-emitting fuels at existing plants or for new capacity additions. This includes the use of biomass or natural gas in place of coal or oil.	Yes	Yes			Yes	Neg	Yes	CA, FL
ES	Encourage Combined Heat and Power Systems	Distributed generation with clean combined heat and power (CHP) systems reduces fossil fuel use and GHG emissions both through the improved efficiency of the CHP systems, relative to separate heat and power technologies and by avoiding transmission and distribution losses associated with central power stations that are located far away from where the electricity is used. Implementation of these systems by residential, commercial, institutional, and industrial energy consumers could be encouraged through a combination of regulatory changes and incentive programs.	Yes	Yes	Yes		Yes	Neg-Low	Yes	MI, FL, VT
RCI	Energy Efficiency for Demand Side Management (DSM)	This option focuses on what are typically termed DSM activities—programs, usually delivered by utilities or government-designated agencies, designed to reduce energy consumption and/or change the timing of energy use. Examples of DSM programs include technical assistance for and implementation of energy efficiency and renewable energy measures, electrical demand response, alternative rate schedules, and research activities.	Yes	Yes	Yes	Yes	Yes	Neg	Yes	CT, IA, NM
RCI	Improved Building Codes	Building energy codes specify minimum energy-efficiency requirements for new buildings or for existing buildings undergoing a major renovation. Given the long lifetime of most buildings, amending state and/or local building codes to include minimum energy-efficiency	Yes	Yes				Neg	Yes	VT, NC, MT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
		requirements and periodically updating energy-efficiency codes could provide long-term GHG savings.								
RCI	Appliance Standards	Appliance efficiency standards reduce the market cost of energy-efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. Work with federal agencies and others toward raising federal appliance and equipment energy-efficiency standards where applicable; and to implement, in concert with other states, higher-than-federal energy efficiency standards for appliances where technological advances allow.	Yes					Neg	Yes	AZ, CT, WA
RCI	Public Education for Energy Efficiency	This option focuses on public education and outreach to stimulate decisions that yield energy efficiency savings with a goal of reducing residential energy consumption. Consumer education is an integral component of most existing Demand Side Management programs offered by investor-owned and consumer-owned utilities.	Yes	Yes				Neg	Yes	IA, UT
ES	Green Power Purchasing	Green power purchasing refers to a variety of consumer-driven strategies to increase the production and delivery of low-GHG power sources beyond levels achieved through renewable portfolio standard and other mandatory programs. These sources include solar, wind, geothermal, biogas, biomass, and low-impact hydroelectric energy. Green power purchasing programs provide consumers with information about alternative green sources of energy they can select, rather than the traditional, more carbon-intensive sources.	Yes	Yes	Yes	Yes	Yes	Neg-Low	Yes	AR, NC, NM

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
ES	Time of Use Rates	Time-of-use electricity rate schedules and in-home displays can enable electricity consumers to better manage energy use. Programs could include installation of end-user energy displays with hourly usage, pricing, and GHG emissions display capabilities.	Yes	Yes			Yes	Neg	Yes	CO, NM
RCI	Efficiency Improvements in Government Buildings	This policy recommendation sets energy efficiency goals for new construction and major renovations, and provides energy efficiency targets that are much higher than code standards in government buildings. This also includes developing life-cycle GHG accounting protocols and a minimum of ENERGY STAR-rated appliances for all government procurement. Government agencies could retain funds saved by improving energy efficiency for funding additional energy efficiency investments. All new or retrofitted government buildings should meet stringent green building third-party verification requirements.	Yes	Yes				Neg-Low	Yes	SC, UT
TLU	Pay-As-You-Drive Insurance	Pay-as-you-drive automobile insurance seeks to convert the typically fixed cost of automobile insurance to a per-mile cost. Ideally, this would serve to provide an incentive for drivers to drive less (reducing VMT), at the same cost overall as traditional insurance.	Yes					Neg	Yes	AZ, MD, VT
TLU	Feebates to Improve Vehicle Efficiency	Feebates provide an incentive to purchase more efficient vehicles. This is done by providing a monetary incentive for more fuel efficient vehicles, and a tax on less fuel efficient vehicles. Ideally, this program is operated such that it is revenue neutral, with the revenue from taxing less efficient vehicles counterbalancing the incentives toward more efficient ones.	Yes					Neg-Low	Yes	ME, NC, PA
TLU	Reduced Vehicle Idling	Reduce unnecessary idling of heavy-duty vehicles, including trucks and buses through public and private fleet anti-idling policies, targeted education of bus and truck operators, creation of low-cost means to access available	Yes	Yes	Yes	Yes		Neg-Low	Yes	AZ, MI, NM

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
		technologies that reduce or eliminate idling, and increased availability of electrification at privately-owned truck stops.								
TLU	Reduced Speed Limits	Reduced vehicle speeds improve fuel economy, reduce CO_2 emissions, and improve safety. This could be implemented by requiring interstates, freeways, and major arterials to be signed with a maximum speed that is lower than the current speed and by enhanced police enforcement or speed camera installation. Significant enforcement resources may be needed for this measure to achieve the expected reductions.	Yes	Yes				Low	Yes	MN, NM, NY
TLU	Low Carbon Fuel Use	Seek to increase the use and market penetration of low carbon fuels (LCFs) to offset traditional fossil fuels such as gasoline, diesel, jet fuel, and others derived from crude oil. Various options or a combination of options to increase LCF use would include: carbon fuel accounting, fuel quality standards, LCF infrastructure development, LCF standard and credits for compliance, high carbon fuel tax, state government fleet 'leadership' programs for adoption of LCFs, and carbon reduction requirements.	Yes					Neg-High	Yes	MN, NM, SC
TLU	Smart Growth	Promote smart growth and efficient transportation and land use through the adoption of transportation and land use policies that follow more sustainable smart growth principles. Smart growth seeks to create more compact communities, featuring increased density and a mix of land uses that generate less vehicle traffic, while being more supportive of auto trip reduction measures. Smart growth also sites commercial and industrial facilities and growth with ready access to an efficient, multi-modal freight transportation system.	Yes	Yes				Neg	Yes	AR, SC, VT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Increased Transit Use	Develop policies to encourage the use of transit to replace single occupant vehicle trips. Create, enhance, and promote public transit options and enhance transit service through route expansion and increased service frequency.	Yes	Yes				Neg-High	Yes	CA, MI,VT
TLU	Improved Rail Efficiency	Encourage the expanded use of rail for efficient freight movement where it is practical to do so. Facilitate transportation infrastructure improvements that increase rail capacity, support connectivity, and reduce rail freight system bottlenecks.	Yes	Yes				Neg-Low	Yes	MI, MT, WA
A, F, W	Biomass Feedstocks for Electricity Use	Set goals to increase biomass feedstock use and offset fossil fuels used in the production of electricity.	Yes	Yes				Neg-Low	Yes	AK, CO
A, F, W	Biomass Feedstocks to Offset Fossil Transportation Fuels	Set goals to increase biomass feedstock use to offset fossil transportation fuels.	Yes					Low-High	Yes	AK, AR, VT
W	Wastewater Energy Efficiency	Wastewater treatment plants typically are the largest consumer of electricity on most municipal bills, often consuming more than one-third of the energy consumed for all municipal services. In many instances, opportunities exist to reduce energy consumption at these facilities. The savings realized by energy-efficient measures could be used to fund improved water quality.	Yes	Yes				Neg-Low	Yes	PA, SC, VT
A	Install Methane Digesters at Local Farms	Develop incentives to encourage an expansion of regional methane digesters that can offer larger-scale and higher technology treatment. Regional digesters would accept manure from smaller farms, as well as food and green waste from nearby municipalities that otherwise would not be able to provide enough feedstock for a digester. The ancillary benefits associated with this strategy include some reduction in landfill use, reduced energy use from fewer vehicle	Yes		Yes			Low-High	Yes	CA, PA, VT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
		miles traveled to other disposal locations, and improved soil structure for agricultural purposes through the land application of organic matter resulting from the digesters.								
A	Improve Soil Carbon Sequestration	Develop policies that increase the net carbon sequestration capacity of local agriculture by (1) increasing the acres of farmland managed with regenerative cropping practices that improve the rate of biological sequestration of atmospheric carbon as soil organic matter; and (2) decreasing practices, and the use of products that release carbon into the atmosphere.	Yes		Yes			Neg-Low	No	PA, RI
A	Improved Nutrient Management	Create incentives and provide support for farmers wishing to transition their livestock operations from grain-intensive practices (which usually requires importing of grain/nutrients into the state) to continuous management-intensive grazing, which by contrast takes advantage of more local resources and increases sequestered carbon in pasturelands.	Yes		Yes			Neg-Low	No	PA, VT
A, F	Land Use Management to Protect Open Spaces	Reduce the rate at which existing crop/pasture, rangeland, forests, and open spaces are converted to developed uses. The carbon sequestered in the soils and above ground biomass of these open spaces and working lands is often much higher than in developed land uses. Policies that preserve open space and working lands provide additional GHG benefits by reducing the VMT that would otherwise occur from unwise or unplanned development.	Yes					Low-High	No	MT, MI, VT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
A	On-Farm Energy Efficiency	Seek to reduce GHG emissions from farming by reducing the amount of fossil fuel consumed by farming and harvesting practices through improved technologies and increases in efficiency.	Yes		Yes			Neg-Low	Yes	MI, SC, WA
F	Urban Forestry	This includes programs to plant new trees throughout existing communities and municipalities.	Yes	Yes				Neg	Yes	MT, NC, PA
F	Afforestation	Increase carbon stored in forests through expanding the forestland base. Establishing new forests, on historically non-forested land ("afforestation") increases the amount of carbon in biomass and soils compared with preexisting conditions. Afforestation accomplished with stocking/planting and other practices (e.g., soil preparation and erosion control) can increase carbon stocks above baseline levels and ensure conditions that support forest growth.	Yes					Low-High	No	MT, NC, PA
F	Expanded Use of Wood Products	Enhance the use and lifetime of durable wood products. Adopt programs to expand the use of wood products over current baseline rates of use. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Following their useful life (which could be measured in decades), wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition. Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices.			Yes			Low	Yes	ME, MI, VT

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
W	Waste Reduction/Recycling	Develop programs to increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.		Yes	Yes			Neg-Low	Yes	AR, PA, VT
W	Methane Flaring+Energy Programs	Develop policies that incentivize large landfills to collect and control landfill gas emissions for energy generation, specifically direct heat. Policies could include: providing tax credits for landfill gas utilization projects, prioritization of rights-of-way for landfill gas projects, and the provision of assistance for potential project operators to identify the nearest economical end uses.	Yes	Yes				Low	Yes	FL, MI
RCI	Energy Efficiency - Equipment	This can include a variety of policies to upgrade equipment to ENERGY STAR certified products in offices and homes. Equipment includes computers, monitors, printers, copiers, refrigerators, vending machines, water coolers, dishwashers, clothes washers, water heaters, boilers, etc.		Yes	Yes	Yes		Neg-Low	Yes	1
RCI	Energy Efficiency - Facilities	This can include policies to make facility-scale energy improvements. Policies might include a Green Building Ordinance, commercial or residential energy code requirements, programs to weatherize low-income housing, and requiring energy upgrades to facilities at the time of sale.		Yes	Yes	Yes		Neg-Low	Yes	1
RCI	Energy Efficiency - Lighting	Lighting includes both home and building lighting as well as street lights and traffic lights. Policies might include decreasing time street lights are on, installing LED street lights, efficient lighting retrofits, occupancy sensors for lighting, etc.		Yes	Yes	Yes		Neg-Low	Yes	1

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
RCI	Energy Efficiency - Education	Outreach and education programs can provide businesses and residents with information about how they can enact simple measures to save energy and encourage conservation.		Yes	Yes			Neg-Low	Yes	1
RCI	Energy Efficiency - Water	Measures such as adopting a water conservation ordinance, installing low-flow faucets and shower heads, installing high efficiency toilets, and using low maintenance landscaping can reduce water usage, and also reduce energy needed to heat water.		Yes	Yes	Yes		Neg-Low	Yes	1
RCI	Energy Efficiency - Roofs	Building energy efficiency can be improved with green or reflective roofs. A green roof uses a soil medium and plants on top of an impermeable membrane roof. They reduce building energy use by insulating the roof. Reflective roofs reduce the heat entering the building through the roof, reducing air conditioning needs.		Yes	Yes	Yes		Neg-Low	Yes	1
RCI	Renewable Energy Generation	Renewable sources of energy can be used in place of electricity generated by fossil fuels, including solar panels, solar water heaters, wind turbines, and energy generation from landfill methane.		Yes	Yes	Yes		Low-High	Yes	1
RCI	Renewable Energy Procurement	Local utilities can offer green electricity options to their customers by purchasing energy from renewable energy sources such as solar, wind, and biomass.	Yes	Yes	Yes			Low-High	Yes	1
TLU	Transportation - Alternative Fuels	Promote alternatives to gasoline and diesel for transportation, including electric vehicle recharging facilities, conversion of vehicles to biodiesel, compressed natural gas, ethanol, or electric.	Yes						Yes	1
TLU	Transportation - Vehicle Fuel Technology	Provide incentives for the purchase and use of lower GHG vehicles, such as hybrid vehicles, parking and lane incentives for hybrid vehicles, retrofits of older trucks and buses, fuel efficient vehicles (scooters) for parking enforcement	Yes	Yes	Yes			Low-High	Yes	1

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Transportation - Trip Reduction	Numerous options exist for reducing vehicle trips, shifting travel modes from single occupant vehicle to bike, pedestrian, transit, or carpool, incentivizing the use of school buses, increasing telecommuting, etc.	Yes	Yes	Yes			Neg-High	Yes	1
W	Waste - Composting	This can include kitchen or yard composting, along with curbside collection programs for composting of yard wastes.	Yes	Yes	Yes	Yes		Low-High	Yes	1
W	Waste- Methane Flaring	Flaring of methane at landfills converts the methane to carbon dioxide and water, reducing GHG emissions.	Yes	Yes				Neg-High	No	1
W	Waste- Recycling	Recycling programs can be established or expanded at a number of different levels--businesses, homes, construction/demolition, etc. Recycling saves energy in manufacturing compared to producing products from raw materials.	Yes	Yes	Yes	Yes		Low-High	Yes	1
W	Waste- Waste Reduction	Waste reduction programs can be implemented as "pay-as-you-throw" programs to offer incentives to individuals or businesses to reduce waste or local programs to reuse rather than landfill waste, such as reuse of building materials	Yes	Yes	Yes	Yes		Low-High	Yes	1
A, F, W	Carbon Credits	Carbon offsets allow an institution or individual to offset the GHG emissions of their activities by paying for projects that reduce GHG emissions elsewhere. Typical projects might include renewable energy, methane capture from waste, and tree planting.	Yes	Yes	Yes	Yes		Low-High	No	1
F	Urban Forestry	Trees properly planted can reduce the energy needed to heat and cool buildings. By maintaining a healthy urban forest, prolonging the life of trees, and continually increasing tree stock, communities can increase net carbon storage and also reduce local temperatures.	Yes	Yes	Yes			Neg-High	Yes	1

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
ES, RCI, TLU	Carbon Tax	Carbon taxes can be used to discourage activities that result in increased carbon emissions. They can be imposed in a variety of ways, such as a tax on utility bills based on the amount of energy used, a tax on builders of new homes based on the projected carbon emissions over the lifetime of the home.	Yes	Yes			Yes	Low-High	Yes	1
TLU	Reduce VMT	There are numerous ways to reduce VMT including walking, biking, taking transit, ridesharing, carpooling, and telecommuting.				Yes		Neg-Low	Yes	2
TLU	Drive Fuel Efficiently	This includes actions to improve vehicle fuel economy including avoiding rapid starts and stops, maintaining a steady speed, avoiding idling, and combining errands and trips.				Yes		Neg	Yes	2
TLU	Maintain Your Vehicle	This includes actions such as regular oil changes, replacing dirty air filters, regular vehicle tune ups, and keeping tires properly inflated.				Yes		Neg-Low	Yes	2
TLU	Choose a Low-Polluting Vehicle	Use the lowest polluting car possible. When buying a new car, consider the Global Warming Score Vermont's Environmental Performance Label.				Yes		Neg-Low	Yes	2
TLU	Choose an Accessible Neighborhood to Live In	When looking for a place to live, choose a community that is close to work, shops, community services, and transit, and also with sidewalks and good conditions for biking.				Yes		Neg-Low	Yes	2
RCI	Heat Your Home Efficiently	This includes actions to improve a home's energy efficiency including: conducting a home energy audit, sealing air leaks, lowering the thermostat in winter, conducting regular heating system maintenance, and upgrading to a more efficient heating system.				Yes		Neg-Low	Yes	2
RCI	Keep a Low-Emission Lawn	This includes actions such as replacing lawn area with low-maintenance "natural yard" plantings, maintaining lawn equipment, mowing the lawn during cooler time periods, setting the mower height higher, and replacing older equipment with less-polluting equipment.				Yes		Neg-Low	Yes	2

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU, RCI	Choose Less Polluting Recreation Craft and Vehicles	Consider using non-motorized recreational equipment such as canoes, kayaks, bikes, and skis. Consider replacing older recreational vehicles with newer ones meeting new federal standards.				Yes		Neg-Low	Yes	2
TLU	Promote and Support Alternatives to Peak-hour and Drive Alone Employee Commuting.	This includes measures such as encouraging employees to share rides, use public transit, bike, or walk to work, encouraging telecommuting and alternate work schedules, and offering incentives to not drive to work alone.			Yes			Neg-Low	Yes	2
TLU	Participate in a Collaborative Travel Demand Management Program with Other Employers	A number of existing options in the region and state exist for employers to join collaborative travel demand management programs to assist employees in finding alternatives to riding to work alone.			Yes			Low	Yes	2
TLU	Consider Public Transit in Location Criteria when Siting New Facilities	Accessibility to public transit and other commute alternatives should be an important consideration for employers when relocating or adding facilities.			Yes			Low	Yes	2
TLU	Educate Employees on Energy Conservation in Transportation	Employers can provide information to employees about how their actions and transportation choices affect energy use and the environment.			Yes			Neg-Low	Yes	2
TLU	Maintain Fleet Vehicles	This includes selecting fleet vehicles that are fuel efficient and low-polluting, retrofitting diesel engines in trucks and construction equipment with clean diesel engines or technologies, and properly maintaining vehicles to keep them operating efficiently.			Yes			Low	Yes	2
TLU	Rail for Freight Shipments	Selecting rail shipments for goods is generally much more efficient than truck shipments as rail freight is about three times more fuel efficient than trucks, and this reduces congestion on roadways.			Yes			Low-High	Yes	2

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Idling Reduction Practices	This can include strategies such as behavior change to reduce idling, anti-idling policies, and technology approaches such as automatic engine shutdown and auxiliary power units.		Yes	Yes			Neg-Low	Yes	2
TLU	Control Track-out from Construction Sites	Employers and establish no-track-out policies and practices for vehicles leaving construction sites to reduce road dust and fine particulate pollution.			Yes			High	No	2
RCI	Conduct Energy Audits	Have an energy audit performed to look for cost-effective opportunities to reduce the amount of energy used by a building or process.			Yes			Neg-Low	Yes	2
RCI	Upgrade to Efficient Space/Process Heating	Consider switching space and process heating to cleaner fuels, more efficient heating technologies, and electric, solar, or geothermal alternatives.			Yes			Neg-High	Yes	2
RCI	Develop and Implement a Sustainability Plan for Reducing Emissions	This generally includes measuring emissions, establishing performance goals, developing a plan to achieve the goals, and tracking performance.			Yes			Low	Yes	2
All	Support Air Quality Strategies in Municipal Planning	This can be done with goals, objectives, and policies in municipal plans that support air quality improvements, encourage compact, mixed-use development, support bicycle and pedestrian facilities, support transit use, and support alternative energy sources.		Yes				Low	Yes	2
TLU	Support Transit Operations	By transit service available in the municipal area, municipal agencies can reduce local VMT.		Yes				High	Yes	2
All	Establish Municipal/Regional Energy/Climate Action Committee	Energy committees can advise the municipal governing body in developing energy plans, climate action plans, conducting inventories and energy audits, identifying energy or climate action strategies, and education outreach. Over 60 municipalities in Vermont have established an energy or climate action committee.	Yes	Yes				Low	Yes	2

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Update Parking Policies to Provide Air Quality Benefits	Parking strategies can be implemented to reduce driving alone to work. Strategies could include park-and-ride facilities to encourage ride-sharing, reduced parking fees at transit stops, and short term parking limits in central business areas to discourage all-day commuter parking.		Yes				Low-High	Yes	2
F	Support Urban Forestry	Plant trees on municipal land, right-of-ways, and in park and recreation facilities.		Yes				Neg-High	Yes	2
TLU	Encourage Development Patterns for Air Quality Benefits	Adopt regulations and zoning laws that encourage compact, mixed-use development, smart growth, increased density, energy efficiency, and complete streets.		Yes				Low-High	Yes	2
A, F, W	Burning Restrictions	Restrict or ban open burning in densely populated communities and towns.		Yes				High	No	2
TLU	Ensure Municipal Facilities Support Bicyclists and Pedestrians	Municipalities in Vermont have the ability to construct, operate, and maintain bicycle and pedestrian facilities, including bike lanes, sidewalks, and crosswalks in street construction, safe bike parking at municipal facilities including offices, libraries, and parks, and pedestrian amenities such as shade trees and benches.		Yes				High	Yes	2
TLU	Review Road Construction and Maintenance Practices to Reduce Pollutant Emissions	Reduce road dust from construction and industrial sites, unpaved roads, and deposits on paved roads through dust controls like wet sweepers.		Yes				High	Yes	2
TLU	Optimize Traffic Flow	Optimize traffic flows to allow traffic to move more steadily along roadways and at intersections to reduce idling and accelerating, such as through the use of coordinated traffic signals.		Yes				Neg-High	Yes	2
TLU	Include VMT Reduction in Long Range Planning	Include transportation system goals in long-range transportation plans to reduce VMT, emissions, and congestion, and increase transit ridership and non-motorized mode share.	Yes					Low	Yes	2

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Utilize Land Use/Transportation Scenario Planning	Follow best practice of including scenario planning that shows more compact, transit-oriented development patterns in long-range transportation planning.	Yes					Low	Yes	2
TLU	Enhance Regional Travel Models to Evaluate Air Quality	Ensure that regional travel models are usable for air quality purposes and consider alternate modes of transportation such as shared rides, transit use, and bike and pedestrian modes.	Yes					Low-High	Yes	2
TLU	Work with Local Agencies and Employers to Expand Transportation Demand Services	Coordinate, expand, and promote existing travel demand service programs to increase individual and employer participation.	Yes					Low	Yes	2
TLU	Work with Local Agencies to Optimize Traffic Flow	Adjust traffic signals to optimize traffic flow and reduce idling.	Yes					Neg-High	Yes	2
TLU	Support Compact, Transit Served Areas for Funding Priority	Prioritize available funding for areas where local governments have planned for compact growth or have included high-quality facilities for non-auto travel modes.	Yes					Neg-High	Yes	2
TLU	Evaluate Benefits of Multi-County Transit Agency	Merging transit organizations from neighboring jurisdictions can provide greater organizational and operation efficiency, which can support more regional commuter routes and relieve congestion.	Yes					Low	Yes	2
TLU	Support Regional Rail Improvements	Support regional rail improvements and advocate for state-wide rail improvements to enable the optimal use of rail transportation in the region.	Yes					High	Yes	2
TLU	Support Local Government Planning Grants for Transit Development	Provide support to municipal planning efforts that encourage transit oriented development, higher density land use, and mixed use zoning.	Yes					High	Yes	2

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation					$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
			State/ Regional*	Municipal	Employer	Individual	Utility			
TLU	Evaluate Benefits of Regional Transfer of Development Rights	Initiate a discussion among municipalities and state legislators to explore the possibility of enabling and implementing regional transfer of development rights programs in Vermont.	Yes					Low-High	Yes	2
All	Regional Education and Outreach to Improve Air Quality	Initiate an education and outreach program related to improving air quality with the following components: conduct baseline measurements of knowledge and behaviors, segment and identify key audiences, develop and implement targeted marketing messages, and conduct post-message assessment of program.	Yes					Low-High	Yes	2
TLU	Vanpool Service	Vanpool programs use vans to take an established group of employees to and from work. These are well-suited for longer commutes. These services can be provided in a variety of ways such as employer-based or transit company-based programs.	Yes	Yes	Yes			Low-High	Yes	3
TLU	Emergency Ride Home Services	Emergency ride home programs help alleviate the concerns of potential carpoolers or transit users by offering rides on an emergency basis to employees who participate in commuter alternative programs.	Yes	Yes				Low-High	Yes	3
TLU	Congestion Pricing	Congestion pricing programs charge drivers directly for their use of roadways, particularly during times of high-volume traffic. The revenue raised can be used for related programs such as alternative modes of transportation or improved infrastructure.	Yes	Yes				Low-High	Yes	3

Notes:
* State/Regional level of implementation indicates strategies that may require implementing authority at the State level, but may be implemented either statewide or just in the local region.
** $/Ton GHG Reduced represents the range of the cost of the strategy per ton of CO_2e reduced. If costs are negative (i.e., the strategy results in a cost savings), NEG is listed. The range for Low = less than $50/ton CO_2e reduced. The range for High = more than $50/ton CO_2e reduced. The cost per ton of GHG removed estimates were obtained from the state climate action plans, where these are listed as the data source. The cost per ton estimate for data sources 1, 2, and 3 were based on professional judgment.

Sectors:
A = Agriculture; ES = Electricity Supply; F = Forestry; RCI = Residential, Commercial, and Industrial Fuel Use; TLU = Transportation and Land Use; W = Waste

Sector	Energy or GHG Strategy	Strategy Description	Level of Implementation: State/ Regional*	Municipal	Employer	Individual	Utility	$/ton GHG Reduced**	Reduced Fossil Fuel Consumption?	Data Source
	Data Sources: IA, MT, VT, CT, CA, FL, MI, AR, SC, AK, CO, PA, CT, NM, MN, WA, RI are from the corresponding state's climate action plan. 1. ICLEI. Climate Air Pollutant Planning Assistant, Version 1.1. Available online at - http://www.icleiusa.org/action-center/tools/cappa-decision-support-tool. 2. CCRPC. "Keeping Our Air Clean". February 2010. Located online at http://www.ccmpo.info/library/airquality/Keeping_Our_Air_Clean_FINAL_20100222.pdf 3. USEPA "Transportation Control Measures", as part of the Local Government Climate and Energy Strategy Series. March 2011. Located online at http://www.epa.gov/otaq/stateresources/policy/pag_transp.htm#tcm									