# Appendix 2: Plenary Group Recommendations & Appendices

VERMONT

# Plenary Group Recommendations

## to The Governor's Commission on Climate Change

*FINAL REPORT*

*OCTOBER, 2007*

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# Executive Summary

Vermont has long been a leader in recognizing and responding to environmental problems. The climate change issue is no exception. Recognizing the serious implications that global warming and climate variation could have on the economy, environment, and quality of life in New England, Governor James Douglas signed Executive Order 07-05 on December 5, 2005, establishing the Governor's Commission on Climate Change (GCCC)[1] with a charge of helping the state assess and recommend options for state action. This effort added to several climate leadership initiatives already underway such as adopting new low-emission vehicle standards; establishing a working group within state government to reduce greenhouse gas (GHG) emissions from state buildings and operations; groundbreaking work with electric utilities to encourage efficiency and manage demand for power, thus lowering emissions; and leadership roles in regional climate efforts. In addition, the Governor's Executive Order set goals of reducing GHGs based on the recommendations of the Conference of the New England Governors and Eastern Canadian Premiers Action Plan. That goal–the highest set by any state–would reduce emissions from the 1990 baseline by 25% by 2012, 50% by 2028 and, if practicable using reasonable efforts, 75% by 2050.

The Governor directed the six-member GCCC to prepare a report that includes a projection of the State's future greenhouse gas (GHG) emissions and policy recommendations for reducing Vermont's total GHG emissions to achieve these goals, consistent with the state's need for continued economic growth and energy security. Soon after the first meeting of the GCCC, it convened a larger Plenary Group (PG) to diversify the expertise and perspectives of those involved in this effort. Governor Douglas appointed 31 stakeholders, representing a broad range of interests, backgrounds, and capabilities to carry out a year-long process to provide analysis and recommendations on GHG reduction measures.

## Plenary Group Process and Findings

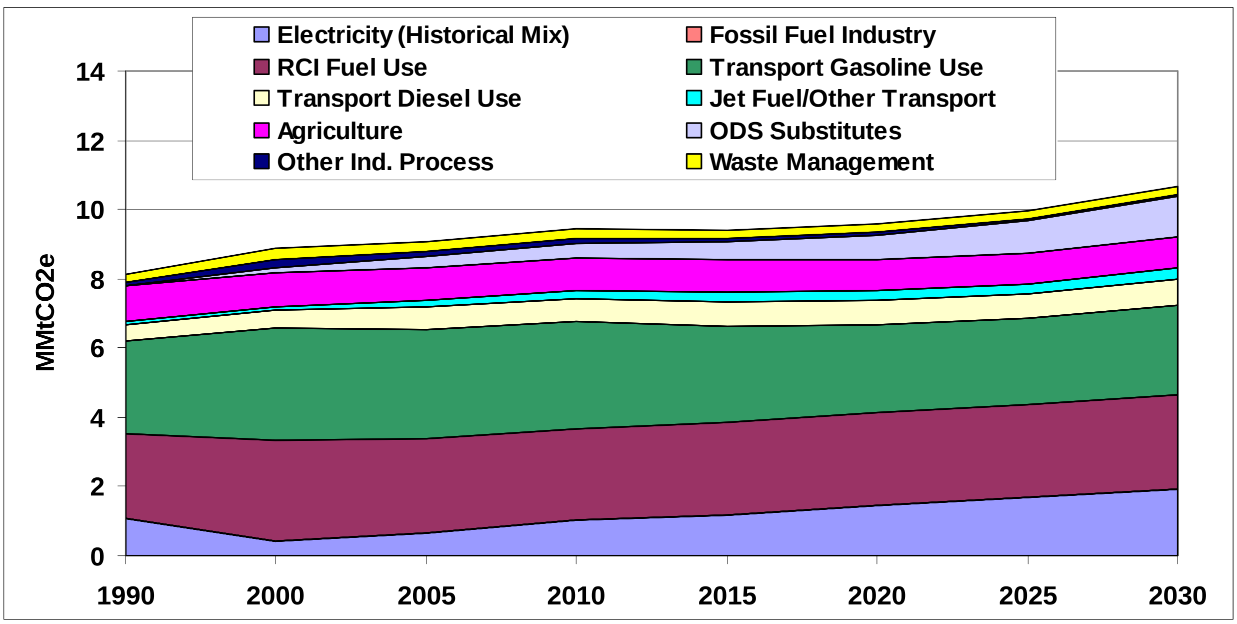
The Vermont Department of Environmental Conservation (DEC) organized the analysis process on behalf of the Governor. DEC's Air Division managed logistics and provided technical reviews. With oversight from DEC, the Plenary Group followed a consensus-building process designed and implemented by the nonprofit Center for Climate Strategies (CCS). Applying a design similar to those used in other successful state climate initiatives, CCS provided both facilitation and technical analysis services to the PG as support in formulating its recommendations. Through the PG process, described in greater detail in Chapter 1, the group was tasked with undertaking a review of (a) an inventory and projection of Vermont's GHG emissions; (b) specific policy options for reducing GHG emissions from all sectors; and (c) findings related to quantified benefits, costs, and feasibility issues associated with options.

[1] Appendix A contains the Governor's Executive Order.

The combined PG met seven times from September 2006 to July 2007. During this same period, four sector-based technical work groups (TWGs) were formed consisting of PG members and a number of additional experts. The TWGs developed initial recommendations in the areas of Energy Supply and Demand (ESD); Transportation and Land Use (TLU); Agriculture, Forestry, and Waste Management (AFW); and Cross-Cutting Issues (CC).

As noted, as part of their charge, the PG reviewed and evaluated an inventory and projection of future GHG emissions for Vermont. Figure ES-1 presents a view of that information. It shows the continued growth of Vermont's GHG emissions by sector under a "low emissions" scenario that assumes continued historic supplies of hydroelectric and nuclear power. Even under this scenario, Vermont's gross GHG emissions could increase from 8.14 million metric tons of carbon dioxide equivalents (MMtCO$_2$e) in 1990 to 10.66 MMtCO$_2$e in 2030, growing by 31% over this period.

**Figure ES-1. Vermont gross GHG emissions* by sector, 1990–2030: historic and projected (assuming continued DSM)**




* Based on low-emission scenario for the electric utility sector (i.e., historic hydro and nuclear power supply levels)
DSM – Demand Side Management (utility and consumer efficiency actions to reduce power demand, and hence emissions)
RCI – Residential, Commercial and Industrial
ODS – Ozone Depleting Substances (which are also powerful greenhouse gases)

Projections such as these underscored the need for across-the-board actions to mitigate Vermont's contributions to global warming through GHG reductions.

Following a year of analysis and deliberations, the Plenary Group came to strong agreement on the 38 strategies recommended in this report. The level of PG support for individual policy recommendations and key findings was documented through a voting process. Barriers to consensus were noted where they could not be resolved. The final recommendations presented here represent a high level of consensus among the group. Almost all of the recommendations–

84%–won unanimous consent; 10% were approved by a super-majority, indicating fewer than five objections.

## Plenary Group Recommendations

The PG offers 38 policy recommendations to the GCCC to help meet the GHG emissions goals in Executive Order 07-05. These recommendations, presented in summary tables below, are described in Chapters 3 through 6; further technical details and explanations can be found in the Appendixes to his report.

Figure ES-2 shows that against Vermont's projected GHG emissions (referred to as the "reference case"), continuation of the state's DSM programs, its adoption of California vehicle emissions standards, and potential expansion of DSM programs could effectively reduce virtually all growth in the state's GHG emissions.  As also shown in Figure ES-2, collectively with these policies, the PG's policy recommendations come very close to achieving the Governor's and General Assembly's aggressive near-term target (within 6%) and substantially exceed the longer-term target. In fact, aggressive carbon sequestration provided by the Agriculture, Forestry, and Waste Management policy options could enable Vermont to approach near-zero GHG emissions or "carbon-neutral" status. This report also notes several co-benefits that could result from implementation of PG-recommended policies.

**Figure ES-2. Historical and projected Vermont GHG emissions: state leadership actions, goals, and PG policy recommendation results**

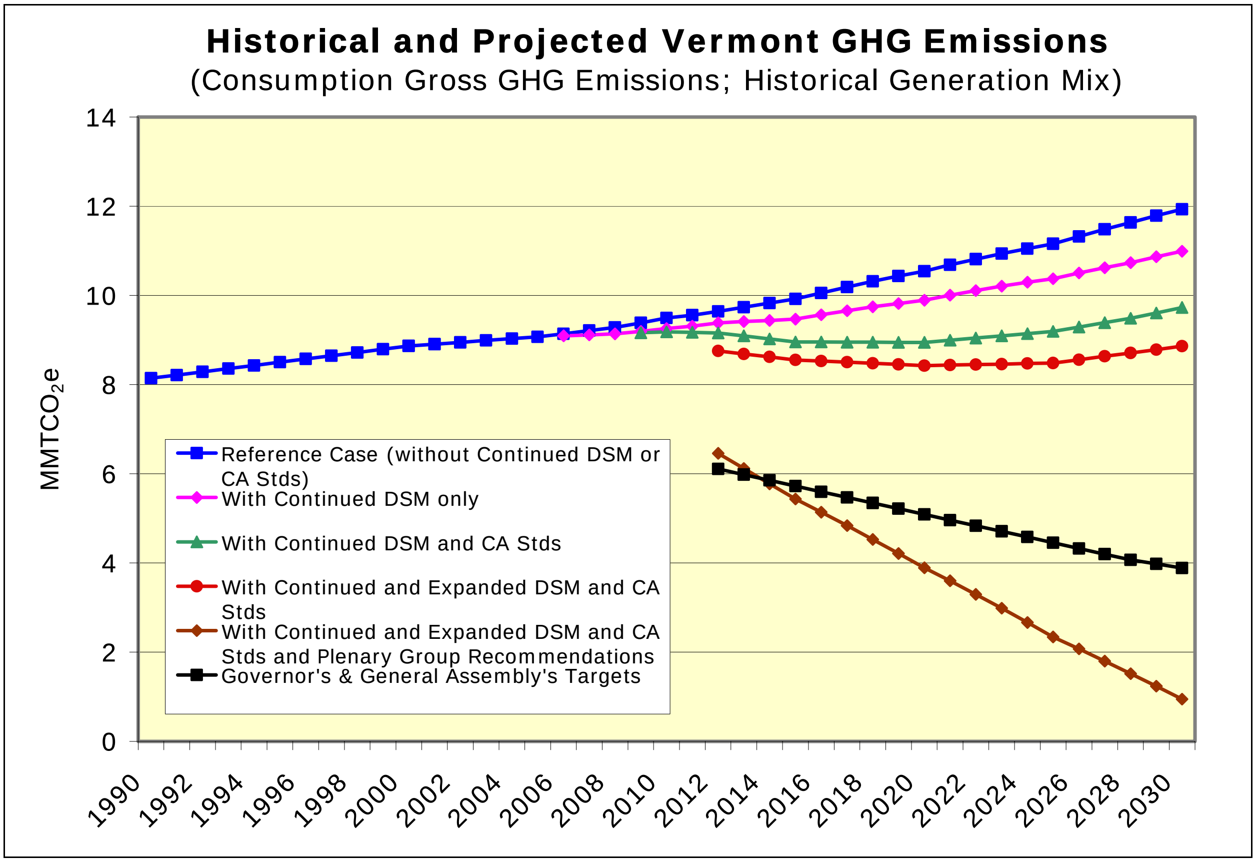



Table ES-3 presents a summary of the Plenary Group's recommendations by sector, showing reductions and cost data for each policy option.

## Table ES-3. Summary of PG policy recommendations by sector

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost–Effective–ness ($\$/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| | **ENERGY SUPPLY AND DEMAND** | | | | | | |
| ESD–1 | Evaluation and Continuation/ Expansion of Existing DSM for Electricity and Natural Gas | 0.7 | 1.7 | 21.5 | –$850 | –$40 | UC |
| ESD–2 | Evaluation and Expansion of DSM to Other Fuels | 0.1 | 0.5 | 5.3 | –$335 | –$64 | Super–Majority |
| ESD–3 | Building Efficiency Codes, Training, Tracking | 0.02 | 0.2 | 2.0 | –$107 | –$55 | UC |
| ESD–4 | Evaluate Potential for Contracting Nuclear Power | | | | | | Super–Majority |
| | (Scenario 1) | 0.5 | 1.1 | 16.7 | –$140 | –$8 | |
| | (Scenario 2) | 0.3 | 0.7 | 10.2 | –$70 | –$7 | |
| ESD–5 | Support for Combined Heat and Power | 0.1 | 0.2 | 2.6 | –$86 | –$34 | UC |

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost–Effective–ness ($/tCO$_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| ESD–6 | Incentives and/or Mandate for Renewable Electricity | | | | | | Super–Majority |
| | (Scenario 1) | 0.1 | 0.4 | 5.4 | $9 | $2 | |
| | (Scenario 2) | 0.2 | 1.2 | 15.7 | $38 | $2 | |
| ESD–7 | GHG Cap-and-Trade and/or GHG Tax | Referred to the GCCC as primarily a funding mechanism. | | | | | |
| ESD–8 | Incentives for Clean Distributed Technologies for Electricity or Heat | | | | | | UC |
| | Natural Gas Fuel Switching | 0.1 | 0.1 | 2.2 | $15 | $7 | |
| | Solar Thermal Water Heating | 0.05 | 0.2 | 2.3 | $67 | $29 | |
| ESD–9 | Wind–Specific Support Measures | | | | | | UC |
| | (New Wind, Scenario 1) | 0.03 | 0.2 | 2.1 | –$6 | –$3 | |
| | (New Wind, Scenario 2) | 0.1 | 0.5 | 6.3 | $10 | $2 | |
| ESD–10 | Hydro-Specific Support Measures | | | | | | UC |
| | (Continued Large Hydro, Scenario 1) | 0.02 | 1.1 | 14.9 | $0 | $0 | |
| | (Continued Large Hydro, Scenario 2) | 0.01 | 0.6 | 8.7 | $0 | $0 | |
| | (New Hydro, Scenario 1) | 0.01 | 0.06 | 0.8 | –$22 | –$27 | |
| | (New Hydro, Scenario 2) | 0.03 | 0.2 | 2.4 | –$64 | –$27 | |
| | **Total** | | | | | | |
| | **Scenario 1 (Generation of Nuclear and Hydro at Historic Levels)** | **1.56** | **5.48** | **72.75** | **–$1,427** | **–$20** | |
| | **Scenario 2 (Generation of Nuclear and Hydro at 50% of Historic Levels)** | **1.56** | **5.37** | **70.35** | **–$1,328** | **–$19** | |
| | **TRANSPORTATION AND LAND USE** | | | | | | |
| TLU-1 | Compact and Transit-Oriented Development Bundle | 0.26 | 0.99 | 10.88 | Net savings | | UC |
| TLU-2 | Alternatives to Single-Occupancy Vehicles (SOVs) | 0.28 | 0.32 | 6.57 | Net savings | | UC |
| TLU-3 | Vehicle Emissions Reductions Incentives | 0.11 | 0.63 | 7.73 | –$42 | –$10 | Majority |
| TLU-4 | Pay-as-You-Drive Insurance | 0.20 | 0.32 | 5.30 | Net savings | | Super-Majority |
| TLU-5 | Alternative Fuels and Infrastructure (LCFS) | 0.12 | 0.42 | 5.75 | N/A | | UC |
| TLU-6 | Regional Intermodal Transportation System – Freight and Passenger | 0.05 | 0.20 | 2.22 | N/A | | UC |
| TLU-7 | Commuter Choice/Commute Benefits | 0.06 | 0.19 | 1.86 | –$1 | –$1 | UC |
| TLU-8 | Plug-in Hybrids [part of TLU-5] | – | – | – | – | | UC |
| TLU-9 | Fuel Tax Funding Mechanism [TWG recommends examining as part of a funding package after reductions policies are chosen] | – | – | – | – | | UC |
| | **Sector total before adjusting for overlaps** | **1.09** | **3.07** | **40.31** | **N/A** | **N/A** | |
| | **Reductions from recent policy actions** | | | | | | |
| | **Sector total plus recent policy actions** | **1.09** | **3.07** | **40.31** | **N/A** | **N/A** | |
| | **AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT** | | | | | | |
| AFW-1 | Programs to Support Local Farming/Buy Local | 0.004 | 0.02 | 0.20 | Not quantified | Not quantified | UC |
| AFW-2 | Agricultural Nutrient Management Programs | 0.08 | 0.10 | 1.6 | $4.2 | $3 | UC |
| AFW-3 | Manure Management Methods to Achieve GHG Benefits | 0.01 | 0.02 | 0.3 | $34 | $136 | UC |
| AFW-4 | Protect Open Space/Agricultural Land | 0.06 | 0.11 | 1.80 | $56 | $31 | UC |

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost–Effective–ness ($/tCO₂e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| AFW-5 | Forestry Programs to Enhance GHG Benefits[1] | 0.03 | 0.12 | 1.30 | $4 | $3 | UC |
| AFW-6 | Increased Forest Biomass Energy Use | Quantified under AFW-5 and ESD options | | | | | UC |
| AFW-7 | Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover | 0.40 | 2.00 | 22.00 | $34 | $2 | UC |
| AFW-8 | Expanded Use of Durable Wood Products (Especially From Vermont Sources) | 0.09 | 0.05 | 1.40 | Not quantified | Not quantified | UC |
| AFW-9 | Advanced/Expanded Recycling and Composting | 0.16 | 0.88 | 9.10 | $37 | $4 | UC |
| AFW-10 | Programs to Reduce Waste Generation | 0.34 | 0.73 | 10.00 | Not quantified | Not quantified | UC |
| AFW-11 | Waste Water Treatment – Energy Efficiency Improvements | 0.00 | 0.01 | 0.14 | –$19 | –$133 | UC |
| AFW-12 | In-State Liquid Biofuels Production | | | | | | |
| | Ethanol Production | 0.03 | 0.42 | 3.7 | $5.0 | $1 | UC |
| | Biodiesel Production | 0.004 | 0.24 | 2.2 | $40 | $18 | UC |
| | **Sector Total After Adjusting For Overlaps** | **1.2** | **4.7** | **54.0** | **$190** | **$4** | |
| | **Reductions From Recent Actions** | **0** | **0** | **0** | **0** | **0** | |
| | **Sector Total Plus Recent Actions** | **1.2** | **4.7** | **54.0** | **$190** | **$4** | |
| | **CROSS-CUTTING ISSUES** | | | | | | |
| CC-1 | GHG Inventories and Forecasts | Not quantified | | | | | UC |
| CC-2 | GHG Reporting | Not quantified | | | | | UC |
| CC-3 | GHG Registry | Not quantified | | | | | UC |
| CC-4 | Public Education and Outreach | Not quantified | | | | | UC |
| CC-5 | Adaptation | Not quantified | | | | | UC |
| CC-6 | Options for Goals or Targets | Not quantified | | | | | UC |
| CC-7 | The State's Own GHG Emissions | Not quantified | | | | | UC |
| | **Sector total after adjusting for overlaps** | | | | | | |
| | **Reductions from recent policy actions** | | | | | | |
| | **Sector total plus recent policy actions** | | | | | | |

UC = unanimous consent; Majority = simple majority; DSM = demand-side management; LCFS = low carbon fuel standard; N/A = not applicable; GHG = greenhouse gases.

Total number of options voted upon = 37. For ESD, positive numbers for Net Present Value (NPV) and Cost-Effectiveness reflect net costs. Negative numbers reflect net cost **savings**.

[1] These estimates are based on the midpoint of results achieved using two different methods.

Table ES-4 reflects an approximation of relative reductions by sector or TWG. This table demonstrates that the Energy Supply and Demand sector and the Transportation and Land Use sector performed comparably well in reducing emissions from the reference case baseline. Agriculture, Forestry, and Waste Management policy options are shown as capable of supplying significant additional amounts of sequestered (stored) carbon, potentially reducing sector emissions far below projected GHG emissions levels.

**Table ES-4. Vermont PG policy options: relative reductions by sector**

| Sector (All values in $MMtCO_2e$) 2030 Data from I&F 5/28/07, Table ES-1 | 2030 | Estimated 2028 | PG Reductions for Sector | Remaining GHG Emissions From Sector | GHG Reduction in Sector (from BAU*) |
|---|---|---|---|---|---|
| Electricity consumption—(low emissions, no new DSM) | 1.91 | 1.86 | | | |
| Residential, commercial, industrial | 2.72 | 2.64 | | | |
| Fossil fuel industry | 0.03 | 0.03 | | | |
| Industrial process | 1.24 | 1.21 | | | |
| Sector total | 5.90 | 5.73 | 3.37 | 2.36 | 58.8% |
| Transportation | 3.64 | 3.54 | | | |
| Sector total | 3.64 | 3.54 | 2.10 | 1.44 | 59.4% |
| Waste | 0.23 | 0.22 | | | |
| Agriculture | 0.90 | 0.87 | | | |
| Sector total | 1.13 | 1.10 | 4.70** | -3.60 | 428% |
| **Overall totals** | **10.67** | **10.37** | **10.17** | **0.20** | **98.1%** |

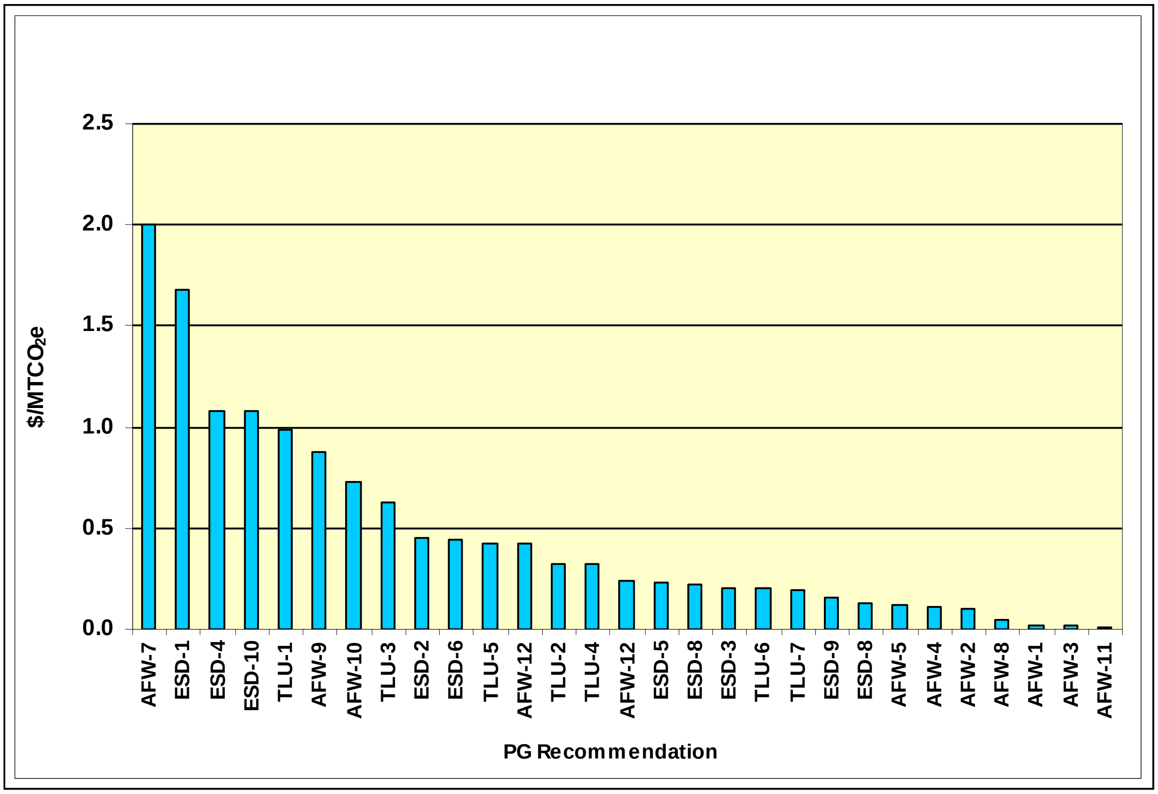
* BAU = business-as-usual

** AFW carbon reductions greater than emissions are accomplished through sequestration.

## Perspectives on Policy Recommendations

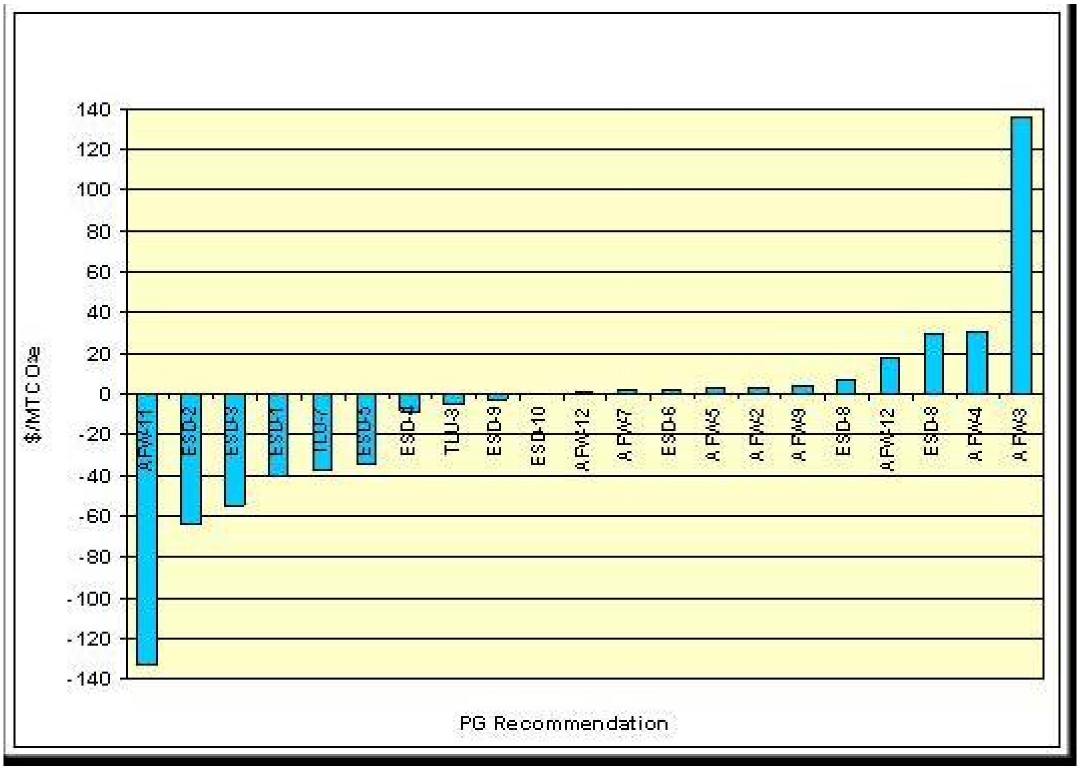
There is large variation in the GHG reductions associated with the policy recommendations brought forward by the PG. Figure ES-3 ranks policy recommendations (for each policy recommendation which was quantified) by estimated tons of GHG reductions, expressed as a cumulative figure for the period 2012–2028.

**Figure ES-3. PG policy recommendations ranked by cumulative GHG reductions, 2007–2028**




There is also variation in the cost (or cost savings) per ton of GHG reduction associated with various policy recommendations. Figure ES-4 presents the estimated dollars per ton cost (or cost savings, depicted as a negative number) for each policy recommendation for which cost estimates were available. This measure is calculated by dividing the net present value of the cost of the option by its cumulative GHG reductions, all for the period 2007–2028.

**Figure ES-4. PG policy recommendations ranked by dollars per ton**




Meeting Vermont's near-term reduction goal will require that the policy options receive further analysis, development, and authorization where necessary (legislative and/or regulatory), and that implementation to the extent possible of recommended policy options proceeds on a prompt and energetic basis. Meeting longer-term goals will require a consistent commitment by successive governors and legislatures, aided by an equal commitment by all stakeholders.

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# Acknowledgments

The Vermont Plenary Group (PG) gratefully acknowledges the following individuals and organizations who contributed significantly to the successful completion of the PG process and the publication of this draft final report:

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Kathryn Bickel
Bill Dougherty
Sivan Kartha
Holly Lindquist
Lewison Lem
Stephen Roe
Will Schroeer
Randy Strait

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The PG wants to recognize the many individuals who participated in the sector-based TWGs, all of whom are listed in Appendix C. Even though this report is intended to represent the results of the PG's work, the group would be remiss if it did not recognize and express appreciation for the time and effort spent in discussion, study, and deliberation of each fellow member of these hardworking groups.

Finally, the PG would like thank the donor organizations that provided financial support to CCS that allowed it to serve the PG throughout this process: VTDEC, John Merck Fund, Marisla Foundation, Merck Family Fund, Rockefeller Brothers Fund, and the Surdna Foundation.

# Members of the Vermont Governor's Commission on Climate Change

Appointed by the Governor, the GCCC comprises six individuals who bring broad perspective and expertise to the topic of climate change in Vermont. The six members are

**Ernest Pomerleau,** (Chair) President, Pomerleau Real Estate
**Donald DeHayes,** Dean, Rubenstein School of Environment and Natural Resources, University of Vermont
**Brian Searles,** Director, Burlington International Airport
**Elizabeth Courtney,** Executive Director, Vermont Natural Resources Council
**Theresa Alberghini DiPalma,** Senior Vice President for Government and External Relations, Fletcher Allen Health Care
**Parker Riehle,** President, Vermont Ski Areas Association

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**Roger Allbee,** Vermont Agency of Agriculture, Food, and Markets
**Paul Cameron,** Brattleboro Climate Protection
**John Casella,** Casella Waste Management
**Paul Comey,** Green Mountain Coffee Roasters
**Sean Cota,** Cota & Cota, Inc.
**Richard Cowart,** Regulatory Assistance Project
**Robert Dostis,** Vermont House Natural Resources and Energy Committee
**Chris Dutton,** Green Mountain Power
**Michael Dworkin,** Vermont Law School, Institute for Energy and the Environment
**David Epstein,** Truex, Cullins & Partners Architects
**Jackie Folsom,** Vermont Farm Bureau
**Don Gilbert,** Vermont Gas Systems
**David Hill,** Vermont Energy Investment Corp. (VEIC) / Efficiency Vermont
**Jon Isham,** Middlebury College
**Thomas A. Jagielski,** IBM
**Jennifer Jenkins,** UVM Gund Institute for Ecological Economics
**Scott Johnstone,** Chittenden County Metropolitan Planning Organization
**Chris Kilian,** Conservation Law Foundation
**David Lewis,** Lewis Motors
**Neale Lunderville,** Vermont Agency of Transportation (VTrans)
**Virginia Lyons,** Vermont Senate Natural Resources and Energy Committee
**Edward Mahoney,** Graduate Theology Program, St. Michaels College
**James Moore,** Vermont Public Interest Research Group (VPIRG )
**David O'Brien,** Vermont Department of Public Service
**Dale Rocheleau,** Central Vermont Public Service Corp. (CVPS)
**Debra Sachs,** Alliance for Climate Action and Vermont Planners Association
**Jim Saudade,** Vermont Agency of Commerce & Community Development
**Bill Sayre,** Economist & Associated Industries of Vermont
**Carl Spangler,** Development Services LTD
**Kyle Trombley, "**Youth Representative," Rutland
**Steve Wheeler,** Vermont Maple Sugar Makers' Association

# Acronyms

| | |
|---|---|
| AEO | Annual Energy Outlook [US DOE] |
| AESC | Association of Energy Service Companies [US DOL] |
| AFW | Agriculture, Forestry, and Waste Management [TWG] |
| ANR | Agency of Natural Resources [VT] |
| ASHRAE | American Society of Heating, Refrigeration and Air-Conditioning Engineers |
| BAU | business-as-usual |
| BC | black carbon |
| CA | California |
| Cal LEV II | California Low-Emission Vehicle Standard |
| CATMA | Campus Area Transportation Management Association |
| CB | commuter benefits |
| CC | Cross-Cutting Issues [TWG] |
| CCMPO | Chittenden County Metropolitan Planning Organization |
| CCS | Center for Climate Strategies |
| CCTA | Chittenden County Transportation Association |
| CCX | Chicago Climate Exchange |
| CFC | chlorofluorocarbon |
| CFL | compact fluorescent light |
| $CH_4$ | methane |
| CHP | combined heating and power |
| CMAQ | Congestion Mitigation and Air Quality |
| CNG | compressed natural gas |
| CNWG | Climate Neutral Working Group |
| $CO_2$ | carbon dioxide |
| $CO_2e$ | carbon dioxide equivalent |
| CVPS | Central Vermont Public Service |
| DEC | [Vermont] Department of Environmental Conservation |
| DMV | Department of Motor Vehicles |
| DPS | [Vermont] Department of Public Service |
| DSM | demand-side management |
| EEC | Energy Efficiency Charge |
| EEU | Energy Efficiency Utility |
| eGRID | Emissions & Generation Resource Integrated Database [US EPA] |
| EIA | Energy Information Administration [US DOE] |
| EPAct | Energy Policy Act of 2005 [US EPA] |
| ESD | Energy Supply and Demand [TWG] |
| FERC | Federal Energy Regulatory Commission |
| FFV | flex fuel vehicle |
| GCCC | Governor’s Commission on Climate Change |
| GHG | greenhouse gas |
| GIS | Generation Information System |
| GMAC | General Motors Acceptance Corporation |
| GPS | global positioning system |

| | |
|---|---|
| GT | geographically targeted |
| GVWR | gross vehicle weight rating |
| GWh | gigawatt-hours |
| GWP | global warming potential |
| HFC | hydrofluorocarbon |
| HVAC | heating, ventilation, and air conditioning |
| IECC | International Energy Conservation Code [US DOE] |
| INL | Idaho National Laboratory |
| IPCC | Intergovernmental Panel on Climate Change |
| ISO | Independent System Operator |
| kW | kilowatt |
| kWh | kilowatt-hour |
| LCFS | low-carbon fuel standard |
| LCIP | least-cost integrated plan |
| LDV | light-duty vehicle |
| LED | light-emitting diode |
| LPG | liquefied petroleum gas |
| M&V | measurement and valuation |
| MANE-VU | Mid-Atlantic–Northeast Visibility Union |
| MMt | million metric tons |
| $MMtCO_2e$ | million metric tons of carbon dioxide equivalents |
| Mt | metric ton |
| MW | megawatts |
| MWh | megawatt-hour |
| $N_2O$ | nitrous oxide |
| NEG-ECP | New England Governors and Eastern Canadian Premiers |
| NEPOOL | New England Power Pool |
| NGO | nongovernmental organization |
| NMP | nutrient management plan |
| NPV | net present value |
| NRC | Nuclear Regulatory Commission |
| NRCS | Natural Resource Conservation Service |
| NYSERDA | New York State Energy Research and Development Authority |
| O&M | operations and maintenance |
| ODS | ozone depleting substance |
| PAYD | pay-as-you-drive |
| PFC | perfluorocarbon |
| PG | Plenary Group |
| PIRG | Arizona Public Interest Research Group |
| PSB | [Vermont] Public Service Board |
| PV | photovoltaics |
| RCI | Residential, Commercial, and Industrial [TWG] |
| REC | renewable energy credit |
| RFF | Resources for the Future |
| RFS | renewable fuel standard |
| RGGI | Regional Greenhouse Gas Initiative |

| | |
|---|---|
| ROI | return on investment |
| RPS | renewable portfolio standard |
| $SF_6$ | sulfur hexafluoride |
| SOV | single-occupancy vehicle |
| SPEED | Sustainable Priced Energy Enterprise Development [Program] |
| T&D | transmission and distribution |
| TLU | Transportation and Land Use [TWG] |
| TMA | Transportation Management Association |
| TMO | Transportation Management Organization |
| TWG | Technical Work Group |
| US DOE | United States Department of Energy |
| US EPA | United States Environmental Protection Agency |
| UVM | University of Vermont |
| UVTMA | University of Vermont Transportation Management Association |
| V.S.A. | Vermont Statutes Annotated |
| VAOT | Vermont Agency of Transportation |
| VEDA | Vermont Economic Development Authority |
| VEIC | Vermont Energy Investment Corporation |
| VEPC | Vermont Economic Progress Council |
| VEPPI | Vermont Electric Power Producers, Inc. |
| VMT | vehicle miles traveled |
| VPIRG | Vermont Public Interest Research Group |
| VSPC | Vermont System Planning Committee |
| VTDEC | Vermont Department of Environmental Conservation |
| VTrans | Vermont Agency of Transportation |
| WWTP | water and wastewater treatment plan |

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# Chapter 1
# Background and Overview

Recognizing the profound implications that global warming and climate variation could have on the hardwood forests, agriculture, snowfall, tourist economy, environment, and quality of life in Vermont, Governor Jim Douglas signed Executive Order 07-05 on December 5, 2005, establishing the Governor's Commission on Climate Change (GCCC).[1] To reduce Vermont's greenhouse gas (GHG) emissions by 25% from 1990 levels by 2012, 50% by 2028, and 75% by 2050, if practicable, the Governor asked the GCCC to:

1. Examine the real and potential effects of climate change on Vermont, including but not limited to the impact of climate change on public health, natural resources, and the economy;

2. Produce an inventory of existing and planned actions that contribute to GHG emissions in Vermont;

3. Educate the public about climate change and develop educational tools that will help Vermonters understand how they, as individuals, can play a role in reducing GHG emissions;

4. Request input from representatives of the business, environmental, forestry, transportation, nonprofit, higher education, municipal, and other sectors regarding opportunities to reduce emissions and conserve energy; and

5. Develop recommendations to reduce GHG emissions in Vermont, consistent with Vermont's need for continued economic growth and energy security in the form of a Climate Change Action Plan.

The Governor's Executive Order also noted the scientific consensus on climate change as embodied by reports issued by the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences. Climate models indicate that global average temperatures could rise from 3 to 10 degrees Fahrenheit by the end of this century. The IPCC predicts that such warming would result in increased rainfall and heavy precipitation events (especially over the higher latitudes) and higher evaporation rates that would accelerate the drying of soils following heavy rain events. For Vermont, projected effects include a replacement of 30%–40% of maple hardwood forests by pine and oak trees, with corresponding impacts on fall foliage and maple sugaring. Patterns of snowfall and duration of snow cover are also expected to be affected. Regional and state impacts are harder to predict than large regional or global impacts, but existing regional modeling indicates that Vermont may experience more smog pollution due to warmer temperatures and greater spread of insects and diseases that find it easier to migrate and survive in warmer, wetter conditions.

[1] Appendix A contains the Governor's Executive Order.

## Vermont's Environmental Leadership

Vermont has long been an environmental leader among U.S. states, and climate change is no exception. Among the first efforts that the PG undertook was a review of numerous policies that Vermont has adopted either to reduce GHG emissions explicitly or which have the effect of reducing GHG emissions as a collateral benefit. Several of these policies have profound climate impacts, as shown by the emission reduction "wedges" illustrated in Figure 1.2.

Examples of Vermont's climate leadership include:

- The nation's most aggressive GHG reduction goals.
- New England Governors and Eastern Canadian Premiers (NEG-ECP) pioneering regional climate change targets.
- California Low-Emission Vehicle Standard (Cal LEV II) requiring substantial GHG reductions from automobiles.
- Regional GHG Initiative (RGGI), the Northeastern Governors' effort to reduce carbon dioxide ($CO_2$) emissions from electricity generation.
- Climate Neutral Working Group (CNWG), directing state agencies and departments to reduce GHG emissions from state buildings and operations.
- Efficiency Vermont, groundbreaking energy efficiency and demand-side management (DSM) programs, making Vermont among the highest ranking states in DSM expenditures per capita.
- Along with other Northeast states, Vermont has led in the development of a GHG registry. The wisdom of this initiative has spread across the nation, blossoming into *The Climate Registry*, a policy-neutral effort encompassing a vast majority of U.S. states, several Canadian provinces, and some Mexican states to assist, recognize, and encourage facilities to reduce GHG emissions. *The Climate Registry* is also likely to serve as the platform for future GHG cap and trade programs.
- Progressive land use policies.
- Pioneering rural mass transit approaches.
- "Cow Power" projects that work with dairy farmers to process their cow manure and farm waste to generate electricity.

## The Plenary Group Process

Following its first meeting in February 2006, the six-member GCCC recognized that its deliberations and work plan would benefit significantly from the involvement and input of Vermont stakeholders with a wide array of expertise and perspectives. The GCCC therefore selected, and the Governor approved, the establishment of a 31-member Plenary Group (PG) of Vermont citizens representing legislators, agriculture, forestry, energy, business, industry, transportation, education, public interest groups, and four state agencies. Through the Vermont Department of Environmental Conservation (DEC), the State selected the Center for Climate Strategies (CCS), a nonprofit organization with an extensive record of helping states develop comprehensive climate action plans, to facilitate a stakeholder-based process. Through this process the PG would identify, prioritize, evaluate, and quantify policy recommendations to reduce GHG emissions from all economic sectors for the GCCC's consideration. This report presents the results of the Plenary Group's effort.

The PG held its first meeting on September 7, 2006, followed by almost a year of intensive fact-finding, analysis, and consensus building. The PG met as a body seven times, concluding with its last meeting on July 26, 2007.[2] During this period, four subordinate, sector-based technical work groups (TWGs) also met for a total of approximately 40 times via teleconference and face-to-face meetings, beginning in September 2007 and concluding in July 2007. All PG and TWG meetings were open to the public, and opportunities to provide input were part of each meeting.

The four TWGs included Energy Supply and Demand (ESD); Transportation and Land Use (TLU); Agriculture, Forestry, and Waste Management (AFW); and Cross-Cutting Issues (CC). The TWGs included interested GCCC and PG members as well as other Vermont citizens with interest and expertise in the specific issues being addressed by each TWG.

The PG process adhered to a model of informed self-determination through a facilitated, stepwise, consensus-building approach. Under the oversight of the GCCC and with the coordination of the DEC, the PG process was conducted by CCS's independent, expert facilitation and technical analysis team. Procedures used in the process were based on those applied successfully by CCS in a number of state climate change planning initiatives since 2000; they were adapted specifically for Vermont.

During the course of its process, the PG reviewed and evaluated a) an inventory and projection of future GHG emissions for Vermont, b) specific policy options for reducing GHG emissions from all sectors, and c) findings related to quantified benefits and costs and feasibility issues associated with options. The PG process sought but did not mandate consensus. It explicitly established and documented the level of PG support for individual policy recommendations and key findings through a voting process among PG members and took note of barriers to consensus where they could not be resolved.

The policy options adopted by the PG—presented in this report as its recommendations for the GCCC's consideration—were developed through a structured, stepwise process. First, a full universe or "catalog" of potential policy options was considered by each TWG, which screened them to identify initial priority options for further analysis. TWGs then developed straw proposals for each of the priority options, defining them sufficiently to evaluate and quantify the GHG reductions that they would potentially achieve and the costs that would be incurred or savings that would be provided. Assisted by CCS's facilitation and technical analysis, the TWGs characterized each policy option using a "template" of key information:

- Policy description,
- Policy design (goals, timing, parties involved),
- Implementation mechanisms,
- Related policies and programs in place,

[2] Members of the GCCC participated in meetings of the PG but did not vote on its final policy recommendations.

- Types of GHG reductions,
- Estimated GHG reductions and costs,
- Key uncertainties,
- Additional benefits and costs,
- Feasibility issues,
- Status of group approval,
- Level of group support, and
- Barriers to consensus.

At each point in the stepwise policy option development process, the TWGs submitted their progress and direction to the PG to secure its explicit approval before proceeding to the next step. In its deliberations, the PG modified various policy options, and revisions and iterations to analyses followed as necessary. In the course of this structured, stepwise policy recommendation development process, significant detail and rigor characterizing the policy recommendations typically emerged as a result. The level of detail provided by the template above and its inclusion of specific attention to implementation and feasibility issues was intended to facilitate review of policy recommendations by the GCCC, and potential future approval by the Governor and, where new statutory authority is required, the General Assembly. It is important to note, however, that additional evaluation, modeling, and implementation considerations (e.g., standard notice and comment rule-making procedures) will be necessary in many cases before actual implementation can proceed.

At the conclusion of the process, the Plenary Group voted on each of the policy options brought forward by the TWGs. Only those options that received unanimous consent, a super-majority (i.e., no more than five objections), or a simple majority of the votes of the PG members were forwarded to the GCCC. A summary of the level of consensus of the PG is shown in Table 1.1. An overview of the PG's policy recommendations is provided in a later section of this chapter. Detailed discussion of the PG's policy recommendations appears in later chapters and the technical appendixes.

**Table 1-1. Level of consensus summary for PG policy recommendations to the GCCC**

| Technical Work Group | No. of Policy Options | Unanimous Consent | Super-Majority | Majority |
|---|---|---|---|---|
| Agriculture and Forestry and Waste | 12 | 12 | 0 | 0 |
| Energy Supply and Demand | 10 | 6 | 3 | 0 |
| Transportation and Land Use | 9 | 7 | 1 | 1 |
| Cross-Cutting Issues | 7 | 7 | 0 | 0 |
| **Total** | **38** | **32** | **4** | **1** |

*Note: One option was tabled, so the total votes only add to 37*

## Vermont GHG Emissions Inventory and Reference Case Projections

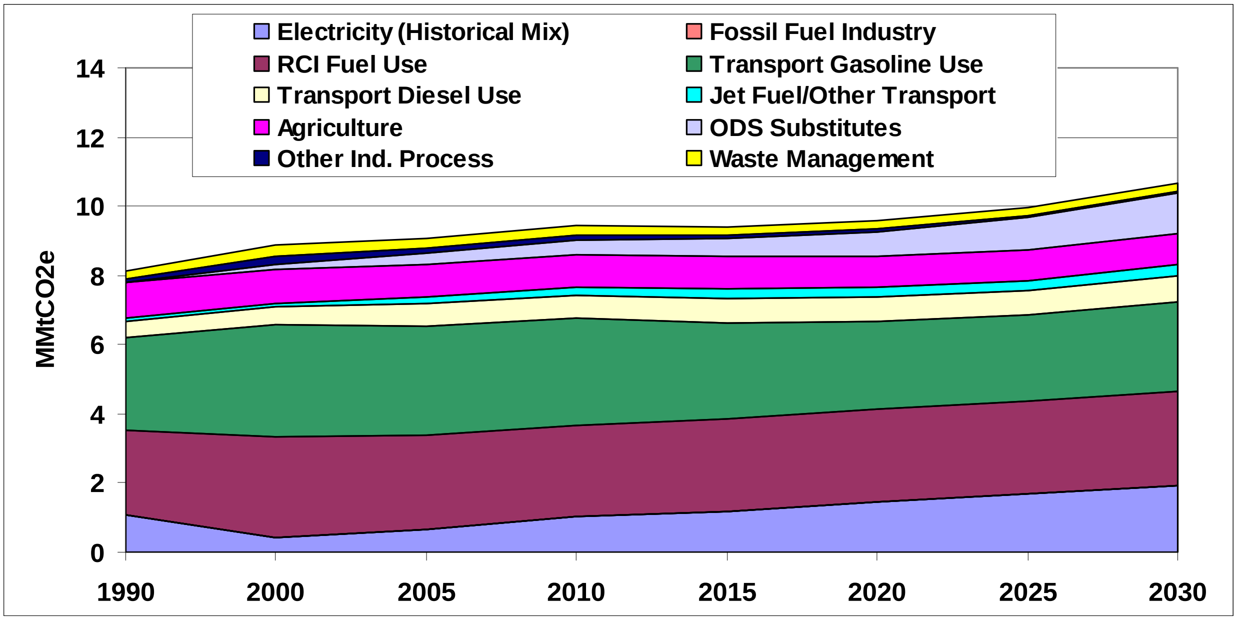
Consistent with the Governor's Executive Order and in cooperation with DEC, CCS prepared a draft document, titled *Vermont GHG Emissions Inventory and Reference Case Projections, 1990–2030* (hereafter *Inventory and Projections*). The emissions projection aimed to capture as accurately as possible the trajectory of Vermont's future emissions, given policies in place as of 2007. Draft results were presented to the PG at its first meeting. Modifications were made to the data, methods, and assumptions during the next several months based on input from state agencies, the TWGs, and others. The *Inventory and Projections* document was approved by the PG in May 2007. The *Inventory and Projections* document includes detailed coverage of all economic sectors and GHG emissions in Vermont, including future emissions trends and assessment issues related to energy, economic, and population growth. The assessment also includes these alternative approaches to quantifying State GHG emissions:

- The distinction between "gross emissions" (leaving aside sequestration) or "net emissions" (in which reductions due to sequestration are subtracted from gross emissions).
- The distinction between "consumption-based" vs. "production-based" accounting for GHG emissions.

The PG's efforts principally focused on gross GHG emissions evaluated on a consumption basis. A more detailed discussion of these issues and the development of Vermont's GHG emissions inventory and projections appears in Chapter 2.

The *Inventory and Projections* assessment reveals substantial emissions growth rates and related policy challenges. Figure 1-1 shows the reference projections for Vermont's gross GHG emissions as potentially increasing from 8.14 million metric tons of carbon dioxide equivalents ($MMtCO_2e$) in 1990 to 10.66 $MMtCO_2e$ in 2030, growing by 31% over that period. Figure 1-1 illustrates the breakdown of historic and forecasted GHG emissions by sector.

**Figure 1-1. Vermont gross GHG emissions by sector, 1990–2030: historic and projected (electricity supply low-emission scenario)**




RCI – Residential, Commercial and Industrial
ODS – Ozone Depleting Substances (which are also powerful greenhouse gases)

The inventory and projection of Vermont's GHG emissions highlights several critical findings, including

- Unlike in most states, electricity sector GHG emissions are not substantial in Vermont. The state has contracts for electricity from the Vermont Yankee nuclear facility and for hydroelectric power from Canada (HydroQuébec). Uncertainty prevails, however, about the State's electricity supply and its associated GHG emissions when these contracts expire in the next decade.
- Not surprisingly given Vermont's rural setting, Vermonters drive more miles than typical Americans. Emissions from transportation—especially from cars and light-duty trucks—account for between one third and one half of Vermont's total GHG emissions.

## Overview of the Plenary Group's Policy Recommendations

The PG's policy recommendations reflect 38 opportunities for the State to reduce its GHG emissions while continuing to grow economically by being more energy efficient, using more renewable energy sources, and increasing the use of cleaner transportation modes, technologies, and fuels. These recommendations are summarized in Tables 1-2 through 1-8. More detailed descriptions appear in subsequent chapters and the technical appendixes.

Tables 1-2 through 1-8 enumerate the sector-based policy recommendations approved by the PG and forwarded to the GCCC for consideration. For each policy option that the PG quantified, GHG emission reductions are presented in three timeframes: in 2012 (the near-term target date specified by the Governor and the General Assembly), in 2028 (the longer-term target date specified by the Governor and the General Assembly), and in cumulative GHG reductions between 2008 and 2028. For costs (or savings) cumulative net present value (NPV) of costs incurred and benefits achieved between 2008 and 2029, cost per ton of $CO_2e$ over the 2008–2028 period, and upfront present value costs for 2008, 2009, and 2010 are typically noted. Unless otherwise specified, GHG reductions are shown in $MMtCO_2e$, and costs or savings are indicated in millions of dollars. An exception is cost-per-ton (or savings-per-ton) figures, which are shown in dollars. Projected GHG reductions are calculated from the reference case scenario agreed to by the PG. Several policy options could not be quantified or the PG decided to not quantify some options for a variety of reasons.

## Agriculture, Forestry, and Waste Management

**Table 1-2. Agriculture, Forestry, and Waste Management summary list of policy options**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2007–2028 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2007–2028 | | | |
| AFW-1 | Programs to Support Local Farming/Buy Local | 0.00 | 0.02 | 0.20 | NQ* | NQ | Unanimous Consent |
| AFW-2 | Agricultural Nutrient Management Programs | 0.08 | 0.10 | 1.60 | $4 | $3 | Unanimous Consent |
| AFW-3 | Manure Management Methods to Achieve GHG Benefits | 0.01 | 0.02 | 0.30 | $34 | $136 | Unanimous Consent |
| AFW-4 | Protect Open Space/Agricultural land | 0.06 | 0.11 | 1.80 | $56 | $31 | Unanimous Consent |
| AFW-5 | Forestry Programs to Enhance GHG Benefits** | 0.03 | 0.12 | 1.30 | $4 | $3 | Unanimous Consent |
| AFW-6 | Increased Forest Biomass Energy Use | *Quantified under AFW-5 & ESD options* | | | | | Unanimous Consent |
| AFW-7 | Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover | 0.40 | 2.00 | 22.00 | $34 | $2 | Unanimous Consent |
| AFW-8 | Expanded Use of Durable Wood Products (especially from VT sources) | 0.09 | 0.05 | 1.40 | NQ | NQ | Unanimous Consent |
| AFW-9 | Advanced/Expanded Recycling and Composting | 0.16 | 0.88 | 9.10 | $37 | $4 | Unanimous Consent |
| AFW-10 | Programs to Reduce Waste Generation | 0.34 | 0.73 | 10.00 | NQ | NQ | Unanimous Consent |
| AFW-11 | Waste Water Treatment – Energy Efficiency Improvements | 0.00 | 0.01 | 0.14 | –$19 | –$133 | Unanimous Consent |
| AFW-12 | In-State Liquid Biofuels Production | | | | | | |
| | Ethanol Production | 0.03 | 0.42 | 3.7 | $5 | $1 | Unanimous Consent |
| | Biodiesel Production | 0.004 | 0.24 | 2.2 | $40 | $18 | Unanimous Consent |
| | **Sector Total After Adjusting for Overlaps** | **1.2** | **4.7** | **54.0** | **$190** | **$4** | |
| | **Reductions From Recent Actions (Table To Be Added Below)** | **0** | **0** | **0** | **0** | **0** | |
| | **Sector Total Plus Recent Actions** | **1.2** | **4.7** | **54.0** | **$190** | **$4** | |

* NQ – not quantified.

** These estimates based on the midpoint of results achieved using two different methods.

**Table 1-3. Agriculture, Forestry, and Waste Management policy options: present values of costs, benefits, net (NPV) and early-year upfront costs ($ millions)**

| | Policy Option | Costs 2008–2028 (A) | Benefits 2008–2028 (B) | NPV 2008–2028 (= A – B) | 2008 Upfront Costs | 2009 Upfront Costs | 2010 Upfront Costs |
|---|---|---|---|---|---|---|---|
| AFW-1 | Programs to Support Local Farming / Buy Local | NQ* | NQ | NQ | NQ | NQ | NQ |
| AFW-2 | Agricultural Soil Carbon Management Programs | $7 | $3 | $4 | $0.48 | $0.45 | $0.43 |
| AFW-3 | Manure Management Methods to Achieve GHG Benefits | $34 | $0 | $34 | $0.25 | $0.47 | $0.67 |
| AFW-4 | Protect Open Space / Agricultural Land | $56 | $0 | $56 | $0.61 | $1.17 | $1.67 |
| AFW-5 | Forestry Programs to Enhance GHG Benefits | $4 | $0 | $4 | $0.29 | $0.27 | $0.26 |
| AFW-6 | Increased Forest Biomass Energy Use | *Included in other forestry practices* | | | | | |
| AFW-7 | Forest Protection - Reduced Clearing and Conversion to Non-forest Cover | $34 | $0 | $34 | $0.27 | $0.51 | $0.73 |
| AFW-8 | Expanded Use of Durable Wood Products (especially from VT sources) | NQ | NQ | NQ | NQ | NQ | NQ |
| AFW-9 | Advanced / Expanded Recycling and Composting | | | $37 | $1.52 | $1.45 | $1.38 |
| AFW-10 | Programs to Reduce Waste Generation | NQ | NQ | NQ | NQ | NQ | NQ |
| AFW-11 | Waste Water Treatment - Energy Efficiency Improvements | | | –$19 | $0.01 | $0.01 | $0.01 |
| AFW-12 | In-State Liquid Biofuels Production | | | | | | |
| | (Ethanol Production) | $5 | $0 | $5 | $0.00 | $0.00 | $0.00 |
| | (Biodiesel Production) | $40 | $0 | $40 | $0.00 | $0.10 | $0.20 |

*NQ = not quantified.

## Energy Supply and Demand

### Table 1-4. Energy Supply and Demand summary list of policy options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| ESD-1 | Evaluation and Continuation/ Expansion of Existing DSM for Electricity and Natural Gas | 0.7 | 1.7 | 21.5 | –$850 | –$40 | Unanimous Consent |
| ESD-2 | Evaluation and Expansion of DSM to Other Fuels | 0.1 | 0.5 | 5.3 | –$335 | –$64 | Super-Majority |
| ESD-3 | Building Efficiency Codes, Training, Tracking | 0.02 | 0.2 | 2.0 | –$107 | –$55 | Unanimous Consent |
| ESD-4 | Evaluate Potential for Contracting Nuclear Power | | | | | | Super-Majority |
| | (Scenario 1) | 0.5 | 1.1 | 16.7 | –$140 | –$8 | |
| | (Scenario 2) | 0.3 | 0.7 | 10.2 | –$70 | –$7 | |
| ESD-5 | Support for Combined Heat and Power | 0.1 | 0.2 | 2.6 | –$86 | –$34 | Unanimous Consent |
| ESD-6 | Incentives and/or Mandate for Renewable Electricity | | | | | | Super-Majority |
| | (Scenario 1) | 0.1 | 0.4 | 5.4 | $9 | $2 | |
| | (Scenario 2) | 0.2 | 1.2 | 15.7 | $38 | $2 | |
| ESD-7 | GHG Cap & Trade and/or GHG Tax | *Referred to the GCCC as primarily a funding mechanism.* | | | | | |
| ESD-8 | Incentives for Clean Distributed Technologies for Electricity or Heat | | | | | | Unanimous Consent |
| | Natural Gas Fuel Switching | 0.1 | 0.1 | 2.2 | $15 | $7 | |
| | Solar Thermal Water Heating | 0.05 | 0.2 | 2.3 | $67 | $29 | |
| ESD-9 | Wind-Specific Support Measures | | | | | | Unanimous Consent |
| | (New Wind, Scenario 1) | 0.03 | 0.2 | 2.1 | –$6 | –$3 | |
| | (New Wind, Scenario 2) | 0.1 | 0.5 | 6.3 | $10 | $2 | |
| ESD-10 | Hydro-Specific Support Measures | | | | | | Unanimous Consent |
| | (Continued Large Hydro, Scenario 1) | 0.02 | 1.1 | 14.9 | $0 | $0 | |
| | (Continued Large Hydro, Scenario 2) | 0.01 | 0.6 | 8.7 | $0 | $0 | |
| | (New Hydro, Scenario 1) | 0.01 | 0.06 | 0.8 | –$22 | –$27 | |
| | (New Hydro, Scenario 2) | 0.03 | 0.2 | 2.4 | –$64 | –$27 | |
| | **Total** | | | | | | |
| | **Scenario 1 (Generation of Nuclear and Hydro at Historic Levels)** | **1.56** | **5.48** | **72.75** | **–$1,427** | **–$20** | |
| | **Scenario 2 (Generation of Nuclear and Hydro at 50% of Historic Levels)** | **1.56** | **5.37** | **70.35** | **–$1,328** | **–$19** | |

Note: Positive numbers for Net Present Value (NPV) and Cost-Effectiveness reflect net costs. Negative numbers reflect net cost savings**.**

**Table 1-5. Energy Supply and Demand policy options: present values of costs, benefits, net (NPV) and early-year upfront costs ($ millions)**

| Policy Option | | Costs 2008–2028 (A) | Benefits 2008–2028 (B) | NPV 2008–2028 ( = A – B) | 2008 Upfront Costs | 2009 Upfront Costs | 2010 Upfront Costs |
|---|---|---|---|---|---|---|---|
| ESD-1 | Evaluation and continuation / expansion of existing DSM for electricity and natural gas | $562 | $1,602 | –$1,041 | $14.62 | $25.21 | $34.79 |
| ESD-2 | Evaluation and expansion of DSM to Other Fuels | $200 | $504 | –$304 | $0 | $2.24 | $4.42 |
| ESD-3 | Building Efficiency Codes, Training, Tracking | $70 | $177 | –$107 | $0 | $0.02 | $0.38 |
| ESD-4 | Evaluate Potential for Contracting Nuclear Power | | | | | | |
| | (Scenario 1) | $1,504 | $1,644 | –$140 | $0 | $0 | $0 |
| | (Scenario 2) | $752 | $822 | –$70 | $0 | $0 | $0 |
| ESD-5 | Support for Combined Heat and Power | $205 | $310 | –$105 | $1.90 | $3.80 | $5.71 |
| ESD-6 | Incentives and/or Mandate for Renewable Electricity | | | | | | |
| | (Scenario 1) | $398 | $390 | $9 | $3.22 | $9.15 | $12.23 |
| | (Scenario 2) | $1,170 | $1,132 | $38 | $9.00 | $21.10 | $30.72 |
| ESD-7 | GHG Cap & Trade and/or GHG tax | *Referred to the GCCC.* | | | | | |
| ESD-8 | Incentives for Clean Distributed Technologies for Electricity or Heat | | | | | | |
| | Natural Gas fuel switching | $1,037 | $1,022 | $15 | $34.51 | $44.93 | $54.40 |
| | Solar thermal water heating | $219 | $151 | $67 | $1.64 | $3.30 | $5.01 |
| ESD-9 | Wind–specific support measures | | | | | | |
| | (New wind, scenario 1) | $150 | $156 | –$6 | $0.64 | $1.86 | $2.55 |
| | (New wind, scenario 2) | $463 | $453 | $10 | $1.79 | $4.34 | $6.54 |
| ESD-10 | Hydro–specific support measures | | | | | | |
| | (Continued large hydro, Scenario 1) | $0 | $0 | $0 | | | |
| | (Continued large hydro, Scenario 2) | $0 | $0 | $0 | | | |
| | (New hydro, Scenario 1) | $36 | $58 | –$22 | $0.14 | $0.42 | $0.57 |
| | (New hydro, Scenario 2) | $106 | $170 | –$64 | $0.40 | $0.96 | $1.43 |

## Transportation and Land Use

### Table 1-6. Transportation and Land Use summary list of policy options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2028 (Million $) | Cost-Effectiveness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| TLU-1 | Compact and Transit-Oriented Development Bundle | 0.26 | 0.99 | 10.88 | Net savings | | Unanimous Consent |
| TLU-2 | Alternatives to Single Occupancy Vehicles (SOVs) | 0.28 | 0.32 | 6.57 | Net savings | | Unanimous Consent |
| TLU-3 | Vehicle Emissions Reductions Incentives | 0.11 | 0.63 | 7.73 | –$42 | –$10 | Majority |
| TLU-4 | Pay as You Drive Insurance | 0.20 | 0.32 | 5.30 | Net savings | | Super–Majority |
| TLU-5 | Alternative Fuels and Infrastructure (LCFS) | 0.12 | 0.42 | 5.75 | NA | | Unanimous Consent |
| TLU-6 | Regional Intermodal Transportation System – Freight and Passenger | 0.05 | 0.20 | 2.22 | NA | | Unanimous Consent |
| TLU-7 | Commuter Choice/Parking Cash-out | 0.06 | 0.19 | 1.86 | –$1 | –$1 | Unanimous Consent |
| TLU-8 | Plug-in Hybrids [part of TLU-5] | – | – | – | – | | Unanimous Consent |
| TLU-9 | Fuel Tax Funding Mechanism [TWG recommends examining as part of a funding package after reductions policies are chosen] | – | – | – | – | | Unanimous Consent |
| | **Sector Total Before Adjusting for Overlaps** | **1.09** | **3.07** | **40.31** | **NA** | **NA** | |
| | **Reductions From Recent Policy Actions** | | | | | | |
| | **Sector Total Plus Recent Policy Actions** | **1.09** | **3.07** | **40.31** | **NA** | **NA** | |

### Table 1-7. Transportation and Land Use policy options: present values of costs, benefits, net (NPV) and early-year upfront costs ($ millions)

| Policy Option | | Costs 2008–2028 (A) | Benefits 2008–2028 (B) | NPV 2008–2028 ( = A – B) | 2008 Upfront Costs | 2009 Upfront Costs | 2010 Upfront Costs |
|---|---|---|---|---|---|---|---|
| TLU-3 | Vehicle Emissions Reductions Incentives | $6 | $77 | –$38 | $0.30 | $0.30 | $0.30 |
| TLU-7 | Commuter Choice/Parking Cash–out | $540 | $647 | –$69 | $1.29 | $1.29 | $1.29 |

## Cross-Cutting Issues

**Table 1-8. Cross-Cutting Issues summary list of policy options**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2028 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| CC-1 | GHG Inventories and Forecasts | *Not quantified* | | | | | Unanimous Consent |
| CC-2 | GHG Reporting | *Not quantified* | | | | | Unanimous Consent |
| CC-3 | GHG Registry | *Not quantified* | | | | | Unanimous Consent |
| CC-4 | Public Education and Outreach | *Not quantified* | | | | | Unanimous Consent |
| CC-5 | Adaptation | *Not quantified* | | | | | Unanimous Consent |
| CC-6 | Options for Goals or Targets | *Not quantified* | | | | | Unanimous Consent |
| CC-7 | The State's Own GHG Emissions | *Not quantified* | | | | | Unanimous Consent |
| | **Sector Total After Adjusting for Overlaps** | | | | | | |
| | **Reductions From Recent Policy Actions** | | | | | | |
| | **Sector Total Plus Recent Policy Actions** | | | | | | |

Table 1-9 reflects an approximation of relative reductions by sector or TWG. This table demonstrates that the Energy Supply and Demand sector and the Transportation and Land Use sector performed comparably well in reducing emissions from the reference case baseline. Agriculture, Forestry, and Waste Management policy options are shown as capable of supplying significant additional amounts of sequestered (stored) carbon, potentially reducing sector emissions far below projected GHG emissions levels.

### Table 1-9. Vermont PG policy options: relative reductions by sector

| Sector (All values in $MMtCO_2e$) 2030 Data from I&F 5/28/07, Table ES-1 | 2030 | Estimated 2028 | PG Reductions for Sector | Remaining GHG Emissions From Sector | GHG Reduction in Sector (from BAU*) |
|---|---|---|---|---|---|
| Electricity consumption—(low emissions, no new DSM) | 1.91 | 1.86 | | | |
| Residential, commercial, industrial | 2.72 | 2.64 | | | |
| Fossil fuel industry | 0.03 | 0.03 | | | |
| Industrial process | 1.24 | 1.21 | | | |
| Sector total | 5.90 | 5.73 | 3.37 | 2.36 | 58.8% |
| Transportation | 3.64 | 3.54 | | | |
| Sector total | 3.64 | 3.54 | 2.10 | 1.44 | 59.4% |
| Waste | 0.23 | 0.22 | | | |
| Agriculture | 0.90 | 0.87 | | | |
| Sector total | 1.13 | 1.10 | 4.70** | -3.60 | 428% |
| **Overall totals** | **10.67** | **10.37** | **10.17** | **0.20** | **98.1%** |

* BAU = business-as-usual

** AFW carbon reductions greater than emissions are accomplished through sequestration.

Figure 1-2 shows the amount of GHG emissions reductions achievable under each individual, quantified policy option cumulatively from 2007–2020, ranked by GHG reduction potential. GHG emissions reduction potential could be quantified for 29 of the 38 policy options recommended by the PG.

**Figure 1-2. Policy recommendations by quantified GHG reduction, 2007–2020**

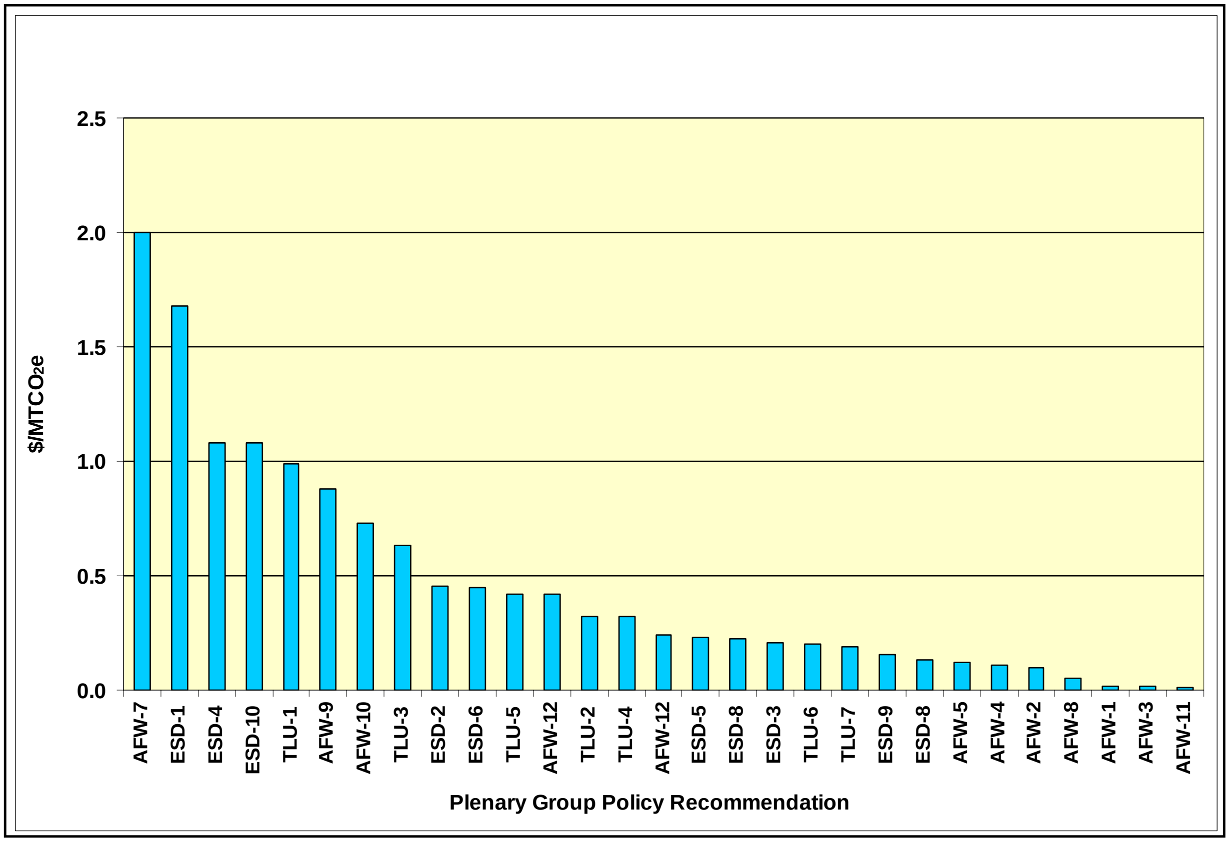


Figure 1-3 ranks the PG's recommended policy options by levelized cost or savings per ton of GHG removed on an NPV basis over the period 2007–2020. Savings are shown dropping below the zero axis line; costs rise above the axis.

**Figure 1-3. Policy recommendations by quantified cost-per-ton GHG removed**

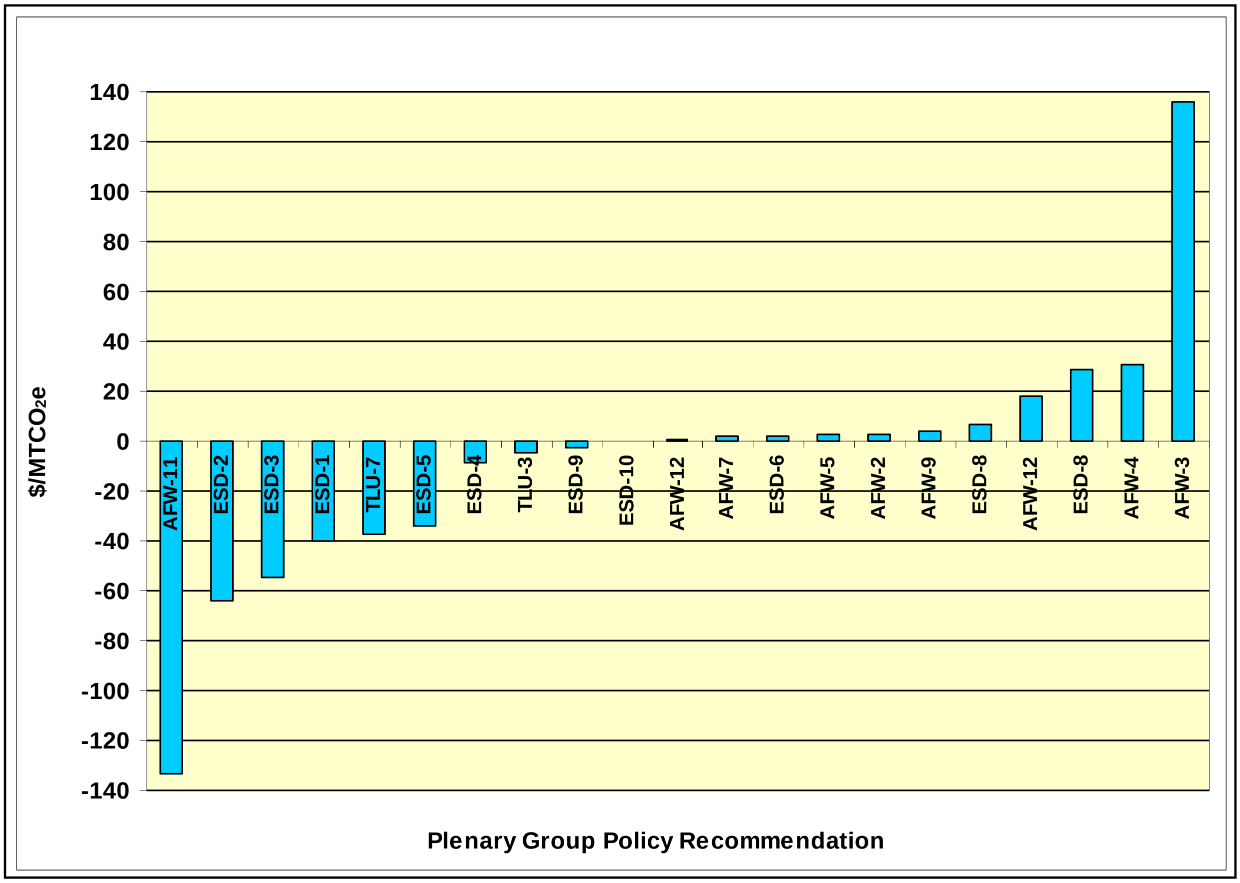
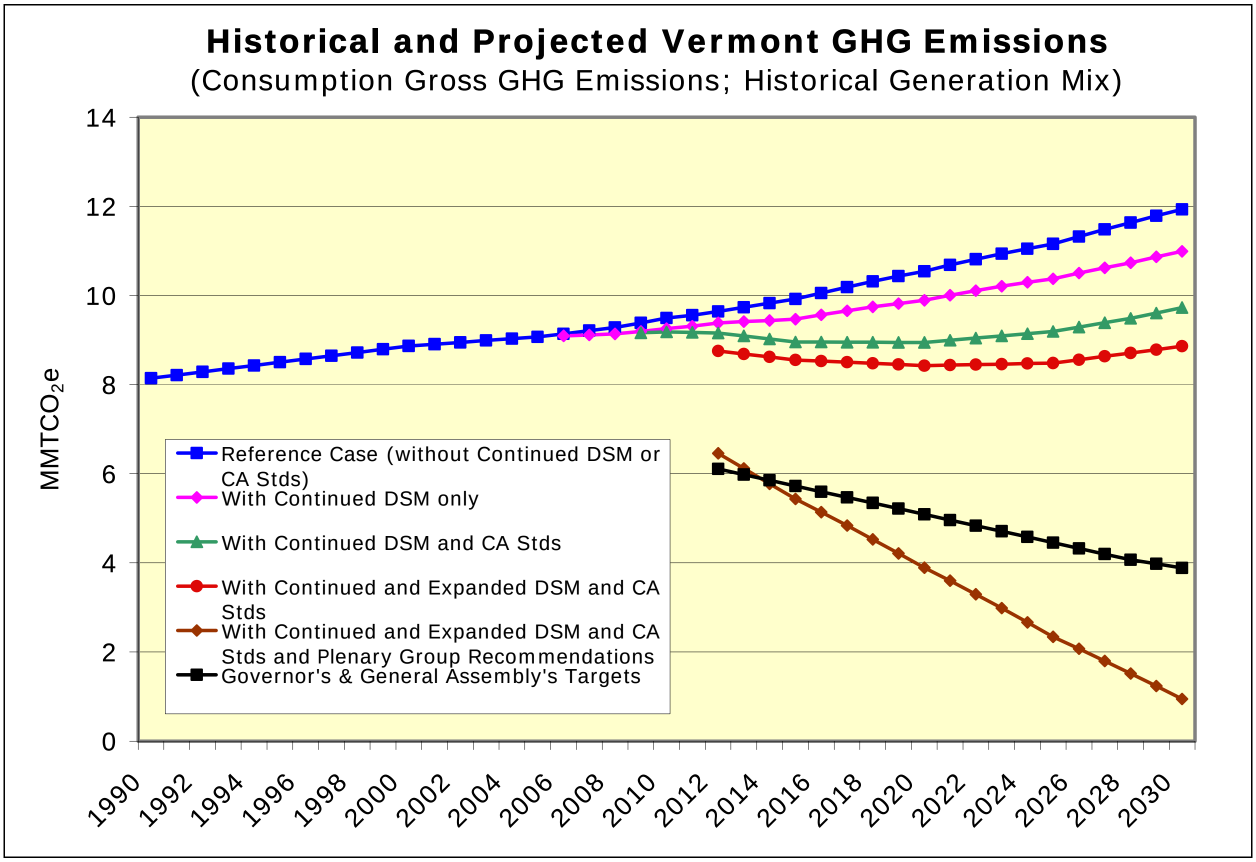


Figure 1-4 reflects projected Vermont GHG emissions as measured on a gross consumption basis, assuming that historical electricity generation levels continue to be provided by the Vermont Yankee nuclear power plant and from HydroQuébec. As illustrated, Vermont's reference case GHG emissions stand to be dramatically reduced through continuation and/or implementation of policies that the state has already adopted (e.g., DSM and California vehicle emission standards). Achieving Vermont's aggressive emissions goals, however, will require additional measures, such as those recommended by the PG. Collectively, with the emissions-reducing policies that Vermont has already adopted, the PG's policy options come very close to the Governor's and General Assembly's aggressive near-term target (within 6%) and substantially exceed the longer-term target. In fact, aggressive carbon sequestration provided by the Agriculture, Forestry, and Waste Management policy options could enable Vermont to approach near-zero GHG emissions or "carbon-neutral" status.

**Figure 1-4. Historical and projected Vermont GHG emissions: state leadership actions, goals, and PG policy recommendation results**



The PG's policy recommendations complement the numerous climate-related efforts underway in Vermont outlined at the beginning of this chapter, underscoring the potential co-benefits of their implementation.

Meeting Vermont's near-term reduction goal will require that the policy options receive further analysis, development, and authorization where necessary (legislative and/or regulatory), and that implementation to the extent possible of recommended policy options proceeds on a prompt and energetic basis. Meeting longer-term goals will require a consistent commitment by successive governors and legislatures, aided by an equal commitment by all stakeholders.

Chapters 3 through 6 and the technical appendixes provide detailed descriptions and analysis of GHG reductions, costs, additional impacts, and feasibility for individual policy options developed by the PG's four TWGs:

- Agriculture and Forestry (AFW)
- Energy Supply and Demand (ESD)
- Transportation and Land Use (TLU)
- Cross-Cutting Issues (CC)

# Chapter 2
# Inventory and Projections of GHG Emissions

## Introduction

This chapter presents a summary of Vermont's greenhouse gas (GHG) emissions resulting from a variety of human endeavors and sinks (carbon storage) from 1990 to 2030. The Center for Climate Strategies (CCS) prepared a draft of Vermont's GHG emissions inventory and reference case projections under contract to the Vermont Department of Environmental Conservation (VTDEC).[1] The draft inventory and reference case projections, completed in May 2007, provided VTDEC with an initial, comprehensive understanding of current and possible future GHG emissions. The draft report was provided to the Plenary Group (and its Technical Work Groups [TWGs]) to assist the Plenary Group in understanding past, current, and possible future GHG emissions in Vermont and thereby inform the mitigation option development process. The VTDEC, Department of Public Service (DPS), Vermont Agency of Transportation (VTrans), as well as members of the Plenary Group and the TWGs provided comments and data specific to Vermont that was used in developing the draft report. Subsequently, the reference case projections report was revised in September 2007 to include emissions reductions associated with the effects of California's light-duty vehicle GHG standards, adopted by Vermont in 2005. In addition, as recommended by the United States Forest Service (USFS), the forest soil organic carbon was removed from the forest sink pool decreasing overall forest carbon sink emissions by –0.7 $MMtCO_2e$ for 1990 through 2020. The information in this chapter reflects the information presented in the final inventory and reference case projections report (hereafter referred to as the *Inventory and Projections*).[2]

Historical GHG emissions estimates (1990 through 2005)[3] were developed using a set of generally accepted principles and guidelines for State GHG emissions inventories, relying to the extent possible on Vermont-specific data and inputs. The reference case projections (2006–2030) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the final *Inventory and Projections* report.

The *Inventory and Projections* covers the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$). Emissions of these GHGs are presented using a common metric, $CO_2$ equivalence ($CO_2e$), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis.[4]

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[1] *Draft Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990–2030,* prepared by the Center for Climate Strategies for VTDEC, May 2007.

[2] *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 199–-2030*, prepared by the Center for Climate Strategies for VTDEC, September 2007.

[3] The last year of available historical data for each sector varies between 2000 and 2005.

[4] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple

It is important to note that the emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Vermont's demands,* corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the State.* The study covers both methods of accounting for emissions, but for consistency, all total results are reported as *consumption-based.*

The *consumption-based* approach can better reflect the emissions (and emissions reductions) associated with activities occurring in the State, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for policy making. Under this approach, emissions associated with electricity exported to other States would need to be covered in those States' accounts in order to avoid double counting or exclusions.

## Vermont GHG Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for Vermont by sector for the years 1990, 2000, 2005, 2010, 2020, and 2030. The following sections discuss GHG emission sources (positive, or *gross*, emissions) and sinks (removal of emissions, or negative emissions) separately in order to identify trends, projections, and uncertainties clearly for each.

Based on the historical emissions provided in Table 2-1, the transportation and the residential, commercial, and industrial (RCI) sectors together have accounted for about 70% of Vermont's total gross GHG emissions from 1990 through 2005. However, future emissions associated with the electricity supply sector could increase significantly depending on how Vermont decides to fill the looming electricity supply gap that is expected to begin in 2012 when its existing contracts with a nuclear power plant (Entergy–Vermont Yankee) and a hydroelectric plant (Hydro-Québec) begin to phase out.

For the purpose of this analysis, we have estimated emissions separately for a "high-emission" and a "low-emission" scenario. Both scenarios have the same emissions from 1990 through 2011. However, after 2011, the high-emission scenario assumes that Vermont will purchase electricity from the New England power system to fill its electricity supply gap, and the low-emission scenario assumes that Vermont will fill its electricity supply gap with electricity generated from a fuel mix that is similar in GHG emissions to its historical fuel mix. VT DPS's forecast for electricity demand was used for both scenarios. In addition, VT DPS has estimated the benefits associated with continuing demand-side management (DSM) programs in existence in 2006 through the 2030 forecast period.[5] For this analysis, the benefits associated with continuing existing DSM programs were also estimated for each of the two scenarios. Table 2-1 shows the emissions for both the high- and low-emission scenarios with and without continuing

measure of changes in the energy available to the Earth-atmosphere system (IPCC, 1996). Holding everything else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth), http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm

[5] Vermont's DSM programs are currently carried out through a contract arrangement with Vermont Efficiency, and this contract arrangement ends in 2008. The DPS prepared two forecasts with one assuming that DSM programs similar to those being implemented through the Vermont Efficiency contract will be continued into the future and the other assuming that the existing DSM programs are discontinued after 2008.

## Table 2-1. Vermont historical and reference case GHG emissions, by sector*

| $MMtCO_2e$ | 1990 | 2000 | 2005 | 2010 | 2020 | 2030 | Explanatory Notes for Projections |
|---|---|---|---|---|---|---|---|
| **Electricity consumption (high-emission scenario, without continued DSM)** | **1.09** | **0.43** | **0.64** | **1.02** | **3.63** | **4.12** | See electricity sector assumptions in Inventory and Forecast Report, Appendix A |
| **Electricity consumption (low-emission scenario, without continued DSM)** | **1.09** | **0.43** | **0.64** | **1.02** | **1.44** | **1.91** | |
| **Electricity consumption (high-emission scenario, with continued DSM)** | **1.09** | **0.43** | **0.64** | **0.78** | **2.98** | **3.18** | |
| **Electricity consumption (low-emission scenario, with continued DSM)** | **1.09** | **0.43** | **0.64** | **0.78** | **0.79** | **0.97** | |
| Coal | 0 | 0 | 0 | 0 | 0 | 0 | |
| Natural gas | 0.047 | 0.018 | 0 | 0 | 0 | 0 | |
| Oil | 0.014 | 0.058 | 0.011 | 0 | 0 | 0 | |
| Wood ($CH_4$ and $N_2O$) | 0.003 | 0.009 | 0.009 | 0.009 | 0.005 | 0.005 | |
| Net imported electricity | 1.03 | 0.06 | 0.06 | 0 | 0 | 0 | |
| System purchases (high-emissions scenario, without continued DSM) | 0 | 0.29 | 0.56 | 1.01 | 3.63 | 4.12 | |
| System purchases (high-emissions scenario, with continued DSM) | 0 | 0.29 | 0.56 | 0.77 | 2.97 | 3.18 | |
| Historical mix (low-emissions scenario, without continued DSM) | 0 | 0.29 | 0.56 | 1.01 | 1.44 | 1.91 | |
| Historical mix (low-emissions scenario, with continued DSM) | 0 | 0.29 | 0.56 | 0.77 | 0.79 | 0.97 | |
| **Residential/commercial/industrial (RCI) fuel use** | **2.43** | **2.88** | **2.71** | **2.62** | **2.66** | **2.72** | |
| Coal | 0.02 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | Based on US DOE regional projections |
| Natural gas | 0.31 | 0.5 | 0.44 | 0.46 | 0.53 | 0.61 | |
| Oil | 2.06 | 2.34 | 2.24 | 2.12 | 2.1 | 2.07 | |
| Wood ($CH_4$ and $N_2O$) | 0.05 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | |
| **Transportation** | **3.22** | **3.88** | **4.02** | **4.01** | **3.52** | **3.64** | |
| Motor gasoline (not including CA standards) | 2.67 | 3.25 | 3.15 | 3.16 | 3.46 | 3.78 | Based on VTrans VMT projections |
| *CA Standards reductions–gasoline* | 0 | 0 | 0 | –0.07 | –0.9 | –1.19 | |
| Diesel (not including CA standards) | 0.45 | 0.54 | 0.67 | 0.70 | 0.75 | 0.83 | Based on VTrans VMT projections |
| *CA Standards reductions–diesel* | 0 | 0 | 0 | 0 | –0.05 | –0.07 | |
| Natural gas, LPG, other | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | Based on US DOE regional projections |
| Jet fuel and aviation gasoline | 0.08 | 0.07 | 0.17 | 0.2 | 0.24 | 0.26 | Based on VTrans aircraft operations projections |
| **Fossil fuel industry** | **0.01** | **0.01** | **0.014** | **0.02** | **0.02** | **0.03** | |
| Natural gas transmission | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | Based on historic trends |
| Natural gas distribution | 0.011 | 0.011 | 0.013 | 0.015 | 0.02 | 0.027 | Based on VT DPS growth estimate |
| **Industrial Processes** | **0.12** | **0.39** | **0.44** | **0.53** | **0.78** | **1.24** | |
| ODS substitutes (HFC and PFC) | 0 | 0.16 | 0.28 | 0.41 | 0.7 | 1.17 | US EPA 2004 ODS cost study report |
| Electric utilities ($SF_6$) | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | Based on US EPA national projections |

| $MMtCO_2e$ | 1990 | 2000 | 2005 | 2010 | 2020 | 2030 | Explanatory Notes for Projections |
|---|---|---|---|---|---|---|---|
| Semiconductor manufacturing (HFC, PFC, and $SF_6$) | 0.07 | 0.17 | 0.11 | 0.07 | 0.04 | 0.03 | Based on US EPA national projections |
| Limestone and dolomite use ($CO_2$) | 0 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | Based on VT manufacturing employment growth |
| Soda ash ($CO_2$) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | Based on 2004 and 2009 projections for US production |
| **Waste Management** | **0.24** | **0.31** | **0.29** | **0.28** | **0.25** | **0.23** | |
| Solid waste management | 0.18 | 0.25 | 0.22 | 0.21 | 0.17 | 0.15 | Primarily based on population |
| Wastewater management | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.08 | Based on population |
| **Agriculture** | **1.02** | **0.96** | **0.96** | **0.94** | **0.92** | **0.9** | |
| Enteric fermentation | 0.52 | 0.5 | 0.48 | 0.47 | 0.46 | 0.44 | Based on USDA livestock projections |
| Manure management | 0.13 | 0.14 | 0.14 | 0.13 | 0.13 | 0.12 | |
| Agricultural soils | 0.38 | 0.32 | 0.34 | 0.34 | 0.34 | 0.34 | Held constant at 2002 levels |
| **Total gross emissions (high-emission scenario, without continued DSM)** | **8.14** | **8.87** | **9.07** | **9.42** | **11.78** | **12.88** | |
| *Increase relative to 1990* | | 9% | 11% | 16% | 45% | 58% | |
| **Total gross emissions (low-emission scenario, without continued DSM)** | **8.14** | **8.87** | **9.07** | **9.42** | **9.60** | **10.67** | |
| *Increase relative to 1990* | | 9% | 11% | 16% | 18% | 31% | |
| **Total gross emissions (high-emission scenario, with continued DSM)** | **8.14** | **8.87** | **9.07** | **9.18** | **11.13** | **11.94** | |
| *Increase relative to 1990* | | 9% | 11% | 13% | 37% | 47% | |
| **Total gross emissions (low-emission scenario, with continued DSM)** | **8.14** | **8.87** | **9.07** | **9.18** | **8.95** | **9.73** | |
| *Increase relative to 1990* | | 9% | 11% | 13% | 10% | 19% | |
| **Forestry and land use**** | **–9.0** | **–9.0** | **–9.0** | **–9.0** | **–9.0** | **–9.0** | Emissions held constant at 2004 levels. |
| **Agricultural soils** | **–0.19** | **–0.19** | **–0.19** | **–0.19** | **–0.19** | **–0.19** | Emissions held constant at 1997 levels. |
| **Net emissions (high-emission scenario, without continued DSM)** | **–1.05** | **–0.32** | **–0.12** | **–0.23** | **1.92** | **3.01** | |
| **Net emissions (low-emission scenario, without continued DSM)** | **–1.05** | **–0.32** | **–0.12** | **–0.23** | **–0.27** | **0.8** | |
| **Net emissions (high-emission scenario, with continued DSM)** | **–1.05** | **–0.32** | **–0.12** | **–0.01** | **1.27** | **2.07** | |
| **Net emissions (low-emission scenario, with continued DSM)** | **–1.05** | **–0.32** | **–0.12** | **–0.01** | **–0.92** | **–0.14** | |

*Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

**Per the advise of the USFS, organic soil carbon sinks (–0.7 $MMtCO_2e$) are excluded due to the uncertainty associated with the estimate for this category.

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents; DSM = demand-side management; $CH_4$ = methane; $N_2O$ = nitrous oxide; US DOE = United States Department of Energy; CA = California; VTrans = Vermont Agency of Transportation; VMT = vehicle miles traveled; LPG = liquid petroleum gas; VT DPS = Vermont Department of Public Service; ODS = ozone-depleting substance; HFC = hydrofluorocarbon; PFC = perfluorocarbon; $SF_6$ = sulfur hexafluoride; US EPA = United States Environmental Protection Agency.

existing DSM programs for the electricity supply sector. Continuation of the DSM programs could lower gross emissions associated with the low-emissions scenario by about 45% by 2020 and 49% by 2030. Under the high-emissions scenario, continuation of existing DSM programs could lower gross emissions by about 18% by 2020 and 23% by 2030.

The reference case projections include the effect of Vermont's adoption of California's (CA's) light-duty vehicle GHG standards. The reductions from this program are itemized in Table 2-1.

For 1990 through 2011, Vermont's net GHG emissions are negative—in other words, the GHG emissions removed from the atmosphere by forests, soils, and other land uses (i.e., carbon sinks) were estimated to be greater than the GHG emissions generated in the State from fossil fuel combustion and other activities. For 2012 through 2030, Vermont's net GHG emissions exceed its carbon sinks under both the low- and the high-emission scenarios without continuing existing DSM programs. However, the forecast suggests that continuing existing DSM programs could result in carbon sinks continuing to exceed emissions under the high-emission scenario through 2020 and under the low-emission scenario through 2030.

Emissions of aerosols, particularly "black carbon" (BC) from fossil fuel combustion, could have significant climate impacts through their effects on radiative forcing. Estimates of these aerosol emissions on a $CO_2e$ basis were developed for Vermont on the basis of 2002 and 2018 emissions data from the Mid-Atlantic–Northeast Visibility Union (MANE-VU) regional planning organization and other sources. The results for current (2002) levels of BC emissions were a total of 0.65 million metric tons (MMt) on a $CO_2e$ basis, which is the midpoint of a range of estimated emissions (0.4–0.9 $MMtCO_2e$). On the basis of an assessment of the primary contributors, it is estimated that BC emissions will decrease substantially by 2018 after new federal engine and fuel standards take effect in the on-road and non-road diesel engine sectors (decrease of about 0.24 $MMtCO_2e$ per year). These estimates are not incorporated into the totals shown in Table 2-1 because a GWP for BC has not yet been assigned by the Intergovernmental Panel on Climate Change (IPCC).

## Historical Emissions

In 2005, on a gross emissions consumption basis (i.e., excluding carbon sinks), Vermont accounted for approximately 9.1 $MMtCO_2e$ emissions, an amount equal to 0.12% of total U.S. gross GHG emissions.[6] Vermont's gross GHG emissions are rising at a somewhat slower rate than those of the nation as a whole.[7] From 1990 to 2005, Vermont's gross GHG emissions increased by 11%, while national emissions rose by 16% during this period.

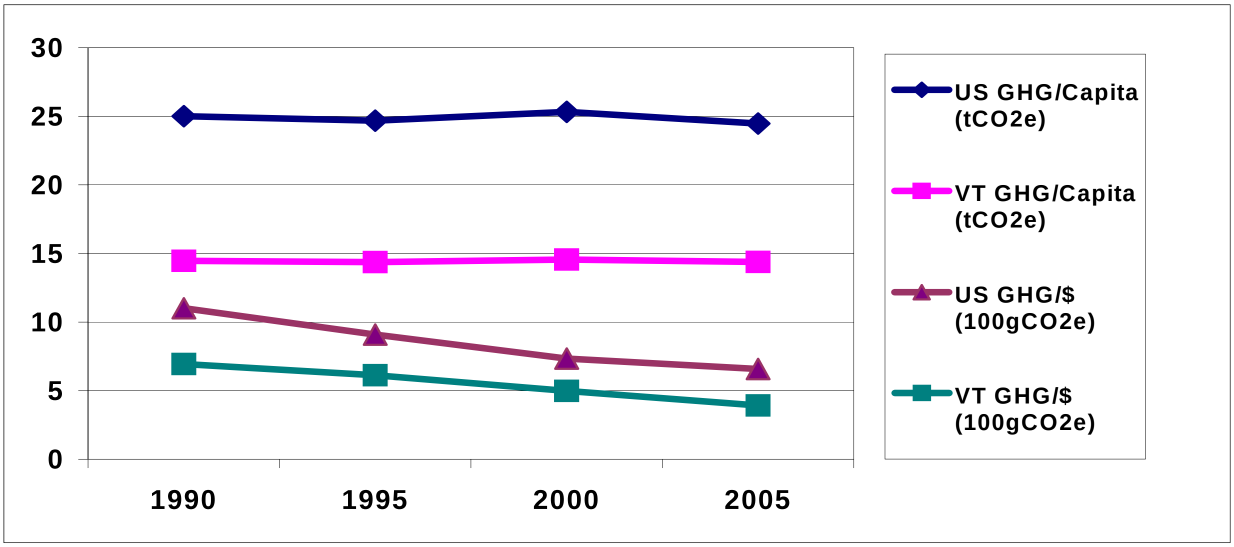
On a per capita gross emissions basis, Vermonters emit about 14 $MtCO_2e$, which is 44% lower than the national average of 25 $MtCO_2e$. Figure 2-1 illustrates the State's emissions per capita

[6] National emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2005*, April 2007, US EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html

[7] *Gross* emissions estimates include only those sources with positive emissions. Carbon sequestration in soils and vegetation is included in *net* emissions estimates. All emissions reported in this section for Vermont reflect consumption-based accounting (including emissions associated with electricity generated in-state and imported electricity). On a national basis, little difference exists between *production-based* and *consumption-based* accounting for GHG emissions because net electricity imports are less than 1% of national electricity generation.

and per unit of economic output. It also shows that, like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990–2004 period. From 1990 to 2004, emissions per unit of gross product dropped by 40% nationally and by 44% in Vermont.

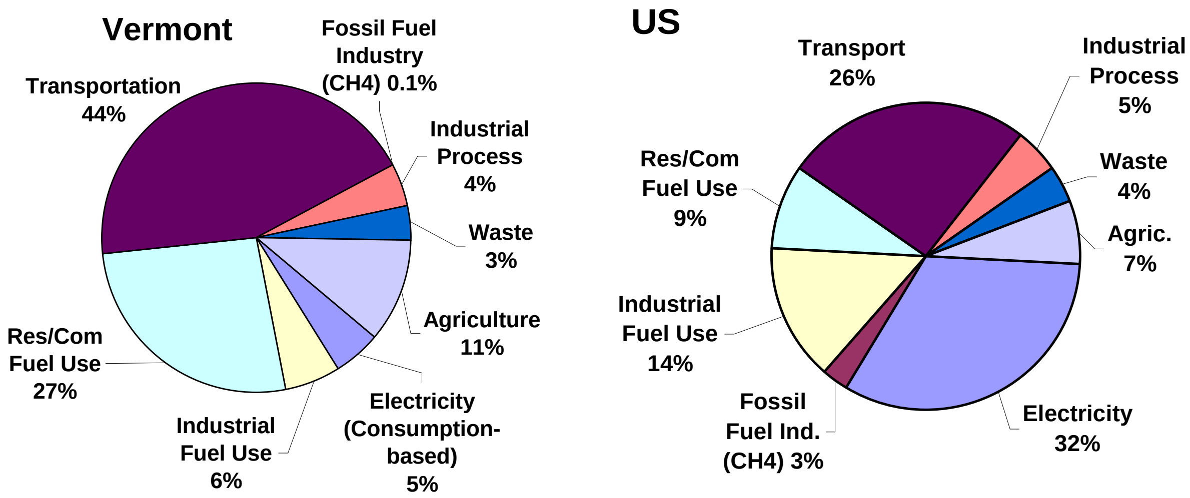
**Figure 2-1. Historical Vermont and US gross GHG emissions, per capita and per unit gross product**




Transportation and use of fossil fuels—natural gas, oil products, and coal—in the RCI sectors historically have been the State's principal sources of GHG emissions. In 2000, the combustion of fossil fuels by the transportation and RCI sectors accounted for 44% and 33%, respectively, of Vermont's gross GHG emissions, as shown in Figure 2-2. For the transportation sector, on-road gasoline and diesel consumption have been the major sources of GHG emissions. For the RCI sectors, consumption of petroleum has been the major source of historical GHG emissions. The relative contribution of agricultural emissions ($CH_4$ and $N_2O$ emissions from manure management, fertilizer use, and livestock) is slightly higher in Vermont (11%) than in the nation as a whole (7%). This is a result of more agricultural activity in Vermont compared with that in the United States on average.

Vermont's electricity demand historically has been met by a mix of generation capacity that has produced low GHG emissions. As a result, emissions associated with the electricity supply sector are significantly lower than those of the nation as a whole, with emissions ranging from as high as 13% of total gross GHG emissions in 1990 to as low as 5% of total gross GHG emissions in 2000. As discussed in the next section, the emissions profile may change significantly after 2012 when Vermont's contract with Entergy ends and its contracts with Hydro-Québec begin to phase out from 2012 through 2020.

**Figure 2-2. Gross GHG emissions by sector, 2000, Vermont and US**




Industrial process emissions were almost 4% of total gross GHG emissions in 2000, but these emissions are rising rapidly because of the increasing use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons.[8] Other industrial process emissions result from $CO_2$ released during soda ash, limestone, and dolomite use. Landfills and wastewater management facilities produce $CH_4$ and $N_2O$ emissions that accounted for 3% of the State's emissions in 2000, slightly less than those of the United States as a whole.

Vermont's forests are estimated to be net sinks for GHG emissions and, with forested lands accounting for about 78% of the State, these sequestered, or negative emissions exceeded GHG emissions produced by other State activities from 1990 through 2005. Because of uncertainties in projecting the future levels of sequestration in the State's forests, the projected sinks were held constant at current levels through 2030.

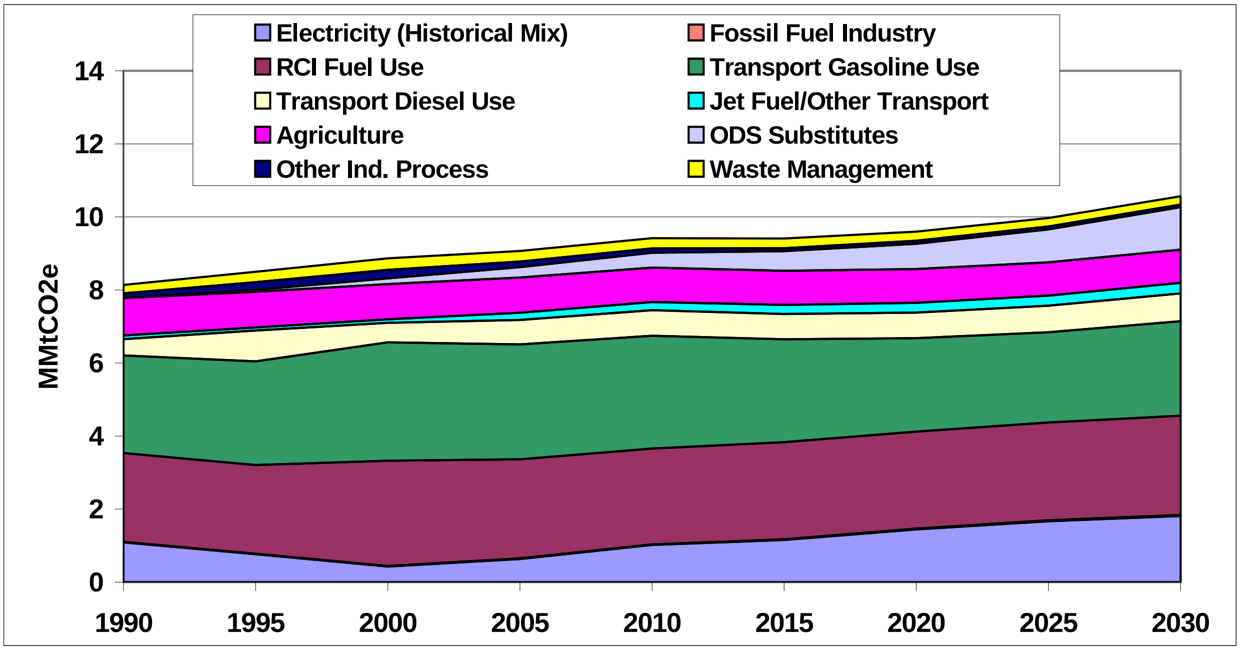
## Reference Case Projections

Relying on the United States Department of Energy (US DOE), Vermont agency projections of population, employment, electricity use, vehicle miles traveled (VMT), and input from VTDEC staff and industry experts, we developed a simple reference case projection of GHG emissions through 2030. As illustrated in Figure 2-3 and shown numerically in Table 2-1 (under the reference case projections for both the high- and low-emission scenarios), Vermont's gross GHG emissions increased by 11% from 1990 to 2005. However, this trend is expected to change over the next 25 years where emissions are projected to increase (from 2005 through 2030) by about 18% (an increase of 1.6 $MMtCO_2e$) under the low-emission scenario and by about 42% (an increase of 3.8 $MMtCO_2e$) under the high-emission scenario without continuing existing DSM programs. Emissions are projected to increase (from 2005 through 2030) by about 7% (an increase of 0.7 $MMtCO_2e$) under the low-emission scenario and by about 32% (an increase of

[8] Chlorofluorocarbons (CFCs) are also potent GHGs; however, they are not included in these GHG estimates since they are addressed through the Montreal Protocol.

2.9 MMt$CO_2$e) under the high-emission scenario without the continuation of existing DSM programs.

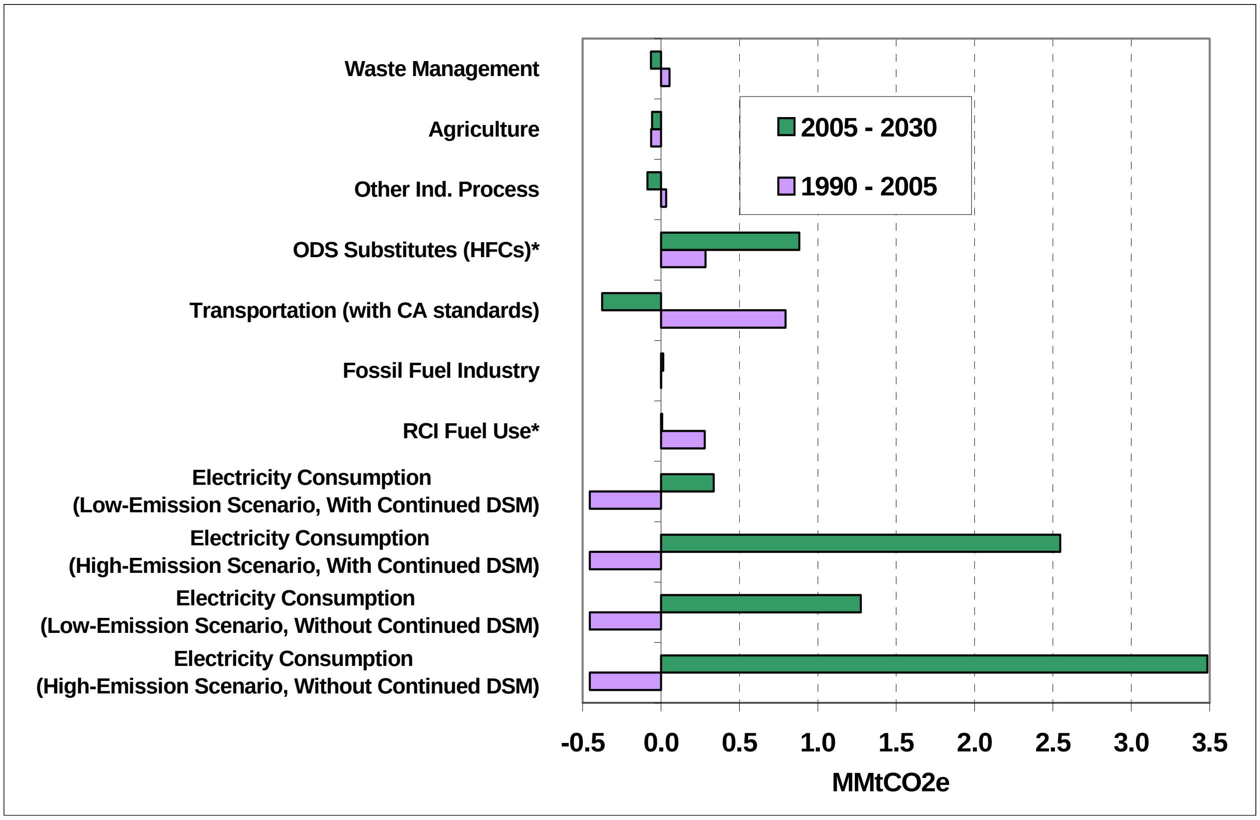
**Figure 2-3. Vermont gross GHG emissions by sector, 1990–2030: historical and projected (electricity supply low-emission scenario; without continued DSM)**




RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone-depleting substance.

As shown in Figure 2-4, the electricity supply sector is projected to be the major contributor to future growth in emissions, followed by significant growth in the use of substitutes for ozone-depleting substances (ODSs) in the industrial processes sector. Growth in emissions associated with the transmission and distribution of natural gas in the fossil fuel production sector and fuel use by the RCI sectors is projected to be relatively low. The contribution of ODS substitutes to total gross GHG emissions is projected to increase from about 3% in 2005 to about 10% by 2030. The contributions of the RCI sectors to total gross GHG emissions are projected to decline from about 30% in 2005 to about 25% by 2030 (for the low-emission scenario without the continuation of existing DSM programs), primarily because of the projected increase in emissions associated with the electricity supply sector and ODS substitutes.

**Figure 2-4. Sector contributions to growth in Vermont gross emissions, 1990–2030: historic and reference case projections (MMtCO$_2$e basis)**




* ODS = ozone-depleting substance; HFCs = hydrofluorocarbons; CA = California; RCI = direct fuel use in residential, commercial, and industrial sectors; DSM = demand-side management.

## A Closer Look at the Two Major Sources: Transportation and Electricity Supply

As shown in Figure 2-2, GHG emissions from transportation fuel use have risen steadily since 1990 at an average rate of slightly over 1.1% annually. Gasoline-powered vehicles accounted for about 82% of total transportation GHG emissions in 1990 and 78% in 2005 and are projected to decrease from 77% to about 70% of total transportation emissions between 2010 and 2030. The decrease in the portion of transportation emissions attributed to gasoline consumption between 2010 and 2020 is due to the adoption of California's light-duty vehicle GHG standards. Diesel vehicles accounted for another 13% of total transportation GHG emissions in 1990 and are projected to increase from 17% to about 20% of total transportation emissions between 2010 and 2030. Although the California light-duty vehicle GHG standards also affect diesel vehicles, the diesel sector is dominated by heavy-duty vehicles, so the impact of the California program on diesel transportation emissions is less significant than its impact on gasoline emissions. Air travel accounted for roughly 2.4% of total transportation emissions in 1990 and 4.3% in 2005 and is projected to increase from 4.9% of total emissions in 2010 to 7.2% of total emissions by 2030. Natural gas and liquefied petroleum gas (LPG) vehicles and lubricants (e.g., automotive oil and grease) account for the remaining transportation sector emissions.

As the result of Vermont's increase in VMT during the 1990s, gasoline use has grown at a rate of 1.4% annually. Meanwhile, diesel use has risen 2.7% annually, suggesting an even more rapid growth in freight movement within or through the State.

Electricity use accounted for about 5% of Vermont's gross GHG emissions in 2000 (about 0.43 $MMtCO_2e$), which is much lower than the national share of emissions from electricity consumption (32%).[9] In total (across the RCI sectors), Vermont has a much lower per capita use of electricity than the United States as a whole (9,170 kilowatt-hours [kWh] per person per year compared with 12,000 kWh nationally, based on 2004 data).[10,11] Overall, total electricity consumption in Vermont increased at an average annual rate of 1.34% from 1990 to 2000 and about 0.9% from 2000 through 2005. Many factors influence a State's per capita electricity consumption, including the impact of weather on demand for cooling and heating; the size and type of industries in the State; the type and efficiency of equipment in use in the residential, commercial, and industrial sectors; implementation of DSM programs; and the fuel mix used to generate the electricity. Thus, the overall historical emissions associated with the electricity sector has varied with emissions declining by about 9% annually from 1990 to 2000, and then increasing by about 8% annually from 2000 to 2005.

Vermont's future emissions associated with the electricity supply sector could increase significantly. Vermont currently has contracts with Vermont Yankee and Hydro-Québec that together supply two thirds of Vermont's electricity. The license with Vermont Yankee ends in 2012 and Vermont's contracts with Hydro-Québec end during the 2012– 2020 period. Thus, it is difficult to estimate GHG emissions for 2012 through 2030 because of the uncertainty about how Vermont will fill its electricity supply gap over this time period. For the purpose of this analysis, we have estimated emissions separately for a high-emission and a low-emission scenario. Both scenarios have the same emissions from 1990 through 2011.

After 2011 the high-emission scenario assumes that Vermont will purchase electricity from the New England power system to fill its electricity supply gap, and the low-emission scenario assumes that Vermont will fill its electricity supply gap with electricity generated from a fuel mix that is similar in GHG emissions to its historical fuel mix. For the low-emission scenario (without continued DSM), GHG emissions are projected to increase from about 0.64 $MMtCO_2e$ in 2005 to 1.9 $MMtCO_2e$ in 2030 (a 200% overall increase in emissions). Based on Vermont DPS forecasts, continuing DSM programs through 2030 could lower emissions for the low-emission scenario by about 39% in 2015, 45% in 2020, and 50% in 2030. For the high-emission scenario (without continued DSM), GHG emissions are projected to increase from about 0.64 $MMtCO_2e$ in 2005 to 4.12 $MMtCO_2e$ in 2030 (a 544% overall increase in emissions). Continuation of existing DSM programs (based on Vermont DPS forecasts) could lower

[9] Unlike for Vermont, for the United States as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, because the United States imports only about 1% of its electricity and exports far less.

[10] Population data for 2004 (626,549 people) from the Vermont Department of Public Health, Agency of Human Services' Web site at http://healthvermont.gov/research/intercensal/TABLE1.XLS. Electricity purchases (including line losses) for 2004 (5,748 gigawatt-hours) from Vermont DPS. Vermont data for 2004 were used for comparison with U.S. per capita data available for 2004.

[11] Census Bureau for U.S. population; Energy Information Administration (EIA) for electricity sales.

emissions associated with the high-emission scenario by about 20% over the forecast period (i.e., 2006 to 2030).

## Key Uncertainties and Next Steps

Some data gaps exist in this inventory, particularly in the reference case projections. Key tasks include 1) developing a better understanding of the electricity generation sources and associated GHG emissions profile that will fulfill future Vermont loads and 2) reviewing and revising key drivers such as the RCI fuel use and the transportation fuel use growth rates that will be major determinants of Vermont's future GHG emissions (see Table 2-2). These growth rates are driven by uncertain economic, demographic, and land-use trends (including growth patterns and transportation system impacts), all of which deserve more thorough review and discussion.

Perhaps the variable with the most important implications for GHG emissions is the emissions profile associated with the generation sources (in-state and out-of-state) that will fill Vermont's energy supply gap from 2012 through 2030. GHG emissions can vary significantly depending on whether Vermont will fill its future demand for electricity based on its historical fuel mix or based on purchases from the New England power system. The assumptions on VMT and air travel growth also have large impacts on the GHG emission growth in the State. Finally, uncertainty remains on estimates for historic GHG sinks from forestry, and projections for these emissions will greatly impact the net GHG emissions attributed to Vermont.

**Table 2-2. Key annual growth rates for Vermont, historical and projected**

| | 1990–2005 | 2005–2030 | Sources |
|---|---|---|---|
| Population | 0.77% | 0.57% | Data for 1990–2005 from Vermont Department of Public Health. Data for 2005–2030 from US Census Bureau. |
| Employment | | | Vermont Department of Labor, based on analysis by the US Bureau of Labor Statistics. Projections data cover the years 2005–2012; the annual growth rates for 2013–2030 are based on those for the years 2005–2012. |
| Goods | –2.66% | 0.08% | |
| Services | 1.22% | 1.40% | |
| Electricity sales | 1.3% | 1.5% | Based on historical and forecast data (that include line losses) provided by Vermont DPS. |
| Vehicle miles traveled | 2.1% | 1.2%–1.4% | VMT projections provided by VTDEC based on historical growth curves for road types from Vermont Agency of Transportation (VTrans); 1.3% per year between 2002 and 2009, 1.4% per year for 2009–2012, and 1.2% per year for 2012–2018. Annual VMT growth rate for 2012–2018 is assumed to continue through 2030. VMT projections are adjusted to account for improvements in fuel efficiency taken from EIA's *Annual Energy Outlook* (AEO2006). Fuel consumption growth rates: 0.7% per year for gasoline and 1.0% per year for diesel between 2002 and 2030. |

DPS = Department of Public Service; VMT = vehicle miles traveled; VTDEC = Vermont Department of Environmental Conservation; EIA = Energy Information Administration (US DOE).

# Chapter 3
# Energy Supply and Demand Sectors

## Overview of GHG Emissions

Vermont's energy supply sector is not currently a major contributor to the state's greenhouse gas (GHG) emissions. Including emissions associated with electricity imported into the state, the contribution of the Energy Supply Sector amounted to only ~7% of Vermont's gross GHG emissions in 2005, including emissions associated with electricity production (0.64 million metric tons of carbon dioxide equivalent [$MMtCO_2e$]) and a much smaller contribution from natural gas transmission and distribution (0.01 $MMtCO_2e$). This very low emission profile arises from the reliance of Vermont's power sector on nuclear power (from Vermont Yankee) and hydroelectric (hydro) power (including power imported from Hydro Quebec), which together supply two thirds of Vermont's electricity. Vermont's future energy supply sector emissions are very sensitive, therefore, to how electricity demand is satisfied after the end date of the current contracts with these two major sources. (See Chapter 2 for further details regarding Vermont's emissions forecast.)

Vermont's demand sector, which comprises the residential, commercial, and industrial sectors, is a significant contributor to the state's GHG emissions. These sectors (including industrial non-$CO_2$ emissions) are responsible for slightly more than one third (35%) of Vermont's current gross[1] GHG emissions (9.1 $MMtCO_2e$ in 2005). Direct emissions result primarily from the on-site combustion of natural gas, coal, and especially heating oil (2.71 $MMtCO_2e$) and also include the release of $CO_2$ and fluorinated gases (hydrofluorocarbons [HFCs] and perfluorocarbons [PFCs]) during industrial processing, the use of sulfur hexafluoride ($SF_6$) in the utility industry, and the leakage of HFCs from refrigeration and related equipment (0.45 $MMtCO_2e$). Overall emissions associated with residential, commercial, and industrial activity increased over the period since 1990 at an average rate of approximately 1.4%/year. This growth is expected to continue in the reference forecast at the slightly slower rate of 1.0%/year, driven by population and economic growth that outpaces gains from increased efficiency.

## Key Challenges and Opportunities

The principal strategy for reducing energy supply and demand emissions includes three main components. First, the state can improve energy efficiency to reduce consumption of electricity and heating fuels in buildings, commercial establishments, and industries. Vermont has already taken important steps in this direction. The state's relatively advanced programs for energy efficiency—historically provided by Vermont's electric and gas utilities and then by Vermont's Efficiency Utility—provide a strong platform on which to build further efforts to reduce emissions in both new and existing buildings.

[1] Gross emissions here denote GHG emissions from activities in Vermont, adjusted for imports of electricity, but not including consideration of estimated "sinks" of GHGs in the forestry and land use sectors.

Second, Vermont can shift toward lower-GHG energy sources in buildings, including renewables such as solar energy for water heating and natural gas as an alternative to heating oil. And third, the state can maintain a low-GHG power sector by preserving the low-GHG sources already in operation and increasing use of new renewables such as wind, hydro, and biomass-based power. Vermont's programs to support lower-GHG energy sources in the supply and demand sectors include its renewables incentive Sustainable Priced Energy Enterprise Development (SPEED) program, which provides long-term contracts to renewables providers, its Clean Energy Development Fund, and various incentives offered through the state utilities.

## Overview of Policy Recommendations and Estimated Impacts

The Plenary Group has recommended to the Governor's Commission on Climate Change (GCCC) a comprehensive set of nine policy options for the energy supply and demand sectors. This portfolio offers the potential for major economic benefits and emissions savings and covers each of the three components of the strategy outlined above.

The first component, which emphasizes energy efficiency, includes policies ESD-1, ESD-2, and ESD-3. The objective of ESD-1 (Evaluation and Continuation / Expansion of Existing DSM for Electricity and Natural Gas) is to achieve significant energy savings in buildings by building on Vermont's existing demand-side management (DSM) efforts. The objective of ESD-2 (Evaluation and Expansion of DSM to Other Fuels) is to extend efficiency efforts to unregulated fuels (oil, liquefied petroleum gas [LPG], and kerosene). ESD-3 comprises three components: Improved Building Codes, Building Commissioning, and Building Efficiency Codes Training and Tracking. The purpose of this set is to improve the energy performance of new buildings, first by near-term updating of building energy codes along with necessary implementation and training activities and, in the longer term, by significantly strengthening building energy codes in accordance with an appropriate and Vermont-specific set of targets.

The second component, which emphasizes lower GHG energy sources in the demand sectors, includes policies ESD-5 (Support for Combined Heat and Power) and ESD-8 (Incentives for Clean Distributed Technologies for Electricity or Heat). ESD-5 is focused on accelerating the adoption of cogeneration of heat and power for major demand centers of heat (such as universities and large industrial users) and potentially for district heating (i.e., a multi-building network of pipelines for distributing centrally-generated heat through a residential or commercial area). ESD-8 aims to encourage clean technologies, such as solar water heaters, rooftop photovoltaics (PV), and on-site wind generation, as well as support for switching to less-carbon-intensive fuels for meeting heating demand.

The third component focuses on ensuring a low-GHG power sector and includes ESD-4, ESD-6, ESD-9, and ESD-10. ESD-4 recognizes the role that nuclear energy has historically had in keeping GHG emissions from Vermont's power sector low and seeks to engage in contracts to ensure that this role continues beyond the expiration of existing contracts for nuclear power. Similarly, ESD-10 recognizes the role that hydroelectric energy has historically had in keeping GHG emissions from Vermont's power sector low and seeks to engage in contracts to ensure that this role continues beyond the expiration of existing contracts for hydroelectric power. It also seeks to provide incentives for expanding in-state small hydro sources within the limits of resource availability and environmental constraints. ESD-6 seeks to expand the role for renewable power through three mechanisms: 1) expansion of voluntary green pricing programs, 2) continued reliance on or strengthening of the SPEED program, accounting for interactions with the renewable programs of other states, and 3) establishment of a renewable portfolio standard (RPS). ESD-9 seeks to support the acceleration of wind generation in Vermont.

The Plenary Group also considered a tenth policy, ESD-7 (GHG Cap-and-Trade and/or GHG Tax), which it is deferring to the GCCC to deliberate on as a potential funding source for the various measures across all the sectors that require appropriations.

The Plenary Group tasked its Technical Work Groups (TWGs) to carry out a preliminary quantification of the costs and emissions impacts of each of these policies. This was done using information sources that were appropriate to the Vermont context. The Plenary Group accepted the TWG's results as helpful preliminary indications of the costs and emissions impacts, with the understanding that more extensive and detailed analysis would be needed before any of the recommended policies are implemented.

The policy recommendations described briefly here, and in more detail in Appendix F, can be expected to result not only in significant emissions and costs savings but can also offer a host of additional benefits. These benefits include reduction in spending on energy by homeowners and businesses; contributions to local economic development; reduced local air pollution; and improvements in comfort, convenience, and indoor air quality as a result of building improvement measures.

In order for the ESD policy options recommended by the GCCC to yield the levels of savings described here, the options must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the policies themselves in place, but also attending to the development of supporting policies that are needed to help make the recommended options effective. Many of these supporting policies are part of the package of options and many are included among the policies recommended as cross-cutting policies (see Chapter 6).

Table 3-1 provides an overview of the results of the preliminary quantification undertaken by the ESD TWG. The results are organized as two scenarios. In Scenario 1, nuclear and large-scale hydroelectricity contracts that are set to expire are renewed (or replaced) in part as a result of efforts under ESD-4 and ESD-10, such that these sources continue to contribute to Vermont's electricity supply at a scale similar to that of today. In Scenario 1, additional renewables enter, in part as a result of measures ESD-5, ESD-6, ESD-9, and ESD-10 (along with the agriculture, forestry, and waste management policy option AFW-3, which supports biogas power) and at the level necessary to keep the power sector emissions low. In Scenario 2, nuclear and large-scale hydroelectricity contribute roughly half what they contribute today, in part as a result of the partial success of efforts under ESD-4 and ESD-10. In this second scenario, additional renewables enter at a higher level, enabling the power sector emissions to remain low despite the lower contribution of nuclear and hydroelectricity.

**Table 3-1. GCCC-recommended policy options and results for Energy Supply and Demand Sectors**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost–Effective–ness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| ESD–1 | Evaluation and Continuation/ Expansion of Existing DSM for Electricity and Natural Gas | 0.7 | 1.7 | 21.5 | –$850 | –$40 | UC |
| ESD–2 | Evaluation and Expansion of DSM to Other Fuels | 0.1 | 0.5 | 5.3 | –$335 | –$64 | Super-Majority |
| ESD–3 | Building Efficiency Codes, Training, Tracking | 0.02 | 0.2 | 2.0 | –$107 | –$55 | UC |
| ESD–4 | Evaluate Potential for Contracting Nuclear Power | | | | | | Super-Majority |
| | (Scenario 1) | 0.5 | 1.1 | 16.7 | –$140 | –$8 | |
| | (Scenario 2) | 0.3 | 0.7 | 10.2 | –$70 | –$7 | |
| ESD–5 | Support for Combined Heat and Power | 0.1 | 0.2 | 2.6 | –$86 | –$34 | UC |
| ESD–6 | Incentives and/or Mandate for Renewable Electricity | | | | | | Super-Majority |
| | (Scenario 1) | 0.1 | 0.4 | 5.4 | $9 | $2 | |
| | (Scenario 2) | 0.2 | 1.2 | 15.7 | $38 | $2 | |
| ESD–7 | GHG Cap-and-Trade and/or GHG Tax | Referred to the GCCC as primarily a funding mechanism. | | | | | |
| ESD–8 | Incentives for Clean Distributed Technologies for Electricity or Heat | | | | | | UC |
| | Natural Gas Fuel Switching | 0.1 | 0.1 | 2.2 | $15 | $7 | |
| | Solar Thermal Water Heating | 0.05 | 0.2 | 2.3 | $67 | $29 | |
| ESD–9 | Wind-Specific Support Measures | | | | | | UC |
| | (New Wind, Scenario 1) | 0.03 | 0.2 | 2.1 | –$6 | –$3 | |
| | (New Wind, Scenario 2) | 0.1 | 0.5 | 6.3 | $10 | $2 | |
| ESD–10 | Hydro-Specific Support Measures | | | | | | UC |
| | (Continued Large Hydro, Scenario 1) | 0.02 | 1.1 | 14.9 | $0 | $0 | |
| | (Continued Large Hydro, Scenario 2) | 0.01 | 0.6 | 8.7 | $0 | $0 | |
| | (New Hydro, Scenario 1) | 0.01 | 0.06 | 0.8 | –$22 | –$27 | |
| | (New Hydro, Scenario 2) | 0.03 | 0.2 | 2.4 | –$64 | –$27 | |
| | **Total** | | | | | | |
| | **Scenario 1 (Generation of Nuclear and Hydro at Historic Levels)** | **1.56** | **5.48** | **72.75** | **–$1,427** | **–$20** | |
| | **Scenario 2 (Generation of Nuclear and Hydro at 50% of Historic Levels)** | **1.56** | **5.37** | **70.35** | **–$1,328** | **–$19** | |

DSM = demand-side management; UC = unanimous consent.

Scenarios 1 and 2 reduce emissions by similar amounts, by design. Emissions reductions relative to reference case projections are roughly 1.5 $MMtCO_2e$ per year by 2012 and 5.4 $MMtCO_2e$ by 2028, with cumulative reductions of more than 70 $MMtCO_2e$ through 2028. Most emissions reductions from the ESD options are in the form of reduced $CO_2$ emissions, with relatively minor reductions of emissions of other GHGs produced via leakage and/or combustion of fuels. The TWG's preliminary analysis also suggests that the ESD policy portfolio could result in net cost *savings* of over $1 billion through the year 2028 on a net present value (NPV) basis.[2] Savings arise primarily from the energy savings resulting from ESD-1, ESD-2, and ESD-3. ESD-4 also produces savings, by virtue of the assumption that nuclear power would be contracted on terms similar to those in current contracts, which provide for a rate-payer price benefit if the market price of electricity rises above an agreed-upon level.

[2] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% per year real discount rate.

# Chapter 4
# Transportation and Land Use

## Overview of GHG Emissions

The transportation sector is the largest source of greenhouse gas (GHG) emissions in Vermont—accounting for 44% of Vermont's gross GHG emissions in 2000. Carbon dioxide ($CO_2$) accounted for about 96% of transportation GHG emissions. Most of the remaining GHG emissions from the transportation sector are due to nitrous oxide ($N_2O$) emissions from gasoline engines. GHG emissions from transportation fuel use have risen steadily since 1990 at an average rate of slightly over 1.1% annually.

Transportation emissions are determined by technologies (types of engines and vehicles), fuels, and activity rates. Activity rates, in turn, are determined in part by population, economic growth, and land use choices that affect the demand for transportation services. GHG emissions from the transportation sector totaled about 3.2 million metric tons of carbon dioxide equivalents ($MMtCO_2e$) in 2000.

Table 4-1 shows historical and projected transportation and land use (TLU) GHG emissions by fuel and source and illustrates their growth. As the result of Vermont's increase in vehicle miles traveled (VMT) during the 1990s, gasoline use has grown at rate of 1.4% annually. Meanwhile, diesel use has risen 2.7% annually, suggesting an even more rapid growth in freight movement within or through the State. GHG emissions from transportation are forecast to grow considerably over the next 15 years in the baseline due to increased demand for current modes of transportation.

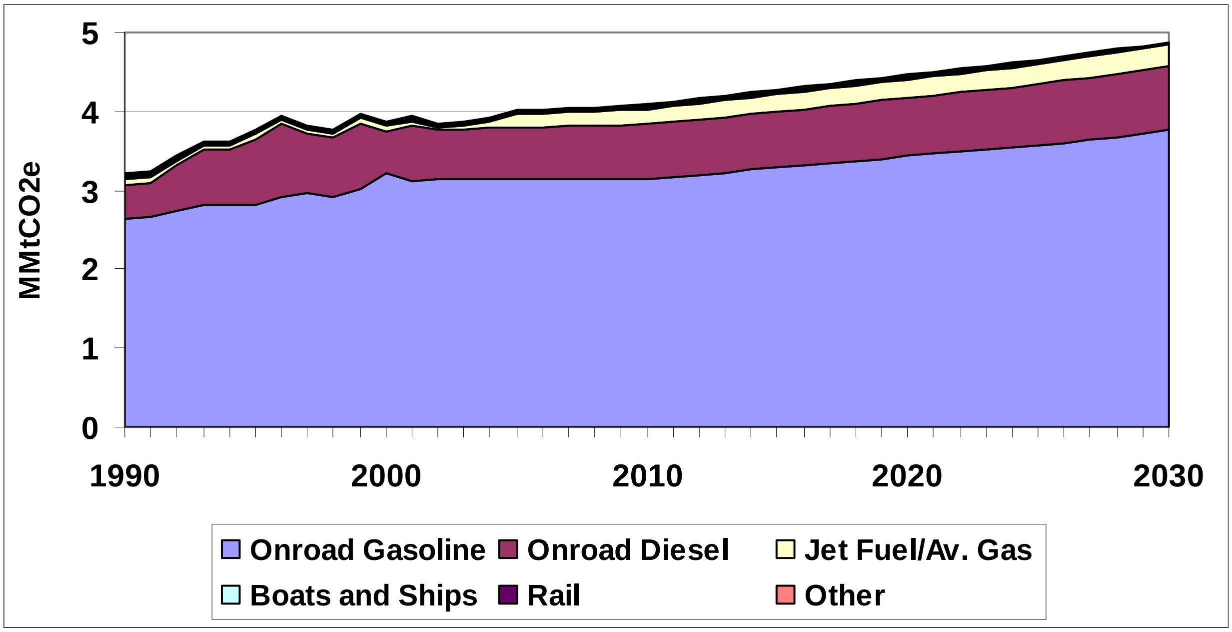
**Table 4-1. Key annual growth rates for Vermont, historical and projected[1]**

| | 1990–2005 | 2005–2030 |
|---|---|---|
| Population | 0.77% | 0.57% |
| Vehicle miles traveled | 2.1% | 1.2%–1.4% |

Gasoline-powered vehicles accounted for about 82% of total transportation GHG emissions in 1990 and 78% in 2005; they are projected to decrease from 77% to about 70% of total transportation emissions between 2010 and 2030. The decrease in the portion of transportation emissions attributed to gasoline consumption between 2010 and 2020 is due to the adoption of California's light-duty vehicle GHG standards. Accounting for the effects of the California (CA) light-duty vehicle GHG standards, average annual growth in gross GHG emissions for the on-road gasoline consumption sector is projected at about –0.7% from 2002 through 2030. In order for the transportation sector to contribute to meeting Vermont's GHG reduction goals, other substantial actions will be necessary. The overall growth in transportation sector emissions, and particularly in VMT, suggests many opportunities and challenges for reducing Vermont's GHG emissions. Figures 4-1 and 4-2 show projected GHG emissions from the transportation sector without and with the adoption of the California (CA) standards for light duty vehicles.

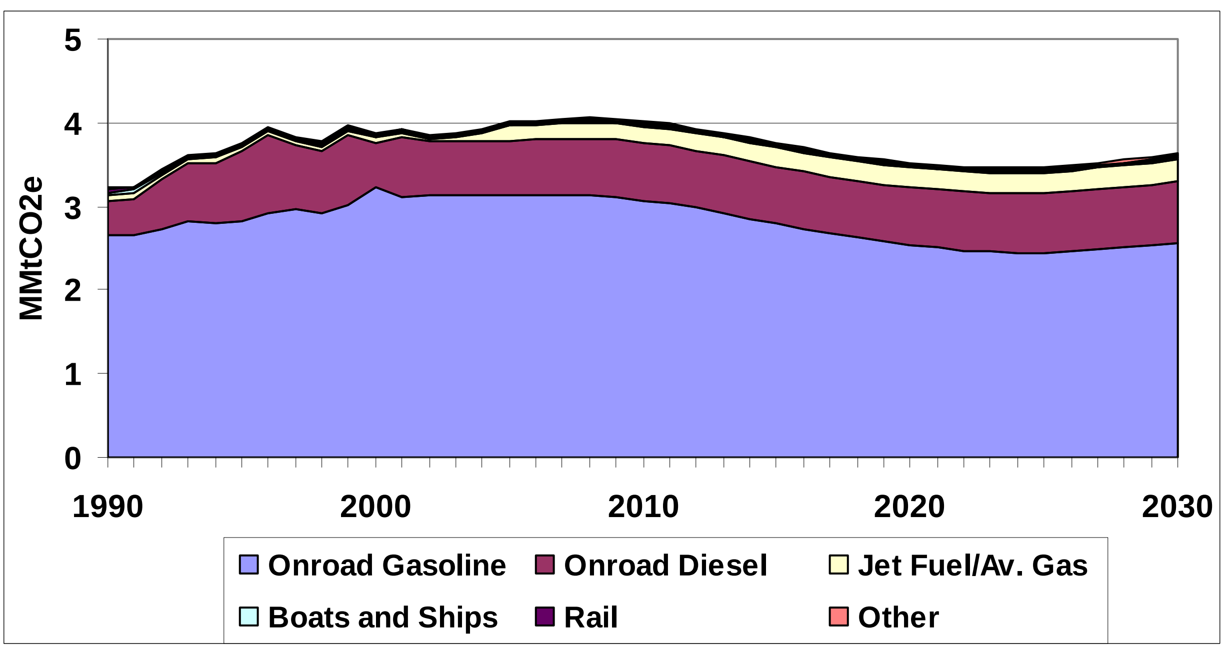
[1] Sources: See GHG Emissions Inventory and Reference Case Projections, Appendix D.

**Figure 4-1. Transportation GHG emissions by fuel, not including CA light-duty vehicle GHG standards, 1990–2030**




$MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

**Figure 4-2. Transportation GHG emissions by fuel, including CA light-duty vehicle GHG standards, 1990–2030**




$MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

## Key Challenges and Opportunities

Policies to reduce emissions from transportation fall into three categories:

1. improving vehicle *fuel efficiency*,
2. reducing the carbon intensity of *fuels*, and
3. reducing *activity rates*, either absolutely or relative to the baseline. Policies may produce modal switches to lower emission means of travel and/or decrease the total amount of travel.

Vermont has substantial opportunities to reduce emissions in each category. In Vermont, and in the nation as a whole, vehicle fuel efficiency has improved little since the late 1980s, yet many studies have documented the potential for substantial increases consistent with maintaining vehicle size and performance. The use of fuels with lower GHG emissions is growing, and larger market penetration is possible. Vermont also has taken steps to increase transit options and plan for growth that reduces emissions, but the state can absorb growth in development patterns that will produce far lower emissions than forecast.

## Overview of Policy Recommendations and Estimated Impacts

The Plenary Group (PG) recommends a set of 9 policy options for the transportation and land use sector that offer the potential for major economic benefits and emissions savings. As summarized in Table 4-2, these policy recommendations could lead to increasing yearly emissions reductions from reference case projections of 1.09 in 2013 to 3.07 $MMtCO_2e$ per year by 2028. Two of the quantified options (TLU-3 and TLU-7) would yield a net cost *savings* of more than $43 million to citizens and the Vermont economy through the year 2028 on a net present value (NPV) basis.[2] The weighted average cost of saved carbon from the policy options for these two options, the only for which quantitative estimates of both costs and savings were prepared, is –$11 per metric ton of $CO_2$ equivalent ($tCO_2e$)**.**

The estimated impacts of the individual policies are shown in Table 4-2. The PG policy recommendations described briefly here (and in more detail in Appendix G) not only result in significant emissions and costs savings but also offer a host of additional benefits. These benefits include (but are by no means limited to) reduced local air pollution, more livable, healthy communities, and increased transportation choices.

In order for the TLU policy options recommended by the PG to yield the levels of savings described here, the options should be implemented in a timely, aggressive, and thorough manner.

To be most effective, the group of policies aimed at VMT reductions and increased transportation choices (TLU-1, Compact and Transit-Oriented Development Bundle; and TLU-2, Alternatives to Single-Occupancy Vehicles [SOVs]) will require change at every level of government and will be most effective with focused leadership by the State, including training, outreach, and technical assistance to local governments.

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[2] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All net present value (NPV) analyses here use a 5% real discount rate.

Most of the recommended policies would produce substantial economic benefits for Vermont. The sources and calculations of these benefits are detailed in Appendix G. Because the form of several of the recommendations leaves the state and its constituents substantial latitude in how to achieve the recommended goals, it was not possible to estimate financial costs and benefits. For example, given the substantial portion of forecast emissions growth driven by increasing driving, growing in more compact, mixed-use patterns is simply essential to meeting the state's emissions reduction targets. For the same reason, changing development patterns also offers the single largest potential emissions reduction from transportation.  As a result, TLU-1 recommends that Vermont adopt the following as a statewide goal: "Vehicle miles traveled in Vermont are equal to the amount driven in aggregate in the year 2000 by the year 2012, and are equal to the 1990 level by 2025." TLU-1 details suggested implementation mechanisms, but the policy option is open enough that we cannot know which approach to developing more compact development patterns the state and each community will choose. As a result, we did have not try to estimate the cost for any potential individual strategies nor the total costs (or savings) for a combination of strategies.

In the case of TLU-1, CCS reviewed experience in, and estimates for, growth planning in other states. With few exceptions, experience and forecasts across a wide variety of planning choices show *substantial* net cost savings from planned growth relative to the kind of growth currently prevalent in Vermont. Vermont and its communities would likely save hundreds of millions of dollars from shorter sewer lines, fewer needed new roads, and fewer needed new schools. But given the wide range of choices available to Vermont communities under recommended TLU-1, it is not possible to put a point estimate on the benefits that will likely be produced by those choices.

Benefits from other recommended options were more straightforward to forecast. Commuter Choice/Commuter Benefits (TLU-7), for example, would more than pay for themselves in reduced auto travel costs.

Table 4-2 presents the Plenary Group's recommended policy options and results for the transportation and land use sector.

**Table 4-2. PG-recommended policy options and results for the transportation and land use sector**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2028 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008-2028 | | | |
| TLU-1 | Compact and Transit-Oriented Development Bundle | 0.26 | 0.99 | 10.88 | Net savings | | UC |
| TLU-2 | Alternatives to Single-Occupancy Vehicles (SOVs) | 0.28 | 0.32 | 6.57 | Net savings | | UC |
| TLU-3 | Vehicle Emissions Reductions Incentives | 0.11 | 0.63 | 7.73 | –$42 | –$10 | SM |
| TLU-4 | Pay-as-You-Drive Insurance | 0.20 | 0.32 | 5.30 | Net savings | | SM |
| TLU-5 | Alternative Fuels and Infrastructure (Low Carbon Fuel Standard) | 0.12 | 0.42 | 5.75 | N/A | | UC |
| TLU-6 | Regional Intermodal Transportation System – Freight and Passenger | 0.05 | 0.20 | 2.22 | N/A | | UC |
| TLU-7 | Commuter Choice/Parking Cash Out | 0.06 | 0.19 | 1.86 | –$1 | –$1 | UC |
| TLU-8 | Plug-in Hybrids [now included in TLU-5] | – | – | – | – | | UC |
| TLU-9 | Examine GHG/Transportation Funding Mechanisms as part of a funding package after reductions policies are chosen. | – | – | – | – | | UC |
| | Sector total before adjusting for overlaps | 1.09 | 3.07 | 40.31 | NA | N/A | |
| | Reductions from recent policy actions | | | | | | |
| | Sector total plus recent policy actions | TBD | TBD | TBD | TBD | TBD | |

UC = unanimous consent; SM = super majority; LCFS = low carbon fuel source; N/A = not available; TBD = to be determined.

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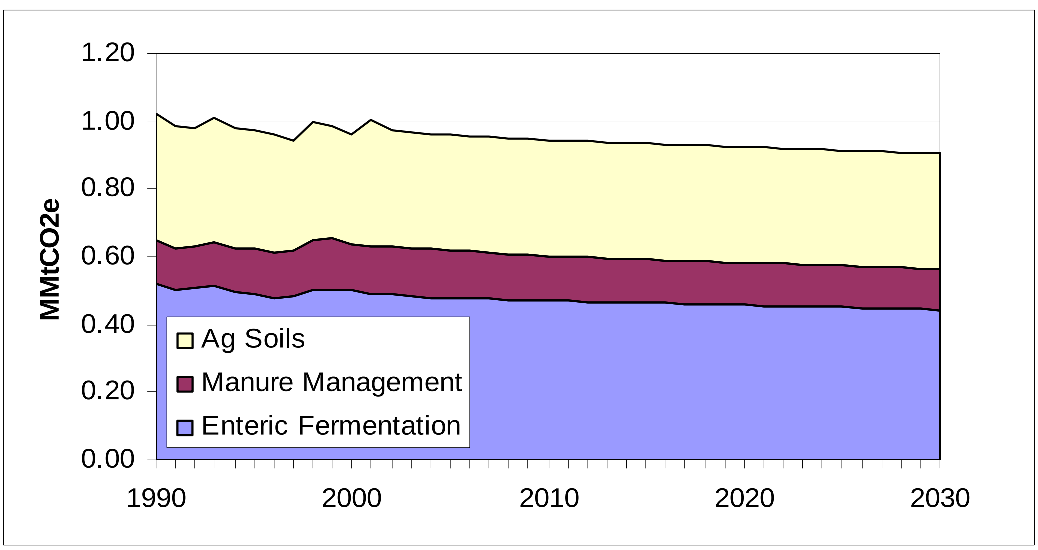
# Chapter 5
# Agriculture, Forestry, and Waste Management

## Overview of GHG Emissions

The agriculture, forestry, and waste management (AFW) sectors are directly responsible for a small amount of Vermont's current GHG emissions. For agriculture, net emissions were 0.96 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2000. Agricultural emissions include methane ($CH_4$) and nitrous oxide ($N_2O$) emissions from enteric fermentation, manure management, agriculture soils, and agriculture residue burning. As shown in Figure 5-1, emissions from agricultural soils and enteric fermentation in cattle account for the largest portions of agricultural emissions. The agricultural soils category includes $N_2O$ emissions resulting from activities that increase nitrogen in the soil, such as fertilizer (synthetic, organic, and livestock) application and production of nitrogen-fixing crops.

Total gross emissions from agricultural sources are fairly constant at about 1 $MMtCO_2e$ from 1990 through 2030. Figure 5-1 shows a slight decline in projected emissions from 2002 to 2030, mainly due to a predicted decrease in the dairy cattle population. With the inclusion of soil carbon flux[1] from agricultural soils (–0.19 $MMtCO_2e$/year; a net sink), the net agricultural sector emissions range from about 0.7 to 0.8 $MMtCO_2e$/year over the forecast period.

**Figure 5-1. Historical and projected GHG emissions from the agriculture sector, Vermont, 1990 to 2030**




Forestland emissions refer to the net $CO_2$ flux[1] from forested lands in Vermont, which account for about 78% of the state's land area. As shown in Table 5-1, US Forest Service (USFS) data suggest that Vermont forests and the use of forest products sequestered on average 9.7 $MMtCO_2e$ per year from 1983 to 1997. The data show an accumulation of carbon in each of the

[1] "Flux" refers to both emissions of $CO_2$ to the atmosphere and removal (sinks) of $CO_2$ from the atmosphere.

forest carbon pools during this period. These rates of sequestration are assumed to remain constant through 2020.

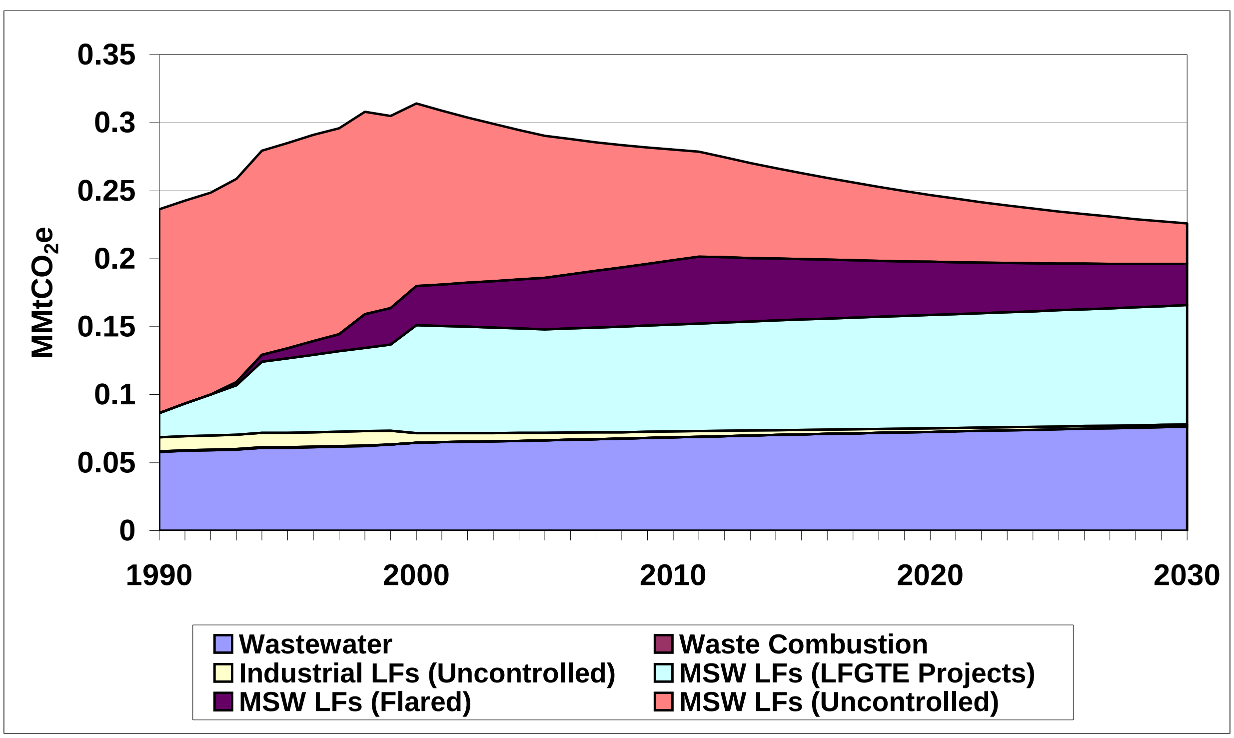
**Table 5-1. GHG emissions (sinks) from forestry**

| Forest Carbon Pool | 1990–2020* $MMtCO_2e$ |
|---|---|
| Live trees | –6.3 |
| Standing dead trees | –0.3 |
| Live understory | –0.03 |
| Down and dead trees | –0.4 |
| Forest floor | –0.5 |
| Soils | –0.7 |
| Harvested wood products and landfilled forestry waste | –1.4 |
| **Total** | **–9.63** |

*Based on USFS data from 1983 to 1997.

Figure 5-2 shows estimated historical and projected emissions from the management and treatment of solid wastes and wastewater. Emissions from waste management consist largely of methane emitted from landfills, while emissions from wastewater treatment include both methane and nitrous oxide. Overall, the sector accounts for less than 0.31 $MMtCO_2e$ emissions per year from 1990 through 2030.

**Figure 5-2. Estimated historical and projected emissions from waste and wastewater management in Vermont**



Opportunities for GHG mitigation in the AFW sector involve measures that can either reduce emissions directly from within the AFW sector or reduce emissions indirectly in other sectors. For example, production of liquid biomass fuels can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply (ES) or residential, commercial, and industrial (RCI) sectors. The primary opportunities for GHG mitigation are as follows:

- *Protection of forest and agricultural land from conversion to developed use*—by protecting these areas from development, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of $CO_2$e to the atmosphere can be avoided.
- *Expand source reduction, recycling, and composting programs in the solid waste sector*—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. Source reduction involves programs to reduce the amount of waste generated, which reduces both landfill emissions and the emissions associated with initial production and distribution of products or packaging.
- *Production of renewable fuels (in-state production from in-state feedstocks)*—production of renewable fuels such as ethanol and biodiesel from crops, crop residue, forestry residue, or municipal solid waste can produce significant reductions when they are used to offset consumption of fossil fuels (gasoline consumption in the transportation sector). This is particularly true when these fuels are produced using processes and/or feedstocks with much lower GHG emissions than those from conventional sources (i.e., those that have lower fossil carbon content than the fuels they displace).
- *Support of organic farming and nutrient management*—organic farming has been shown to result in significant increases in soil carbon compared with conventional cultivation. Additional GHG reductions are also possible to the extent that organic techniques reduce fossil fuel consumption due to less intensive use of farm equipment.
- *Beneficial use of forest biomass*—expanded use of biomass energy from residue removed from forested areas during treatments to reduce fire risk or to achieve other forest management objectives can produce GHG benefits by offsetting fossil fuel consumption (either to produce electricity or heat).
- *Manure management and methane utilization*—methane emissions from manure management can be reduced through the use of anaerobic digesters or other technology. The methane captured can then be used to create electricity, steam, or heat to offset fossil fuel use.

Additional opportunities for reducing GHGs include expanded production and use of wood products, programs to improve wastewater treatment efficiency, and programs to support local farming and food networks.

## Key Challenges and Opportunities

The protection of forested land, open spaces, and agricultural land combined (AFW-4 and AFW-7) offer the largest opportunity for reductions in GHG emissions, with a combined potential reduction of 2.1 $MMtCO_2e$/year by 2028. Forest protection will be much more likely to succeed if the other forestry policy options (including AFW-5, AFW-6, and AFW-8) are also adopted. Collectively, these options provide a variety of economically driven incentives to keep forest land from being developed, while providing an increase in the types of wood products that produce GHG benefits (through long-term carbon storage). An additional greenhouse benefit of AFW-4 and AFW-7 not incorporated in this reduction potential is the indirect emission savings resulting from a reduction in vehicle miles traveled due to more efficient development patterns (hence, these options can be seen as supporting the smart growth development objectives of option TLU-1).

Additional significant greenhouse emission reduction opportunities exist through municipal solid waste source reduction programs (AFW-10) and the improvement of current recycling and composting practices (AFW-9). Combined, these options are estimated to provide GHG reductions of 1.6 $MMtCO_2e$ in 2028. Reductions occur both through lower landfill emissions and through lower energy consumption used in the manufacturing and distribution of products and packaging. A challenge of the AFW-9 policy option is that broadening the range of wastes composted to include mixed municipal solid waste may not be feasible at small-scale facilities due to equipment requirements, higher capital costs, and poor marketability of compost residue (Vermont currently composts only separated organic waste). Co-operating a landfill with an organic composting operation also requires additional equipment for odor control and may result in additional costs. Increasing recycling may also have the effect of reducing revenue for landfill operators because lower quantities of waste are being landfilled. There is an overlap between this option and AFW-10 (Programs to Reduce Waste Generation). The extent to which AFW-10 achieves the waste reduction goals could result in a reduction of materials available for recycling, as well as landfill methane emissions avoided (due to lower amounts of waste being landfilled).

Option AFW-12 seeks to promote the production of renewable fuels (e.g., biodiesel and ethanol) to achieve significant GHG reduction benefits (0.7 $MMtCO_2e$ in 2028). This GHG benefit is in addition to the emission reductions achieved by substituting biofuels for petroleum related products (see TLU-5, Alternative Fuels and Infrastructure [LCFS]). For biodiesel, this analysis focuses on the incremental benefits of in-state production derived from the lower carbon content of in-state feedstocks (vegetable oil and algal oil) compared to the importation of out-of-state feedstock supplies (e.g., soybean oil). For ethanol, the benefits are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned starch-based production in the United States. Hence, all ethanol production targeted by this policy is assumed to occur via cellulosic technology (or technology achieving similar benefits), as per the policy design. Feedstocks for the fiber needed by this policy could come from crop residue, forestry biomass, or municipal solid waste fiber.

It should be noted that cellulosic technology is relatively nascent and there is currently no commercial production of ethanol from cellulosic feedstock in the United States. This option provides Vermont with an opportunity to position itself as a creator of sustainably produced biofuels by focusing on cellulosic ethanol and biodiesel derived from stringent agricultural and forestry practices. However, biofuels research and development is still at an early stage in Vermont. Tapping the capacity of in-state organizations, including Vermont’s educational institutions, and the cellulosic ethanol expertise at Dartmouth College should help to accelerate the development of the cellulosic ethanol sector.

Additional benefits of this policy option would be the creation of additional jobs in-state to serve the local biofuels industry and the availability of additional options for local farmers with high value crops. However, it is unclear whether the levels of feedstock production described in this option would create significant disruption to Vermont's current agricultural systems that supply food and livestock feed. Additional study in this area is warranted.

## Overview of Policy Recommendations and Estimated Impacts

The Plenary Group (PG) recommends a set of 12 policy options for the AFW sector that offer the potential for significant emissions savings. Table 5-2 summarizes the potential emission reductions resulting from the adoption of the AFW policy recommendations. Table 5-2 also indicates the sectors where the emission reductions will likely occur. This is important as some of the AFW recommended policy options offer emission reductions in sectors other than AFW and the true GHG benefit of these policies will be delivered across multiple sectors.

Total GHG reductions from reference case projections are estimated to be 4.7 $MMtCO_2e$ per year in 2028 with a cumulative savings of 54 $MMtCO_2e$ from 2007 to 2028. The net present value of the costs is approximately $210 million over the same period.[2] The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was $4 per $MtCO_2e$. Although a cost estimate for options AFW-1 (local farming support), AFW-6 (increased biomass energy use) and AFW-10 (waste reduction) were not developed for this sector, the PG believes that the cost to the Vermont economy would still be relatively low if this package of options were implemented.

The estimated impacts of the individual recommended policies are shown in Table 5-2. The PG policy recommendations described briefly here (and in more detail in Appendix H) not only result in significant emissions savings but also offer a host of additional benefits. These benefits include 1) support of Vermont agricultural producers in the production of biofuels crops, development of new markets for agricultural byproducts, production of crops to support locally consumed foods, and training/outreach covering energy production and organic farming; 2) creation of jobs in the biomass energy and liquid biofuels feedstock/production industries; 3) healthier forests with lower fire risk through development of markets for forestry residue; 4) reduced fossil fuel dependence; and 5) research and development work to be conducted by Vermont universities to support many of the policies for this sector.

[2] The net costs are based on fuel expenditures, operations, maintenance and administrative costs, and amortized, incremental equipment costs. All net present value (NPV) analyses here use a 5% real discount rate.

**Table 5-2. PG-recommended policy options and results for the agriculture, forestry, and waste management sector**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Sector where GHG reductions occur | Net Present Value 2007–2028 (Million $) | Cost-Effective-ness ($\$/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2007–2028 | | | | |
| AFW-1 | Programs to Support Local Farming/Buy Local | 0.004 | 0.02 | 0.2 | TLU | Not quantified | Not quantified | UC |
| AFW-2 | Agricultural Nutrient Management Programs | 0.08 | 0.10 | 1.6 | Ag | 4.2 | 3 | UC |
| AFW-3 | Manure Management Methods to Achieve GHG Benefits | 0.01 | 0.02 | 0.3 | Ag, ESD, and RCI | 34 | 136 | UC |
| AFW-4 | Protect Open Space/Agricultural Land | 0.06 | 0.11 | 1.8 | Ag and TLU | 56 | 31 | UC |
| AFW-5 | Forestry Programs to Enhance GHG Benefits | 0.01–0.04 | 0.06–0.18 | 0.6–2.0 | Forestry | 4 | 3 | UC |
| AFW-6 | Increased Forest Biomass Energy Use | Quantified under ESD options | | | ESD and RCI | Quantified under ESD options | | UC |
| AFW-7 | Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover | 0.4 | 2.0 | 22 | Forestry | 34 | 2 | UC |
| AFW-8 | Expanded Production and Use of Durable Wood Products (Especially From VT sources) | | | | Forestry, ESD, and RCI | * | * | UC |
| | A. Supply | 0.09 | 0.05 | 1.4 | | | | |
| | B. Demand | 1E-4 | 2E-4 | 3E-3 | | | | |
| AFW-9 | Advanced/Expanded Recycling and Composting | 0.16 | 0.88 | 9.1 | Waste, ESD, and RCI | 37 | 4 | UC |
| AFW-10 | Programs to Reduce Waste Generation | 0.34 | 0.73 | 10 | Waste, ESD, and RCI | Not quantified | Not quantified | UC |
| AFW-11 | Waste Water Treatment – Energy Efficiency Improvements | 0.004 | 0.01 | 0.14 | Waste and ESD | –19 | –133 | UC |
| AFW-12 | In-State Liquid Biofuels Production – Ethanol Production | 0.03 | 0.42 | 3.7 | TLU | 5.0 | 1 | UC |
| | In-State Liquid Biofuels Production – Biodiesel Production | 0.004 | 0.24 | 2.2 | | 40 | 18 | |
| | **Sector total after adjusting for overlaps**[†] | **1.2** | **4.7** | **54** | | **210** | **4** | |
| | **Reductions from recent actions** | **0** | **0** | **0** | | **0** | **0** | |
| | **Sector total plus recent actions** | **1.2** | **4.7** | **54** | | **210** | **4** | |

[*] Costs for the supply component of this option are captured under AFW-5. For the demand component, the costs could not be quantified.

[†] This energy efficiency option has overlap with policies in the RCI Technical Work Group (TWG); reductions and costs were removed from the AFW total.

## Agriculture, Forestry, and Waste Management Sector Policy Descriptions

The Agriculture, Forestry, and Waste Management Sector includes emissions and mitigation opportunities related to use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, control of agricultural methane emissions, production of renewable fuels, reduction of transport emissions from imported agricultural commodities, efficient treatment of waste and wastewater, and recycling of waste material. These options are detailed in Appendix H.

### AFW-1. Programs to Support Local Farming/Buy Local

Programs that promote the production, storage, processing, distribution and consumption of locally grown food products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embodied energy (i.e., those products that travel long distances between the grower and consumer). For this policy, the term "local" should be construed to include the broader New York and New England region.

The PG recommends that Vermont increase sales and consumption of local farm products by 50% and increase storage and processing capacity of locally grown farm products by 20% by 2012 above current levels. From todays approximate 12% consumption of local food, by the year 2028, local food systems need to be constructed to shift to 30% local (regional) food consumption. Reductions in GHG emissions occur through offsetting imported foods with high embedded GHG (from transportation) with local foods that have significantly lower embedded GHG.

### AFW-2. Agricultural Nutrient Management Programs

The PG recommends that Vermont use conservation practices to increase the incorporation of organic green manures, implement grass-based rotations and cover-cropping, which will reduce soil erosion, maintain/increase soil organic matter level, and increase overall soil tilth. In addition, producers should maximize the use of farm organic wastes to improve crop fertility and to lower the importation of oil-based synthetic fertilizers. The goals are to implement nutrient management plans (NMPs) aimed at increasing soil carbon levels and minimizing nitrogen run-off and subsequent $N_2O$ emissions on 75% of farm acreage by 2012 and 90% by 2028. The policy also aims to use injection technology to incorporate manure on 10% of liquid dairy manure and processed wastewater by 2012 and increase acreage managed under cover crop to 25% of annual cropland by 2012 and 50% by 2028. Nitrous oxide reductions occur when nitrogen runoff and leaching are reduced, and carbon dioxide reductions occur as soil carbon levels in crop soils are increased above business-as-usual levels. Increasing the levels of carbon in soils indirectly sequesters carbon from the atmosphere.

### AFW-3. Manure Management Methods to Achieve GHG Benefits

The methane emissions inherent from the anaerobic decomposition process of manure and other wastes may be captured and used as an energy source. Methane and nitrous oxide emissions can occur at several different places in the manure management process. Management techniques can reduce GHG emissions and, with energy recovery, offset fossil-based energy. The PG recommends digesting half of dairy cattle manure in Vermont by 2028, and composting 50% of the poultry and livestock manure produced on farms by 2028. Vermont can also implement nutrient management strategies that meet the Natural Resource Conservation Service (NRCS) Technical Practice Code 590 on 90% of the land that receives manure or processed wastewater by 2028. This option covers producer incentives to adopt programs to increase the number of methane capture and energy recovery projects or other manure management techniques that reduce methane and nitrous oxide emissions. A key need for future research is to develop and promote composting or other treatment methods that do not create significant nitrous oxide and methane emissions.

### AFW-4. Protect Open Space/Agricultural Land

The PG recommends that Vermont reduce the rate at which existing crop and pasture are converted to developed uses. The carbon sequestered in soils and aboveground biomass can be higher in agricultural lands than in developed land uses. Policies are also needed to protect working farms and forests (see AFW-7) from unwise and unplanned development. The policy aims to reduce the rate at which agricultural lands are converted to development by 25% by 2012 and 50% by 2020 and maintain this reduced rate of conversion through the policy period.

### AFW-5. Forestry Programs to Enhance GHG Benefits

Carbon dioxide is captured and stored in trees, soil, and other forest biomass. Forest management activities that promote forest production have the potential to increase net carbon dioxide sequestration rates and enhance GHG benefits. Retaining forest management where it is currently practiced and expanding the area covered by management plans would stimulate the rate of production, in terms of both forest growth and the amount of biomass harvested. Carbon stored in harvested biomass is addressed in AFW-8. Use of biomass waste from forestry programs for energy purposes is covered under AFW-6.

The PG recommends increasing net carbon sequestration in Vermont’s forests by 3% per year by implementing forest management on 1–3 million acres by 2028. That means implementing forest management on 47,619 to 142,857 acres per year from 2008 to 2028. This change in forest management is anticipated to increase the amount of carbon sequestered and stored in forest biomass as a result of enhanced forest growth rates.

### AFW-6. Increased Forest Biomass Energy Use

The PG recommends that Vermont increase the use of low value wood material, including logging and mill residues, by appropriate processing centers and end users (electricity, heating, or liquid fuels). Offsetting fossil fuel use with biomass for energy, in applications such as distributed generation, combined heat and power, and community energy systems will yield additional GHG emissions reductions benefits. The goal is to increase production and use of forest biomass energy feedstocks in Vermont by 5% in 2010 and 30% in 2028. The availability of feedstocks, however, depends on forest capacity to produce biomass (AFW-5), as well as competition for wood from other policy options (e.g., AFW-8 and AFW-12). An assessment conducted by the AFW Technical Work Group (TWG) suggests that there are sufficient biomass resources for all of the PG policy options (see Appendix H).

### AFW-7. Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover

Forestland captures and stores carbon dioxide in trees, soil, and other forest biomass. Developed areas contain lower amounts of biomass and its associated carbon. These developed areas also sequester less carbon dioxide than forested areas. The PG recommends reducing the rate of forest loss by 7% by 2010 and 50% by 2028. This policy option will be much more likely to succeed if the other forestry policy options are also adopted. Collectively, these options provide a variety of economically driven incentives to keep forest land from being developed, while providing an increase in the types of wood products that provide GHG benefits (through sequestered carbon and biomass energy).

### AFW-8. Expanded Production and Use of Durable Wood Products (Especially from VT Sources)

The PG recommends increasing the supply and demand of wood products produced and used in Vermont. Increasing production of high density, quality sawlogs with subsequent use of these products in durable wood products (e.g., building materials and furniture) is important for ensuring net carbon benefits associated with the forest management envisioned in AFW-5. Improvements in the efficiency of wood utilization can enhance the amount of carbon stored in durable wood products. Development of markets for high value wood materials promotes the retention of forestland as actively managed, productive forests, thereby enhancing carbon dioxide sequestration.

This policy seeks to implement forest management on 95,238 acres per year and harvest 1.3%/year from 2008 to 2028. It also seeks to increase wood products use by 2% by 2012 and 10% increase by 2028. Wood products have lower embodied energy than many types of building materials (e.g., cement and steel). To the extent that wood products displace products with higher embodied energy, additional GHG benefits occur.

### AFW-9. Advanced/Expanded Recycling and Composting

The PG recommends that Vermont 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). The goal is to increase the current per capita diversion from 30% to 50% by 2028. Reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing and distribution of products from raw materials. Use of waste materials as a fuel source can further reduce emissions by offsetting fossil-based energy sources. The PG finds that combinations of defining, developing, implementing, and promoting sustainable recycling practices are needed to make sure that recycling and composting increase in Vermont. Specific recommendations are outlined in the Implementation Mechanisms section of AFW-9 in Appendix H.

### AFW-10. Programs to Reduce Waste Generation

The PG recommends that Vermont institute programs to reduce waste generation at the source to reduce downstream emissions at the waste management site and for transporting these materials to the site. GHG reductions would also occur upstream, through lower energy use in product manufacturing and distribution. The policy would reduce the rate of municipal solid waste generation to 50% below the 2005 actual rate of 5.4 pounds per person per day.

### AFW-11. Water and Wastewater Treatment – Energy Efficiency Improvements

The PG recommends that Vermont pursue energy efficiency programs at water and wastewater treatment plants (WWTPs). These programs can reduce GHG emissions by reducing consumption of electricity to run pumps, fans, and other electrical equipment. Included in this option is a review of the potential for installing anaerobic digesters for biosolids and subsequent use of the methane as an energy source for generating electricity (e.g., using internal combustion engines or microturbines). The goal is to develop an energy conservation, management, and efficiency plan to increase energy efficiency of plant operations by 25% and to use wastewater digester gas to produce energy where feasible.

### AFW-12. In-State Liquid Biofuels Production

The PG recommends that Vermont increase incentives for biofuels (biodiesel and ethanol) production in the state. Use of biodiesel offsets the consumption of diesel fuel produced from petroleum (petrodiesel). Since biodiesel has a lower GHG content than petrodiesel, overall GHG emissions are reduced. This option also seeks to offset fossil fuel use (gasoline) with in-state production of ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content. The goal levels and timing for increasing production of biofuels in Vermont are provided in the AFW-12 policy option description in Appendix H.

This option is paired with TLU-5 on Alternative Fuels and Infrastructure, which targets methods for increasing biofuels consumption in the state. Optimum GHG benefits are achieved when the biofuel consumed in the state is produced in-state from crops that are much more efficient than conventional crops/production methods (i.e., have lower carbon content). For example, cellulosic ethanol has a much lower carbon content than conventional starch-based (corn) ethanol. Also, several crop types could be used to supply vegetable oil for biodiesel production that are more efficiently produced than soybean oil. There appears to be limited in-state capacity for significant vegetable oil production (one of the primary feedstocks for biodiesel production). Similarly, there is limited in-state production capacity for starch-based feedstocks to produce ethanol. Therefore, this option includes incentives for research and development of cropping systems and emerging technologies (e.g., algal biodiesel and cellulosic ethanol), as well as scaling up these cropping/production systems to a commercial level.

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# Chapter 6
# Cross-Cutting Issues

## Overview of Cross-Cutting Issues

Many issues relating to climate policy cut across multiple, or even all, sectors. The Plenary Group (PG) addressed such cross-cutting issues explicitly in a separate Cross-Cutting Issues (CC) Technical Work Group (TWG). These issues include inventorying and forecasting Vermont's greenhouse gas (GHG) emissions; reporting and registration of GHG emissions and reductions by companies and other entities, possibly for long-term credit and/or recognition; a wide variety of public education and outreach initiatives regarding climate change; an assessment of Vermont's GHG reduction goals; adaptation; and leading by example. The CC TWG developed policy options addressing these issues.

Some initiatives are already under way in Vermont for inventorying, reporting, and registering GHG emissions. Vermont is also leading by example through its multiagency Climate Neutral Working Group (CNWG). Implementation of the PG's recommendations regarding multistate initiatives—such as the *Regional Greenhouse Gas Initiative* or *The Climate Registry*—will help ensure that Vermont's interests are adequately represented in the development of broader regional and national initiatives that are likely to ultimately frame national climate change policy outcomes.

## Key Challenges and Opportunities

The GHG reporting and registry programs referenced above present special challenges and opportunities. Regional, national, and international efforts involve reconciling the interests and perspectives of different states and provinces. This is especially true in New England with its relatively small states adjacent to Canada. Vermont will especially benefit from the enhanced effectiveness of GHG reporting and registry programs if they are implemented on a broader regional and/or national basis instead of through separate, state-by-state efforts. The PG similarly recognized the importance of improving Vermont's GHG emissions inventory and forecasting capability. These are essential elements of understanding where emissions reduction opportunities lie, what emission trends are developing, and the extent to which progress is being made toward goals.

Public education and engagement programs can be difficult to develop and measure, but successful climate action will ultimately hinge on the public's awareness of climate risks and solutions. Many community- and nonprofit-based climate outreach efforts are already underway in Vermont. The State may be able to effectively leverage and support these and additional public engagement efforts by utilizing its low population density to precisely target specific audiences.

Establishing GHG reduction goals or targets creates a future vision that helps drive progress toward it. The PG reviewed the aggressive goals already established by the Governor and the Legislature and concluded that the 2012 target of reducing emissions 25% below 1990 levels was difficult, but within range, and the longer-term 2028 target of 50% below 1990 levels was achievable, particularly with efforts to protect and enhance Vermont's ability to biologically sequester carbon in its farms and forests.

## Overview of Policy Recommendations

Cross-cutting issues include policies and measures that may apply broadly across sectors and activities. Cross-cutting recommendations typically encourage, enable, or otherwise support emissions mitigation activities and/or other climate actions. The PG recommended that seven such policies be adopted and implemented by Vermont as listed in Table 3-1. All seven are enabling policies and were thus not quantified in terms of tons of GHGs directly reduced or expected costs to do so.

**Table 3-1. PG policy option recommendations for Cross-Cutting Issues**

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| CC-1 | GHG Inventories and Forecasts | *Not quantified* | | | | | UC |
| CC-2 | GHG Reporting | *Not quantified* | | | | | UC |
| CC-3 | GHG Registry | *Not quantified* | | | | | UC |
| CC-4 | Public Education and Engagement | *Not quantified* | | | | | UC |
| CC-5 | Adaptation | *Not quantified* | | | | | UC |
| CC-6 | Options for State GHG Goals or Targets | *Not quantified* | | | | | UC |
| CC-7 | The State's Own GHG Emissions | *Not quantified* | | | | | UC |

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; UC = unanimous consent.

GHG emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks, the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. The primary responsibility for preparing GHG inventories and forecasts should lie with the Vermont Department of Environmental Conservation (DEC), because much of the necessary capacity already exists there.

GHG reporting is the measurement and reporting of GHG emissions by sources to the State in order to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and help Vermont prepare periodic state GHG inventories. GHG reporting is also a necessary precursor to participation in all GHG registry and reduction programs.

A GHG registry enables uniform measurement and recording of GHG emissions reductions in a central repository. Along with other Northeast states, Vermont has been leading an effort to establish a common, high-integrity GHG emission reductions registry system. During the course of the PG's efforts, broad state interest in GHG reporting and registries coalesced in the establishment of *The Climate Registry*, a uniform GHG reduction registry platform suitable for all states. Building on the progress established by the California Climate Action Registry and the Eastern Climate Registry, a wide array of states developed a unified path forward that promises to meet most if not all of the GHG reporting and registry needs of the states, including voluntary GHG reporting, mandatory GHG reporting, and allowance reconciliation. Ultimately, this registry could serve as the foundation for trading and other transactions associated with GHG reductions. *The Climate Registry* now includes all but a few U.S. states, several Canadian provinces, and some Mexican states. Vermont's ground-floor involvement in the formation of *The Climate Registry* should enhance its ability to ensure that key sources and sectors (e.g., agriculture and forestry, biological carbon sequestration) are included as soon as possible.

Public education and engagement proposed by the PG will be the foundation for long-term success of all mitigation actions advanced in the State. It is vital to foster a broad awareness of climate change problems and effects (including co-benefits such as clean air and public health) and to encourage action among the State's citizens. These efforts are already underway in Vermont, because many diverse, forward-looking community, academic, and nonprofit groups have developed education and outreach activities and initiatives to engage Vermont citizens.

Because of the buildup of GHGs in the atmosphere that has already resulted from manmade emissions, Vermont will experience the effects of climate change for years to come, even if immediate action is taken to reduce its future GHG emissions. It is thus essential that the State develop a plan to identify its vulnerabilities due to a changing climate and to adapt to and manage the projected impacts of global warming to the greatest extent possible.

The GHG goals established by Gov. Douglas's Executive Order 07-05 and the Vermont Legislature call for reducing Vermont's GHG emissions to 25% below 1990 levels by 2012, 50% below 1990 levels by 2028, and 75% below 1990 levels by 2050. The policy options being considered by the GCCC-PG primarily address the 2012 short-term goals and the 2028 medium-term goals because of the uncertainties inherent in quantifying policy options as far out as 2050. The PG's quantified policy recommendations aggregate to a total slightly short (~6%) of the 2012 goal on a statewide basis. However, projected GHG reductions in 2028 exceed the mid-term goal significantly. As a result, total cumulative emissions from 2012 to 2028 (i.e., the area under the curve) reflect greater reductions than would have been achieved by comporting with straight-line emissions between the 2012 and 2028 targets. Because the atmospheric lifetime of GHGs is long (decades to centuries), the cumulative burden of GHG emissions determines the degree of climate impact this century, so this area-under-the-curve comparison makes sense. However, the PG recommends no delay in implementing GHG emissions reductions in order to avoid the need for steeper reductions in the future. Further, implementation of the proposed policies is expected to provide significant benefits to Vermont's economy by reducing fuel costs through efficiency measures, by reducing the export of capital from the state, and by stimulating the Vermont economy through the creation of jobs in energy efficiency and renewable energy development.

The PG believes that the State can and should take the lead in demonstrating that GHG emission reductions can be achieved by analyzing its current operations, identifying significant GHG sources, and implementing changes in technology and behavior. The State has already established reduction targets for its own GHG emissions, wherein each agency is establishing its own reduction efforts, aided by participation in the CNWG. The CNWG will be helpful for setting an example and building expectations.

Detailed descriptions of the individual Cross-Cutting Issues policy options as presented to and approved by the PG can be found in Appendix I.

# Appendix A
# Executive Order

This appendix contains Executive Order No. 07-05. It created the Governor's Commission on Climate Change. The Plenary Group was convened shortly afterwards to undertake the climate planning process described in Appendix B.

**Vermont Governor's Commission on Climate Change –**
**Executive Order No. 07-05  December 5, 2005**

WHEREAS, the Conference of the New England Governors and Eastern Canadian Premiers recognizes that "scientific evidence of the destabilizing human influence on global climatic systems is continuing to build, creating a growing momentum for a response;" and

WHEREAS, it is imperative that governments work individually and collectively to address the economic, environmental and societal consequences of climate change; and

WHEREAS, Vermont's goal is to reduce emissions by an amount consistent with the recommendations of the Conference of the New England Governors and Eastern Canadian Premiers Climate Change Action Plan; and

WHEREAS, the goals established by the Conference are to reduce region-wide greenhouse gas emissions from the 1990 baseline by twenty-five percent by 2012, fifty percent by 2028 and, if practicable using reasonable efforts, seventy-five percent by 2050; and

WHEREAS, the State of Vermont, recognizing that state government activities contribute to climate change, has been proactive in developing ways in which state government can reduce greenhouse gas emissions; and

WHEREAS, in 2003 a Climate Neutral Working Group was established by Executive Order to recommend ways by which state government agencies and departments could reduce greenhouse gas emissions from state government buildings and operations; and

WHEREAS, the State of Vermont has implemented many of the recommendations of the Climate Neutral Working Group, including replacing older state-owned automobiles with more fuel-efficient vehicles, including hybrid vehicles, encouraging state employees to use these fuel-efficient vehicles rather than their own vehicles, building more efficient state facilities, purchasing only energy- efficient devices and developing a State Agency Energy Plan to reduce state government's energy use; and

WHEREAS, recognizing that emissions from cars and other vehicles are the largest source of greenhouse gas emissions in Vermont, the Agency of Natural Resources is implementing new emissions standards that will reduce Vermont's greenhouse gas emissions; and

WHEREAS, several entities within state government, including the Department of Environmental Conservation, the Department of Public Service, and the Public Service Board are participating in developing the Regional Greenhouse Gas Initiative (RGGI), under which signatory states would act together to control emissions of carbon dioxide from electricity-generating power plants within those states; and

WHEREAS, it is important that the State of Vermont take the lessons learned from these efforts and develop and implement an effective statewide greenhouse gas emissions reduction program; and

WHEREAS, it is important for Vermonters to understand climate change and its economic, environmental and societal consequences, and be provided strategies to take personal responsibility for addressing the problem.

NOW THEREFORE, pursuant to the authority vested in me as Governor of the State of Vermont, I, James H. Douglas, do hereby create the Governor's Commission on Climate Change. The Commission shall consist of no more than six members appointed by the Governor. The Governor shall appoint a Chair. The Vermont Department of Environmental Conservation shall provide administrative and technical support to the Commission, and the Commission may call upon other state agencies or departments to assist as appropriate in implementing this Order and achieving its purposes.

The Commission shall be advisory to the Governor and shall have the following functions and duties:

1. To examine the real and potential effects of climate change on Vermont, including, but not limited to the impact of climate change on public health, natural resources and the economy; and

2. To produce an inventory of existing and planned actions that contribute to greenhouse gas emissions in Vermont; and

3. To educate the public about climate change and develop educational tools that will help Vermonters understand how they, as individuals, can play a role in reducing greenhouse gas emissions; and

4. To request input from representatives of the business, environmental, forestry, transportation, non-profit, higher education, municipal and other sectors regarding opportunities to reduce emissions and conserve energy; and

5. To develop recommendations to the Governor to reduce greenhouse gas emissions in Vermont, consistent with Vermont's need for continued economic growth and energy security. These recommendations, and all other pertinent information, shall be included in a Climate Change Action Plan that shall be submitted to the Governor no later than September 1, 2007. The Commission may also, as it sees fit, make interim recommendations to the Governor prior to issuing a final report.

This Executive Order shall take effect upon signing and shall expire upon the issuance of a final Climate Change Action Plan by the Commission.

Witness my name hereunto subscribed and the Great Seal of the State of Vermont hereunto affixed at Montpelier this 5th day of December, 2005.

James H. Douglas, Governor

By the Governor:

Neale F. Lunderville, Secretary of Civil and Military Affairs

Executive Order No. 07-05

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# Appendix B
# Description of Plenary Group Process

This appendix contains a memo by the Center for Climate Strategies describing the facilitated stakeholder process that Vermont's Plenary Group would follow (presented at the group's first meeting, September 7, 2006.)

Date: August 13, 2006

To: Jeff Wennberg, Commissioner, Vermont DEC

cc: Ernie Pomerleau, GCCC Chair
Dick Valentinetti, Director, Vermont APCD
Harold Garabedian, Deputy Director, Vermont APCD
Jeff Merrell, Environmental Analyst, Planning Section, Vermont APCD

From: Tom Peterson, Center for Climate Strategies
Ken Colburn, Center for Climate Strategies

Re: Vermont Climate Action Plan Process

**1. Background and Purpose, Structure, and Goals of the Process**

On December 5, 2005 Governor Douglas issued Executive Order 07-05 establishing a Governor's Commission on Climate Change (GCCC)—a broad-based group of six Vermont leaders—charged with developing a comprehensive Vermont Climate Change Action Plan by September 1, 2007. The GCCC is to oversee a public effort to examine climate change impacts on the State; secure input from all sectors regarding existing, planned, and potential ways to reduce greenhouse gas emissions; help educate the public about such opportunities; and consider ways to save money, conserve energy, and bolster Vermont's economy, natural resources, and public health. The Governor has tasked the Vermont Department of Environmental Conservation (DEC) with administering the GCCC process and providing technical support to it. In turn, you have selected the Center for Climate Strategies (CCS) to partner with you in forming and conducting a statewide public climate action planning process to meet these goals.

This memorandum represents our agreement moving forward in terms of the basic process design, schedule, budget, and the technical team for the project, recognizing of course that flexibility will be important as we proceed. It spells out our recommendations for the Vermont Climate Action Plan (VCAP) process based on our conferrals with you to date and our experience leading similar initiatives in other states.

The GCCC and DEC will direct and administer the development of the VCAP, but believe that input and assistance from an array of participants providing an even broader reflection of Vermont's interests and expertise will contribute materially to the process, particularly in important areas of technical focus. Accordingly, the GCCC and DEC will identify and select a broad cross-section of public members to serve as a Plenary Group (PG) and to form the core of accompanying sector-based Technical Work Groups (TWGs). The TWGs will focus on identifying and recommending potential policy options for PG consideration in the following areas: energy supply and use (including industrial process GHG emissions); transportation and land use; agriculture, forestry, and waste; and cross-cutting issues such as public education and emissions reporting. In considering policy options to reduce greenhouse gas (GHG) emissions in these sectors, the PG will be advised by the TWGs and the public. The TWGs will consider a wide array of policy options by sector, identify priority options for analysis, assess the GHG reduction benefits, costs, and other attributes of these options, and submit them for review, modification, and approval by the PG. The PG, in turn, will combine and forward a multi-sector set of recommended policy options to the GCCC for its consideration and approval in making its final recommendations to the Governor.

The goal of the PG will be to seek (but not mandate) consensus on its recommendation to the GCCC of a comprehensive series of individual potential policy actions to reduce GHG emissions in Vermont. The level of support for specific actions and the full range of PG views will be documented. Statewide targets and or goals—to the extent that they are sought and developed—will be based on further discussions with the GCCC, the DEC, and the PG.

Following final review and approval of recommended policy options by the GCCC, CCS will compile and provide the GCCC's recommendations to the Governor, GCCC, and DEC in a final report. This report will include the following items and issues:

1. Executive Summary
2. Background, Purpose and Goals
    a. Description of the GCCC and PG Process
    b. Overview of Potential Climate Impacts in Vermont
    c. History and Status of State Actions
    d. Inventory and Forecast of State Emissions
3. Policy Recommendations
    a. Agriculture, Forestry, and Waste
    b. Energy Supply and Use (including Industrial Processes)
    c. Transportation and Land Use
    d. Cross-Cutting Issues (including public education and outreach, GHG emissions reporting, and GHG registries).
4. Appendices

## 2. Timing and Milestones

The GCCC has been appointed and has held its initial framing meeting. The members of the PG, however, must be identified and formally invited to participant in the VCAP development effort. In addition, an updated GHG emissions inventory must be compiled, along with a forecast reflecting anticipated growth in Vermont's GHG emissions, along with a compendium or "catalog" of climate actions considered or undertaken in Vermont and other states. Further, it may be appropriate at some point to consider a meeting of the GCCC's Plenary Group coincident with a broader climate change symposium, perhaps sponsored by UVM and attended by Vermont political and other leaders.

GCCC, DEC, and CCS have jointly identified September 7, 2006 as the target date for convening the PG. Following this launch, up to five additional PG meetings will be held through July 2007. The PG's recommendations to the GCCC would be reviewed and finalized by the GCCC in August 2007, allowing the GCCC to provide its report to the Governor by September 1, 2007 as directed in Executive Order 05-07. We expect one or two TWG conference calls to be held between PG meetings as needed. Periodic meetings of the GCCC during the September 2006 through July 2007 period, and its work meetings in August 2007, will be scheduled in consultation with the GCCC and DEC.

### 2.1 Draft Project Calendar (assuming 6 PG meetings)

| | |
|---|---|
| September 7, 2006 | 1st PG meeting |
| November 2006 | 2nd PG meeting |
| January 2007 | 3rd PG meeting |
| March 2007 | 4th PG meeting |
| May 2007 | 5th PG meeting |
| July 2007 | 6th PG meeting |
| August 2007 | GCCC review meetings (as needed) |
| Between PG Meetings | Work group conference calls and meetings |

### 2.2 Draft PG and TWG Meeting Agendas

MEETING ONE

- Introductions
- Purpose and goals
- Review of the PG process and GCCC role and oversight
- Review of the Draft Vermont GHG emissions inventory and forecast
- Identification of existing actions being taken in Vermont and other states
- Key policy opportunities and issues
- Preliminary formation of TWGs; next meeting agenda

Interim TWG calls will cover: (1) suggested revisions to the draft inventory and reference case forecast; (2) review and suggested modifications to the "catalog" of potential Vermont policy actions; and (3) preliminary ranking of policy options and suggested initial priorities for analysis.

MEETING TWO

- Recommended updates to inventory and reference case forecast
- Discussion of additions to the "catalog" of potential Vermont policy actions, as needed
- Review and discussion of initial TWG priority options for analysis

- Review of TWG plans

Interim work group calls will cover: (1) suggested final revisions to the state emissions inventory and reference case forecast; (2) review of the PG modifications to the list of initial TWG priority options for analysis; and (3) next steps regarding the development of straw proposals for the design and analysis of initial policy options.

MEETING THREE

- Final agreement on inventory and reference case forecast
- Approval of TWG lists of initial policy priorities for analysis
- Discussion of policy design and implementation mechanisms for policy options; process for developing straw proposals for policy options

Interim TWG calls will cover: (1) development of straw proposals for design parameters for individual policy options; (2) identification of potential implementation mechanisms for policy options; and (3) next steps for analysis and quantification of policy options.

MEETING FOUR

- Review of policy options list, straw proposals for policy design, and early results of analysis
- Guidance to TWGs on additions, deletions, and modifications of policy options
- Identification of alternative policy designs and implementation mechanisms, as needed.

Interim TWG calls will cover: (1) revisions to draft final policy priorities and design parameters, including implementation mechanisms; and (2) next steps for draft analysis and quantification of policy options and design alternatives.

MEETING FIVE

- Review of options list, with results of analysis and cumulative emissions reductions potential
- Identification of consensus and non-consensus options
- Identification of barriers and alternatives for non-consensus options, with guidance to the TWGs for additional work on policy options
- Review of progress and plans toward final report progress and plans

Interim TWG calls will cover: (1) final revisions to policy design parameters, including implementation mechanisms; and (2) final analysis and quantification of policy options and alternatives.

MEETING SIX

- Progress report on non-consensus policy options list and cumulative emissions reductions potential

- Identification of consensus and non-consensus options from remaining list
- Identification of barriers and alternatives for non-consensus options, and proposals for resolution by the PG
- Discussion and final resolution of barriers and determination of consensus for remaining options
- Summary of the process, review of steps for review and transmittal of the final report

Interim TWG Activity: CCS team completes PG updates to policy options and drafts final report language.

REVIEW BY GCCC OF THE PLENARY GROUP RECOMMENDATIONS

FINAL GCCC REPORT TO THE GOVERNOR

## 3. Process Design

### 3.1 Activities of the PG process will be:

- Stepwise: The process will follow a set master schedule of discussion and decision items (milestones) and iterate to consensus (final agreement on recommendations).
- Fact-based: Technical analysis and policy design will be achieved through preliminary and joint fact-finding and, ultimately, joint policy development. PG and TWG members will be assisted in this task by CCS's facilitation and technical consulting team.
- Consensus-driven: The VCAP process will seek but not mandate consensus. Final recommendations by the PG to the GCCC will be made through decision criteria and voting procedures that allow a full expression of viewpoints. Four voting categories will be used, including: unanimous consent (all agree), super majority (e.g., 75 percent agree), majority (51 percent agree), and minority view (less than 50 percent agree).
- Self-determined: The process will start with no pre-commitments to particular policies. Priorities for analysis and final recommendations will be self-determined through informed judgments by the PG and TWGs. CCS will provide PG and TWG members with a compendium ("catalog") of existing actions in Vermont and other states to assist in identifying potential priority options for evaluation.
- Informal and non-binding: The process will be advisory and non-binding to the DEC, the GCCC, or the Governor in order to provide public input for potential future policy decisions. It will be structured as an informal consensus-building effort to provide a full opportunity for PG members to make voluntary decisions regarding policy recommendations.
- Transparent: The process will be transparent. Policy options will include clear design parameters such as levels, timing, coverage, and implementation

mechanisms. Technical analyses will include clear disclosure of data, methods, sources, and key assumptions and uncertainties. Proceedings will be posted to the project website by CCS after review for accuracy by DEC.

- Inclusive: The process will be overseen by the GCCC, administered by the DEC, and facilitated and coordinated by CCS. It will include a diverse group of PG and TWG members and provide regular opportunities for public input.
- Flexible: Throughout the process, the facilitation team will check with the GCCC, DEC, the PG, and participants regarding progress and any potential needs for revision. Based on conferral with the GCCC and DEC, CCS will share proposed changes openly with participants.

### 3.2 Key steps and parameters of the process include:

- Under the guidance of the GCCC and DEC and with the facilitation and assistance of CCS, the PG and TWGs will explore solutions in all sectors: energy supply and use, including industrial processes; transportation and land use; agriculture, forestry, and waste; and cross-cutting issues such as public education and GHG emissions reporting.
- The process will start with examination of a compendium or "catalog" of related policy actions being undertaken in Vermont or other states and regions; add new options as appropriate; adapt options to Vermont's specific circumstance; and reflect prioritization based on PG preferences.
- Mitigation of all GHGs will be examined, including carbon dioxide, methane, nitrous oxide, synthetic gases and, potentially, black carbon. Emissions will be expressed in metric tons (MT) of carbon dioxide equivalent (CO2e) units.
- A historical emissions and carbon storage inventory and reference case forecast will be developed for years 1990-2020.
- Recommendations for action will reflect the time period from the present to year 2020, with estimated benefit and cost impacts reported for years 2010, 2020, and cumulative through 2020.
- Recommendations may include state-level and multi-state actions (e.g., regional and national approaches), as well as voluntary and mandatory approaches.
- Recommendations will include both quantified and non-quantified actions, with emphasis on numerical analysis of GHG reduction potential and cost effectiveness to the extent possible under available funding and project timetables. Secondary impacts and additional issues will be evaluated on a case-by-case basis depending on PG input and resource availability.
- PG discussions will explore alternative policy designs and additional analysis as needed to reach final consensus, with assistance from the CCS facilitation team and the TWGs.
- The PG recommendations to the GCCC will include recommendations and participants' collective views on each policy option, including alternative views

as needed.

At the conclusion of the PG processes, its recommendations will be presented to the GCCC for its review and evaluation. A final report reflecting the GCCC's judgment and recommendations will be forwarded to the Governor.

### 3.3 State Leadership and Management

Vermont Governor Jim Douglas initiated and authorized the GCCC. GCCC Chairman Ernest Pomerleau, with the assistance of DEC Commissioner Jeffrey Wennberg and CCS, will launch and oversee a broader Plenary Group to allow substantial public input and assistance in considering appropriate climate policy responses for Vermont. CCS will organize and coordinate the PG process with logistical and notice support and assistance from DEC. CCS will report to DEC and the GCCC on behalf of the PG and provide facilitation and technical analysis to the PG and technical work groups. CCS will provide DEC documents for review prior to website posting for PG meetings, and will coordinate with DEC staff on technical assistance, logistical support, and other issues as needed.

### 3.4 Facilitation

Tom Peterson and Ken Colburn will serve as facilitators of the PG and consultants to the GCCC, with assistance from other members of the CCS technical consultant team. This facilitation team will also manage the TWGs. Facilitation responsibilities include:

- Reporting to the GCCC and DEC on behalf of PG members and providing coordination and management support for the PG process
- Direction and coordination of technical consultants and TWG leaders, including TWG meetings and calls
- Planning and supervision of PG meetings, calls, reports, and documents
- Facilitation and management of PG meetings
- Coordination of CCS activities with the GCCC and DEC, and other state agency technical and support staff as needed
- Conducting public meetings as needed.

To support facilitation and project management, CCS will provide a project website (www.vtclimatechange.us) for access by participants. This website will be used to share documents throughout the process. CCS will develop and design the site in coordination with DEC so that it is consistent with and links directly to existing State sites. DEC will approve the design of the site. CCS will be responsible for posting documents and managing the site. At the conclusion of the process, public materials from the website will be transferred to DEC for ongoing management and use by the State.

## 3.5 Facilitator Guidelines

As a part of its role as evaluative facilitator, CCS voluntarily abides by the model standards of conduct by the American Arbitration Association, American Bar Association, and the Association for Conflict Resolution as applicable to the PG process as an informal, consensus building initiative.

## 3.6 Technical Consulting

The CCS technical consultant team will serve as a neutral and expert group to inform and support the development of technical and policy consensus. Technical staff will perform analyses and provide support based on PG and TWG decisions. The team will be composed of the process facilitators and four technical work group leaders. Other consultants will be deployed as needed for specialized analysis or additional capacity. State agency staff and TWG members will be asked to assist in the formulation and analysis of options.

Prospective CCS TWG leaders include:

- Bill Dougherty/Sivan Kartha: Energy Supply & Use, Industrial Processes
- Will Schroeer/Lewison Lem/Karl Hausker: Transportation & Land Use
- Tom Peterson/Steve Roe/Katie Bickel/Holly Lindquist: Agriculture, Forestry, & Waste
- Ken Colburn/Randy Strait: Cross-Cutting Issues
- If necessary, CCS will adjust staffing of work groups in consultation with DEC.

General responsibilities of TWG leaders include:

- Providing assistance with fact finding for policy options and analysis
- Development of TWG plans and recommendations
- Development of TWG schedules, agendas, documents, presentations and reports
- Presentations to the GCCC, PG and TWG group members
- Coordination with facilitators, PG members, TWG members, consultants, agency staff
- Liaison with technical experts outside the process, as necessary
- Development of final report language, tables, and graphs.

Preliminary fact finding prior to the first PG meeting will include:

- Development of a draft Vermont emissions inventory and reference case forecast
- Identification of a compendium or "catalog" of conceivable Vermont GHG mitigation options for the PG's consideration, based on actions considered or undertaken in Vermont and/or other states.

Joint fact finding after the first PG meeting will include:

- Finalization of Vermont's GHG emissions inventory and reference case forecast

- Identification of a compendium or "catalog" of potential policy options for Vermont
- Identification of actions already underway in Vermont
- Ranking and identification of initial priority policy options for analysis
- Development of initial policy design parameters and evaluation methods (including technical agreement on appropriate data sources, methods and assumptions for analysis of policy options) and joint model development as needed
- Identification and analysis of alternative policy designs, including implementation mechanisms
- Final benefit and cost analysis, related analysis of secondary impacts, and feasibility and additional issues as needed
- Statewide and sector-based economic modeling, as needed subject to resource and time availability.

## 4. Participants

### 4.1 The Governor's Commission on Climate Change

The GCCC, appointed by the Governor, will provide overall direction and oversight to the PG process. GCCC members may also participate as members of the PG and TWGs.

### 4.2 Plenary Group Members

Individuals reflecting a variety of Vermont organizations and companies from all economic sectors will be selected by the GCCC and DEC to be members of the PG. They will be tasked with developing and approving recommendations for policy actions to be forwarded to the GCCC with assistance from the CCS team.

### 4.3 Technical Work Groups

TWG members will be comprised primarily of PG members assigned to specific sectors of interest. These work groups will be augmented with additional technical experts and interested parties as desired. PG members will be selected by the GCCC and DEC with assistance from CCS. TWGs will be organized during or promptly after the first PG meeting. The TWGs will advise the PG and complete tasks designated by the PG as priorities. Four TWGs will cover appropriate sectors, including: (1) energy supply and use (including heat and power, fuel supply, energy efficiency and conservation, and waste energy recapture); (2) transportation and land use; (3) agriculture, forestry, and waste management; and (4) cross-cutting issues such as public education, GHG emissions reporting, and registries.

The TWGs will be tasked with providing guidance to the PG on priority policy options for analysis, technical analysis and design of policy options, alternative approaches, and developing the PG's final recommendations to the GCCC.

### 4.4 The Public

The meetings of the PG will be conducted in accordance with open meetings and public information requirements of the State. Meeting notices, advance materials, and summaries of previous meetings will be made available to the public through the project website and other means. Opportunity for public input will be provided as a routine part of PG and TWG meeting agendas and by other means as may be developed to support the process and specific policy development.

### 4.5 State Agencies

State agency representatives will serve as voting members and/or non-voting technical advisors of the PG and TWGs. DEC will administer the PG process in coordination with CCS and assist CCS with planning and implementation of the process. DEC will provide input on policies and issues identified by PG members, the public, and TWG's as needed. DEC will provide logistical support for meetings, meeting facilities, public notice, and posting of materials as needed, with assistance and coordination by CCS.

### 4.6 Participant Guidelines

Advisory groups and technical work group members are expected to follow appropriate codes of conduct during the process, including:

- Attendance is strongly requested at all meetings to provide continuity to the stepwise process. Alternates may be named when absolutely necessary.
- Active involvement in proposals and evaluations is needed from each member to fully support the process of joint policy development.
- Good faith participation and full support of the process are required.
- In exchanging information and views, PG members should make fact-based offers and statements, and refrain from personal comments.
- PG and TWG members do not represent the State or advisory groups in contacts with the media.

# Appendix C
# Members of Technical Work Groups

* = Governor's Commission on Climate Change (GCCC) member
** = Plenary Group (PG) member

## ENERGY SUPPLY AND DEMAND

**Alan Betts,** Vermont Academy of Science and Engineering
**Debra Baslow,** Vermont Department of Buildings and General Services
**Gina Campoli,** Vermont Agency of Transportation (VTrans)
**Paul Comey,** Green Mountain Coffee Roasters**
**Sean Cota,** Cota and Cota, Inc.**
**Elizabeth Courtney,** Vermont Natural Resources Council (VNRC)*
**Richard Cowart,** Regulatory Assistance Project (RAP)**
**Robert DeGeus,** Vermont Department of Forests, Parks and Recreation
**Robert Dostis,** Vermont House Natural Resource and Energy Committee**
**Chris Dutton,** Green Mountain Power**
**Michael Dworkin,** Vermont Law School, Institute for Energy and the Environment**
**Don Gilbert,** Vermont Gas Systems**
**David Hill,** Vermont Energy Investment Corp. (VEIC) / Efficiency Vermont**
**Thomas Jagielski,** IBM**
**James Moore,** Vermont Public Interest Research Group**
**David O'Brien,** Vermont Department of Public Service**
**Dale Rocheleau,** Central Vermont Public Service Corp. (CVPS)**

Thanks also to Riley Allen, James Brown, David Lamont, Ellen Crivella, Janet Doyle, Matt Cota, Cheryl Jenkins, David Lyons, Bruce Bentley, and Brian Kieth for their participation on various TWG calls.

## TRANSPORTATION AND LAND USE

**Paul Cameron,** Brattleboro Climate Protection**
**Gina Campoli,** Vermont Agency of Transportation (VTrans)
**Chris Cole,** Chittenden County Transportation Authority
**Elizabeth Courtney,** Vermont Natural Resources Council (VNRC)*
**Catherine Dimitruk,** Northwest Regional Planning Commission
**Chuck Gallagher,** Vermont Agency of Transportation (VTrans)
**Colin High,** Resource Systems Group
**David Hill,** Vermont Energy Investment Corp. (VEIC) / Efficiency Vermont**
**Scott Johnstone,** Chittenden County Metropolitan Planning Organization**
**Chris Kilian,** Conservation Law Foundation**
**David Lewis,** Lewis Motors**
**Polly McMurtry,** Vermont Planners Association

**James Moore,** Vermont Public Interest Research Group**
**Jim Saudade,** Vermont Agency of Commerce and Community Development**
**Brian Searles,** Burlington International Airport*
**Carl Spangler,** Development Services LTD**

Thanks also to Eleni Churchill, Charles Mark, T.J. Poor, Aaron Frank, Meredith Birkett, David O'Brien, and Elaine Wang for their participation on various TWG calls.

## AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT

**Philip Benedict,** Vermont Agency of Agriculture, Food, and Markets
**John Casella,** Casella Waste Management**
**Elizabeth Courtney,** Vermont Natural Resources Council (VNRC)*
**Donald DeHayes,** University of Vermont / Rubenstein School of Natural Resources*
**Steve Faust,** Ensave
**Jackie Folsom,** Vermont Farm Bureau**
**Jennifer Jenkins,** University of Vermont / Gund Institute for Ecological Economics**
**Debra Sachs,** 10% Challenge / Alliance for Climate Action**
**William Sayre,** Economist, and Associated Industries of Vermont**
**Steve Wheeler,** Vermont Maple Sugar Makers' Association**
**Netaka White,** Vermont Biofuels Association
**Sandy Wilmot,** Vermont Department of Forests, Parks and Recreation

Thanks also to Paula Calabrese, Craig Metz, Abe Collins, Amos Baehr, Bill Driscoll, Elaine Wang, Erhard Frost, Jamie Fidel, Bruce Shields, and Bill Keeton for their participation on various TWG calls.

## CROSS-CUTTING ISSUES

**Theresa Alberghini DiPalma,** Fletcher Allen Health Care*
**Nadine Barnicle,** Canter Barnicle Communications
**Alan Betts,** Vermont Academy of Science and Engineering
**Paul Cameron,** Brattleboro Climate Protection**
**Paul Comey,** Green Mountain Coffee Roasters**
**Jon Isham,** Middlebury College**
**Virginia Lyons,** Vermont Senate Natural Resources and Energy Committee**
**Edward Mahoney,** Graduate Theology Program, St. Michaels College**
**David O'Brien,** Vermont Department of Public Service**
**Parker Riehle,** Vermont Ski Areas Association*
**Debra Sachs,** 10% Challenge / Alliance for Climate Action**
**Lisa Ventriss,** Vermont Business Roundtable
**Jeff Wennberg,** Vermont Department of Environmental Conservation

Thanks also to T.J. Poor, Elaine Wang, and Mark McElroy for their participation on various TWG calls.

# Appendix D
# Greenhouse Gas (GHG) Emissions Inventory and Reference Case Projections

See the report entitled "Final Vermont GHG Inventory and Reference Case Projection, 1990–2030," dated September 2007, for detailed documentation. The report is available at http://www.anr.state.vt.us/air/Planning/htm/ClimateChange.htm

# Appendix E
# Methods for Quantification

This appendix describes in brief the methodologies used in quantifying the greenhouse gas (GHG) impacts and costs of policy recommendations and provides some examples of the distinction between direct and indirect costs. These methods are based on the following widely accepted methods used by climate change mitigation policy analysts:

- **Focus of analysis—**Net GHG reduction potential in physical units of million metric tons of carbon dioxide equivalent ($MMtCO_2e$) and net cost per metric ton reduced in units of $/$MtCO_2e$.
- **Geographic inclusion—**Measure GHG impacts of activities that occur within the state, regardless of the actual location of emissions reductions.
- **Direct vs. indirect effects—**Define *direct effects* as those borne by the entities implementing the policy recommendation. For example, direct costs are net of any benefits or savings to the entity. Define *indirect effects* as those borne by entities other than those implementing the policy recommendation. Quantify these effects on a case-by-case basis depending on magnitude, importance, need, and availability of data. (See additional discussion and list of examples below.)
- **Non-GHG (ancillary) impacts and costs—**Include in qualitative terms where deemed important. Quantify on a case-by-case basis as needed, depending on need and where data are readily available.
- **Discounted and "levelized" costs—**Discount a multiyear stream of net costs (total costs net of any savings) to arrive at the "net present value cost" of a policy. Discount costs in constant 2005 dollars using a 5% annual real discount rate for the period 2008 through 2028. Capital investments are represented in terms of levelized or amortized costs through 2028. Create a levelized cost per ton by dividing the present value cost by the cumulative reduction in tons of GHG emissions. This is a widely used method to estimate the dollars per ton cost of reducing GHG emission (all in $CO_2$ equivalents). A levelized cost is a present value average used in a variety of financial cost applications.
- **Time period of analysis—**Count the impacts of actions that occur during the project time period and, using levelized emissions reduction and cost analysis, report emissions reductions and costs for specific target years such as 2012 and 2028.
- **Aggregation of impacts—**Avoid simple double counting of GHG reduction potential and cost when adding emission reductions and costs associated with all of the policy recommendations. Note and/or estimate interactive effects between policy recommendations using analytical methods where overlap is likely.
- **Policy design specifications—**Include timing, goal levels, implementing parties, and the type of implementation mechanism.

- **Transparency—**Include data sources, methods, key assumptions, and key uncertainties. Use data and comments provided by the Plenary Group (PG) and Technical Work Groups (TWGs) to improve data sources, methods, and key assumptions using their expertise and knowledge to address specific issues in Vermont.

The approaches here do not necessarily take a standard cost-benefit perspective as used in regulatory policy impact analysis. For instance, there is no direct/indirect distinction under standard procedures: one takes the societal perspective, tallies everything, and quantifies where possible. Regarding GHG mitigation costs, often the best available data are focused at the level of implementation as opposed to the societal level. Regarding GHG benefits, market prices (monetized benefits) are normally taken as good proxies of societal costs and benefits in standard analysis unless there are market imperfections or subsidies that create distortionary effects. Because we do not have good information on the dollar value of GHG reduction benefits, we use physical benefits instead, measured as $MMtCO_2e$.

The "direct cost" approach described here is useful in estimating the costs (and benefits) to the implementing entity, that is, person, company, or governmental body. "Indirect costs" (and benefits) are those experienced by other entities in society. In examining utility demand-side management (DSM) programs for gas and electric utilities, analysts sometimes look at three perspectives: participant, nonparticipant, and societal (the latter being equivalent to standard cost-benefit perspective). Depending on program design, direct cost to a DSM participant can be high or low (if the latter, it may be attributable to a shifting of some costs to nonparticipants).

Note also that the direct cost approach does not necessarily account for market imperfections or subsidies. Typically, a state perspective on direct costs takes any federal government subsidies as a given. For example, substantial federal government subsidies exist for some alternative fuels. If the existing market price (with subsidy) of the alternative fuel is used in cost analysis, the option appears as relatively low cost. If the subsidy were included in the cost analysis (i.e., looking at societal costs in the standard cost-benefit perspective), then the alternative fuel would appear more costly.

For additional reference, we recommend the economic analysis guidelines developed by the Science Advisory Board of the US Environmental Protection Agency (US EPA) available at: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html.

## Examples of Direct/Indirect Net Costs and Benefits, Energy Demand

**Direct Costs and/or Benefits**

- Net capital costs (or incremental costs relative to standard practice) of improved buildings, appliances, equipment (cost of higher efficiency refrigerator versus refrigerator of similar features that meets standards)
- Net operation and maintenance (O&M) costs (relative to standard practice) of improved buildings, appliances, equipment, including avoided/extra labor costs for maintenance (less changing of compact fluorescent light (CFL) or light-emitting diode (LED) bulbs in lamps relative to incandescent bulbs)
- Net fuel (gas, electricity, biomass) costs (typically as avoided costs from a "total resource cost" or societal perspective)

## Examples of Direct/Indirect Net Costs and Benefits, Energy Supply

**Direct Costs and/or Benefits**

- Net capital costs (or incremental costs relative to reference case technologies) of renewables or other advanced technologies resulting from policies
- Net O&M costs (relative to reference case technologies), renewables, or other advanced technologies resulting from policies
- Avoided or net fuel savings (e.g., gas, coal, biomass) of renewables or other advanced technologies relative to reference case technologies resulting from policies

Total system costs (net capital + net O&M + avoided/net fuel savings + net imports/exports + net transmission and distribution (T&D) costs) relative to reference case total system costs

## Examples of Direct/Indirect Net Costs and Benefits Not Quantified

There are other types of cost/benefit analyses that could affect the number in this report that were not undertaken as part of this project. These include:

**Direct Costs and/or Benefits (not quantified)**

- Cost value of net water use/savings
- Cost/value of net materials use/savings (for example, raw materials savings via recycling, or lower/higher cost of low global warming potential (GWP) refrigerants)
- Direct improved productivity as a result of industrial measures (measured as change in cost per unit output, for example, for an energy/GHG-saving improvement that also speeds up a production line or results in higher product yield) Indirect Costs and/or Benefits
- Re-spending effect on economy
- Net value of employment impacts

**Indirect Costs and/or Benefits (not quantified)**

- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (e.g., value of damage by air pollutants on structures or crops)
- Net embodied energy of materials used in buildings, appliances, equipment, relative to standard practice
- Improved productivity as a result of an improved working environment, such as improved office productivity through improved lighting fixtures and natural lighting (though the inclusion of this as indirect might be argued in some cases).

**Indirect Costs and/or Benefits**

- Re-spending effect on economy
- Higher cost of electricity reverberating through economy
- Energy security
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (e.g., value of damage by air pollutants on structures or crops)

## Examples of Direct/Indirect Net Costs and Benefits: Agriculture, Forestry, and Waste Management (AFW)

**Direct Costs and/or Benefits**

- Net capital costs (or incremental costs relative to standard practice) of facilities or equipment (e.g., manure digesters and associated infrastructure, generator; ethanol production facility)
- Net O&M costs (relative to standard practice) of equipment or facilities
- Net fuel (e.g., gas, electricity, biomass) costs or avoided costs
- Cost/value of net water use/savings

**Indirect Costs and/or Benefits**

- Net value of employment impacts
- Net value of human health benefits/impacts
- Net value of ecosystem health benefits/impacts (e.g., wildlife habitat; reduction in wildfire potential)
- Value of net environmental benefits/impacts (e.g., value of damage by air or water pollutants on structures or crops)
- Net embodied energy of water use in equipment or facilities relative to standard practice
- Reduced VMT and fuel consumption associated with land use conversions (e.g., as a result of forest/rangeland/cropland protection policies)

## Examples of Direct/Indirect Net Costs and Benefits: Transportation and Land Use (TLU)

**Direct Costs and/or Benefits**

- Incremental cost of more efficient vehicles, net of fuel savings
- Incremental cost of implementing Smart Growth programs, net of saved infrastructure costs
- Incremental cost of mass transit investment and operating expenses, net of any saved personal vehicle operating costs

**Indirect Costs and/or Benefits**

- Health benefits of reduced air and water pollution
- Ecosystem benefits of reduced air and water pollution
- Value of quality-of-life improvements
- Value of improved road safety
- Energy security
- Net value of employment impacts

# Appendix F
# Energy Supply and Demand
# Policy Recommendations

## Summary List of Policy Options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2030 (Million $) | Cost–Effective–ness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| ESD-1 | Evaluation and Continuation / Expansion of Existing DSM for Electricity and Natural Gas | 0.7 | 1.7 | 21.5 | –$850 | –$40 | UC |
| ESD-2 | Evaluation and Expansion of DSM to Other Fuels | 0.1 | 0.5 | 5.3 | –$335 | –$64 | Super-majority |
| ESD-3 | Building Efficiency Codes, Training, Tracking | 0.02 | 0.2 | 2.0 | –$107 | –$55 | UC |
| ESD-4 | Evaluate Potential for Contracting Nuclear Power | | | | | | Super-majority |
| | (Scenario 1) | 0.5 | 1.1 | 16.7 | –$140 | –$8 | |
| | (Scenario 2) | 0.3 | 0.7 | 10.2 | –$70 | –$7 | |
| ESD-5 | Support for Combined Heat and Power | 0.1 | 0.2 | 2.6 | –$86 | –$34 | UC |
| ESD-6 | Incentives and/or Mandate for Renewable Electricity | | | | | | Super-majority |
| | (Scenario 1) | 0.1 | 0.4 | 5.4 | $9 | $2 | |
| | (Scenario 2) | 0.2 | 1.2 | 15.7 | $38 | $2 | |
| ESD-7 | GHG Cap-and-Trade and/or GHG Tax | Referred to the GCCC as primarily a funding mechanism. | | | | | UC |
| ESD-8 | Incentives for Clean Distributed Technologies for Electricity or Heat | | | | | | UC |
| | Natural Gas Fuel Switching | 0.1 | 0.1 | 2.2 | $15 | $7 | |
| | Solar Thermal W ater Heating | 0.05 | 0.2 | 2.3 | $67 | $29 | |
| ESD-9 | Wind-Specific Support Measures | | | | | | UC |
| | (New Wind, Scenario 1) | 0.03 | 0.2 | 2.1 | –$6 | –$3 | |
| | (New Wind, Scenario 2) | 0.1 | 0.5 | 6.3 | $10 | $2 | |
| ESD-10 | Hydro-Specific Support Measures | | | | | | UC |
| | (Continued Large Hydro, Scenario 1) | 0.02 | 1.1 | 14.9 | $0 | $0 | |
| | (Continued Large Hydro, Scenario 2) | 0.01 | 0.6 | 8.7 | $0 | $0 | |
| | (New Hydro, Scenario 1) | 0.01 | 0.06 | 0.8 | –$22 | –$27 | |
| | (New Hydro, Scenario 2) | 0.03 | 0.2 | 2.4 | –$64 | –$27 | |
| | **Total** | | | | | | |
| | **Scenario 1 (Generation of Nuclear and Hydro at Historic Levels)** | **1.56** | **5.48** | **72.75** | **–$1,427** | **–$20** | |
| | **Scenario 2 (Generation of Nuclear and Hydro at 50% of Historic Levels)** | **1.56** | **5.37** | **70.35** | **–$1,328** | **–$19** | |

DSM = demand-side management; UC = unanimous consent; GHG = greenhouse gas; GCCC = .Governor’s Commission on Climate Change.

Note: Positive numbers for Net Present Value (NPV) and Cost-Effectiveness reflect net costs. Negative numbers reflect net cost **savings**.

## ESD-1. Evaluation and Continuation / Expansion of Existing DSM for Electricity and Natural Gas

### Policy Description

ESD-1 builds on Vermont's substantial existing demand-side management (DSM) efforts. It seeks to ensure that Vermont continues to achieve cost-effective energy efficiency, that energy efficiency services are adequately funded, and that they are fully integrated into the utility planning environment.

This policy seeks to stabilize and ensure that efficiency programs remain appropriately designed to deliver cost-effective system-wide programs, are appropriately targeted to ensure that reliable service is delivered at the lowest cost when considering alternative transmission and capacity additions, and are designed to exploit emerging opportunities for cost-effective energy efficiency.

### Policy Design

1. Ensure adequate funding, sound and appropriately focused program design, and ongoing delivery of electric and gas efficiency programs to capture all reasonably available cost-effective energy efficiency potential.
2. Explore ways to better integrate the efficiency utility into the resource planning environment in Vermont. Such a role is currently being deliberated in the context of Docket 7081 by the Vermont Public Service Board (PSB). For better resource planning and continuity, consider ways to effectively further institutionalize the role of Efficiency Vermont as a going concern rather than a time bounded performance contractor.
3. Explore ways to empower consumers to effectively respond to advanced time-of-use pricing programs (including reliance on utility or efficiency utility programs initiatives).
4. Consider ways to mitigate rate impacts of energy efficiency programs by allowing amortization of efficiency expenditures in order to reduce electric rate impact and increase generational equity.
5. Explore new avenues of oversight, accountability, and incentives for efficient delivery of efficiency services to ensure that the ratepayer funds used to deliver efficiency services are used as effectively as possible.
6. Foster the development of an effectively functioning competitive market for delivering efficiency services and/or programs. Ensure that the program strategies of the Energy Efficiency Utility (EEU) are consistent with this policy.
7. Foster resource neutrality in the planning, delivery, and payment for supply- and demand-side resources (e.g., allow regional cost recovery of investments in energy efficiency that avoid bulk transmission expenses otherwise borne by load-serving entities in the region).

**Goals:**

Based on results of the study by GDS Associates, Inc. (a consulting and engineering firm) titled *Vermont Electric Energy Efficiency Potential Study Final Report* (dated January 2007), an electric sector target of a 31% reduction relative to the reference case is recommended, to be achieved by 2028. This target, which was identified based on current commercial technologies, is a reasonable bound on what can be achieved, especially in light of future technological gains. The target thus should be updated on a periodic basis to take into account the commercialization of new technologies and other factors affecting the potential for or desirability of energy efficiency.

The ESD-1 and ESD-2 goals have been established in light of their combined potential to reduce greenhouse gas (GHG) emissions. The goals are defined with the explicit condition that they are to be met using efficiency measures and not by measures that switch from electricity to more carbon-intensive fuels that ultimately increase GHG emissions. It is also recognized that there may be measures that increase electricity consumption but decrease GHG emissions (such as shifting from conventional vehicles to plug-in hybrids) or that increase fuel consumption but decrease total GHG emissions (such as combined heat and power [CHP]). These types of measures should not be excluded from consideration.

Based on a preliminary estimate of energy efficiency opportunities in Vermont, the following are suggested targets:

- Efficiency improvements by 2015 that are sufficient to reduce consumption by 15% relative to the Vermont Department of Public Service reference projection.
- Efficiency improvements by 2028 that are sufficient to reduce consumption by 31% relative to the Vermont Department of Public Service reference projection. (Note that the 2028 goal is a provisional goal to be updated in light of emerging efficiency opportunities.)

**Timing:** as above.

**Parties Involved:** Residential, commercial, and industrial consumers of electricity and natural gas.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed that include greater specificity of the public cost stream and the total efficiency improvement potential and possible alternatives to an efficiency utility.

## Implementation Mechanisms

Efficiency Utility or Gas Utility, or other delivery modes for achieving energy efficiency cost-effectively.

## Related Policies/Programs in Place

Vermont has a history of leadership in the development and delivery of electric sector energy efficiency programs, beginning with early energy efficiency investment programs run by Vermont's electric utilities (and later by Vermont's Efficiency Utility). The majority of investments in energy efficiency within the electric sector are delivered under the auspices of

Efficiency Vermont. The remainder is delivered through the City of Burlington's Burlington Electric Department. Vermont Gas delivers its own energy efficiency programs, primarily directed toward thermal programs targeted at its own customers.

In 2004, Vermont led the nation in investment in energy efficiency programs of roughly $16.5 million, or $47.35 per customer. Vermont recently completed studies of electric energy efficiency potential, concluding that with an increase in investment, Vermont could reduce its 2015 electricity demand by 15% through cost-effective energy efficiency investments. After extensive review of the analysis and proposals, the Vermont PSB increased the efficiency investment by 75% above 2005 spending levels. (A complete summary of the analysis of the potential is available at the Vermont PSB's Web site at http://www.state.vt.us/psb/document/act61.htm). By 2008, Vermont expenditures on electric sector energy efficiency will be $31.75 million per year or approximately $91 per customer, almost double that of 2004. The Vermont PSB's Order noted that a further increase in funding would likely capture additional cost-effective efficiency savings, but that alternative funding mechanisms should be explored.

> In this Order we establish the Energy Efficiency Utility (EEU) budgets for 2006, 2007 and 2008 and announce a subsequent process to develop a means of financing energy efficiency services to reduce the impact of the Energy Efficiency Charge (EEC) on electricity rates in the near term. This Order is the outcome of a comprehensive, ten-month-long workshop process that followed Legislative action removing the former cap of $17.5 million on the annual EEU budget and requiring the Board to set a new level based on objectives and criteria in the law. In this Order we raise the 2006 funding level to $19.5 million, and establish funding levels of $24 million and $30.75 million for 2007 and 2008, respectively. We also conclude that higher funding levels may be appropriate, if the effect of levels on electricity rates in the near term can be reduced.

Based on increased program activity, Vermont is now projecting roughly level growth between 2008 and 2015, assuming these program funding levels continue over time.

In parallel and overlapping initiatives, Vermont is blazing new trails for use of energy efficiency resources by strategically targeting programs toward geographically constrained areas of the state in an effort to avoid later costly investments in transmission facilities. Programs associated with this initiative are known as geographically targeted (GT) efficiency programs. Vermont regulators are now deliberating over the establishment of a central planning and coordinating body known as the Vermont System Planning Committee (VSPC) that will be charged with, among other things, the systematic and strategic use of energy efficiency investments through GT programs to avoid or defer transmission investments. In the meantime, the Vermont PSB has directed that the increased program funding levels of the Efficiency Utility be directed toward constrained areas as a pilot and transition mechanisms pending the establishment of a broader planning framework.

Along with neighboring states, Vermont has also helped shape the character of the market for installed electric capacity (Forward Capacity Market) to include energy efficiency as an integral component of the resource base. This market is used in the region to ensure that there is adequate installed capacity to meet future demands for electricity. As it is designed, installed capacity can be bid in and delivered through either generation resources or energy efficiency programs and resources. In the future, Vermont will bid in and invest in energy efficiency programs to meet its own commitments associated with the development of emerging markets for capacity. Vermont is currently working with other states in the region to establish regional standards for measurement and valuation (M&V) of efficiency programs that participate in the market.

The nature and character of the efficiency utility and the programs and opportunities that may be explored through the efficiency utility will continue to evolve over time. The Vermont General Assembly is currently debating legislative proposals for requiring utility plans and investments in advanced metering technology and advanced time-of-use pricing programs known as “real-time” or “critical-peak-pricing” programs. Vermont’s efficiency programs, over time, will inevitably change in response to changing market circumstances and new technologies, including opportunities presented by advanced meter equipment and advanced time-of-use rates.

The Vermont General Assembly is also entertaining a proposal to expand the scope of programs delivered through the efficiency utility to include nonregulated fuels, such as heating oil, propane, and kerosene. Movement in this direction could potentially require substantial expansion of efficiency program activities (see ES-2).

More broadly, Vermont’s efficiency utility mechanism is undergoing tremendous change and will need to respond to and help inform the delivery of programs and policy choices for Vermont consumers and, in concert with the broader planning efforts, Vermont utilities, Vermont regulators, and the Vermont General Assembly.

In summary, Vermont has been a leader in its reliance on energy efficiency as a resource alternative to energy and new transmission resources. EVT is already undergoing major expansion and changes through the targeting of its program activities around GT and, potentially, nonregulated fuels in the future. It operates in a complex and dynamic market and technological environment.

## Type(s) of GHG Reductions

Net reduction in GHG emissions arising from electricity production (either in-state or out-of-state as appropriate) and natural gas usage.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** The Department of Public Service Electric Energy Efficiency Potential Study, prepared by GDS Associates.[1] Marginal emissions coefficients are reported by Independent System Operator (ISO) New England for the shorter term, as are the emissions coefficients of likely new generators (natural gas or a combination of natural gas with other generation types). While Vermont’s embedded resource mix reflects its overall costs, any reduction in energy demand that occurs in Vermont will reduce load in the region at the margin. Over the shorter term, this will translate into reductions in marginal emissions from embedded resources. Over the longer term, this will help displace investments in new generating capacity.

**Quantification Methods:** This analysis, which estimates potential and costs for electricity energy efficiency, builds on the recent comprehensive study “Vermont Electric Energy Efficiency Potential Study Final Report,” January 2007, by GDS Associates, prepared for the Vermont Department of Public Service. This study identified a total technical potential for

[1] http://www.publicservice.vermont.gov/energy-efficiency/vteefinalreportjan07v3andappendices.pdf

savings of 34.6% of electricity consumption in 2015 based on current technologies. It then took into account a maximum penetration rate (of 80%) and the slow stock turnover expected between the current year, 2007, and 2015, which together limited the achievable potential to 22.1%. This was modestly reduced to 19.4% by cost-effectiveness considerations, given fuel price projections available at the time of the study.

For this analysis, the GDS study results were adapted using the following assumptions:

1. We assume an ongoing DSM program up to the 2030 time horizon of the analysis, allowing much more time for stock turnover and implementation of efficient measures.
2. We assume an ambitious DSM program that incorporates outreach, education, training, and consumer incentives, all of which enable deep and continued penetration of the measures throughout the lifetime of the program.
3. We assume that the existing DSM program is complemented by other non-DSM efficiency measures such as standards, procurement requirements, building codes (see ESD-3), and real-time pricing, which contribute to deeper and more rapid penetration than would be available exclusively using a DSM delivery mode.
4. We neglect the DSM measures that are based on switching from electricity to other fuels. This entails subtracting ~22% of the efficiency potential that comes from such fuel-switching measures in the residential sector.
5. We assume, as does the study by GDS Associates, a modest reduction in each sector's potential to reduce the achievable potential to the cost-effective achievable, to eliminate measures that are not cost-effective.
6. As a result of these steps, we assume that the full energy efficiency potential that is ultimately achievable is the technical potential, minus a fuel switching portion, minus the non-cost-effective portion. This leads to an overall efficiency target of 31% below the reference case. We assume this can be implemented over the 20-year period from 2008 to 2028. Consistent with the results of the GDS Associates study, we assume a levelized cost savings of $52/MWh.

This quantification provides GHG reductions, costs, and savings from a full program of electrical efficiency. A corresponding evaluation of natural gas energy efficiency potential should be included in further detailed analysis.

**Key Assumptions:** As above.

## Key Uncertainties

The major uncertainties associated with the quantification are 1) the avoided energy costs and 2) the future efficiency potential, given technological advances.

## Additional Benefits and Costs

There are several additional benefits of energy efficiency that are not quantified here. As noted in the GDS Electric Energy Efficiency Potential Study, these additional benefits include

- improved electric sector reliability,

- reduced building maintenance costs,
- improved comfort and public health (e.g., elimination of mold due to better ventilation),
- enhanced worker productivity,
- decreased local air pollution,
- economic stimulus of increased discretionary income,
- reduced electricity prices and price volatility,
- improved energy services for low-income households, and
- increased in-state jobs in the energy efficiency industry.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-2. Evaluation and Expansion of DSM to Other Fuels

### Policy Description

ESD-2 aims to extend Vermont's substantial existing demand-side management efforts in electricity and natural gas (see ESD-1) to other fuels used in residential, commercial, and industrial establishments (oil, liquefied petroleum gas [LPG], or kerosene). This policy seeks to establish efficiency programs for fuels that are 1) appropriately designed to deliver cost-effective system-wide programs, 2) appropriately targeted to ensure that reliable service is delivered at the lowest cost, and 3) designed to exploit emerging opportunities for cost-effective energy efficiency.

### Policy Design

Consider various strategies and models for acquisition of energy efficiency through alternatives, including but not limited to an "all-fuels" efficiency utility targeting the above fuels.

**Goals:**

Based on the results of a second GDS Associates study titled *Vermont Energy Efficiency Potential Study for Oil, Propane, Kerosene and Wood Fuels* (dated January 2007, and referred to as the GDS "All-Fuels Study"), a fuel efficiency improvement target of 29% reduction relative to the reference case is recommended, to be achieved by 2028. This target, which was identified based on currently available commercial technologies, is a lower bound on what can be achieved. The target thus should be updated on a periodic basis, to take into account the commercialization of new technologies and other factors affecting the potential for or desirability of energy efficiency.

The ESD-1 and ESD-2 goals have been established in light of their combined potential to reduce GHG emissions. The goals are defined with the explicit condition that they are to be met using efficiency measures, and not through measures that switch from electricity to more carbon-intensive fuels that ultimately increase GHG emissions. It is also recognized that there may be measures that increase electricity consumption but decrease GHG emissions (such as shifting from conventional vehicles to plug-in hybrids) or that increase fuel consumption but decrease total GHG emissions (such as CHP). These types of measures should not be excluded from consideration.

Based on a preliminary estimate of energy efficiency opportunities in Vermont, the following targets are suggested:

- Efficiency improvements by 2016 that are sufficient to reduce consumption by 12% relative to the Vermont Department of Public Service reference projection.
- Efficiency improvements by 2028 that are sufficient to reduce consumption by 29% relative to the Vermont Department of Public Service reference projection. (Note the 2028 goal is a provisional goal to be updated in light of emerging efficiency opportunities.)

These targets are to be achieved through the combined impacts of ESD-2 and ESD-3. ESD-2 focuses on the DSM-related activities, while ESD-3 focuses on buildings codes and other connected activities.

**Timing:** As above.

**Parties Involved:** Residential, commercial, and industrial consumers (primarily of fuels for heating).

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed that include greater specificity of the public cost stream and the total efficiency improvement potential.

## Implementation Mechanisms

Efficiency Utility, coupled with other measures (as described in ESD-3).

## Related Policies/Programs in Place

The explanation of related policies for ESD-1 here is included by reference.

Building codes, appliance standards, time-of-sale disclosure requirements, expanded weatherization assistance, and other policies directed at thermal efficiency from nonregulated fuels and other programs that could similarly reduce the demand for nonregulated fuels (excluding transportation fuels).

In response to legislative request, the Vermont Department of Public Service recently prepared an analysis of efficiency potential for nonregulated fuels, concluding that the potential for reduction was 12% by 2016.[2] The savings potential from an investment of roughly $150 million over 10 years would yield a net benefit of $486 million. Savings opportunities for nonregulated fuels primarily center on thermal efficiencies for space and water heating and are associated primarily with # 2 heating oil.[3]

The Department of Public Service concluded that if an efficiency utility program were relied upon for delivery of the nonregulated fuel efficiency programs, the annual investment requirement would be in the neighborhood of $14.9 million per year.

Vermont would likely need to start slowly with a program like this because of the need for additional service providers. It is unlikely that Vermont could start immediately at a level of nearly $15 million per year.

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[2] Oil prices have risen since the last round of price projections were completed in December 2005. The results of the analysis, however, are relatively insensitive to oil price since there is little disparity between the "achievable potential" identified in the report and the "cost-effective achievable potential" identified in the report.

[3] The Department of Public Service report used avoided cost levels based on 2007 oil that costs around $40 a barrel. In light of current prices of nearly $60 per barrel, this provides a seemingly conservative estimate of the cost-effective savings available. The Department updates it fuel price projections on a biennial basis and should have new price projections in the summer of 2007.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** The Department of Public Service Electric Efficiency Potential Study titled *Final Report: Vermont Energy Efficiency Potential for Oil, Propane, Kerosene and Wood Fuels* (dated January 16, 2007, and hereafter referred to as the GDS All-Fuels Study, prepared by GDS Associates.[4]

The *Avoided Energy Supply Costs in New England* Study prepared for the Avoided-Energy-Supply-Component (AESC) Study Group in 2005 (by ICF, Inc.) and 2007 (by Synapse Energy Economics, Inc.) provide data on projected energy costs.

**Quantification Methods:** This analysis builds on the recent comprehensive GDS All-Fuels Study prepared for the Vermont Department of Public Service. This study identified a total technical potential for savings of fuel consumption in 2016 based on current technologies. It then assumed a maximum penetration rate (of 80%) and the slow stock turnover expected between the current year and 2016, which together limited the achievable potential, which was modestly reduced by cost-effectiveness considerations, given fuel price projections available at the time of the study.

For this analysis, we have adapted the GDS All-Fuels Study results using the following assumptions.

1. We assume an ongoing DSM program up to the 2030 time horizon of the analysis, allowing much more time for stock turnover and implementation of efficient measures.
2. We assume an ambitious DSM program that incorporates outreach, education, training, and consumer incentives, all of which enable deep and continued penetration of the measures throughout the lifetime of the program.
3. We assume that the existing DSM program is complemented by other non-DSM efficiency measures such as standards, procurement requirements, and building codes (see ESD-3), which contribute to deeper and more rapid penetration than would be available exclusively using a DSM delivery mode. The savings associated with existing buildings are estimated under ESD-2, while those associated with new buildings are estimated under ESD-3.
4. We assume that as a result of these steps, the full technical potential is ultimately achievable. The GDS All-Fuels Study included a modest reduction in each sector from the achievable potential to the cost-effective achievable, to eliminate measures that were not cost-effective. This leads to an overall efficiency target of 29% below the reference case. We assume this can be implemented over the 20-year period from 2008 to 2028. Consistent with the results of the GDS All-Fuels Study, we assume a levelized cost of fuel savings of $5.51/MMBtu.

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4 http://www.publicservice.vermont.gov/pub/other/allfuelstudyfinalreport.pdf

**Key Assumptions:** As above.

## Key Uncertainties

The long-term nature of this estimate introduces uncertainties associated with energy prices. (It is worth noting that the AESC2005 and AESC2007 studies differed in their electricity price estimates by ~$20/MWh.

## Additional Benefits and Costs

There are several additional benefits of energy efficiency that are not quantified here. As noted in the GDS All-Fuels Study, these additional benefits include

- reduced building maintenance costs,
- improved comfort and public health (e.g., elimination of mold due to better ventilation),
- enhanced worker productivity,
- decreased local air pollution,
- economic stimulus of increased discretionary income,
- reduced fuel prices and price volatility,
- improved energy services for low-income households, and
- increased in-state jobs in the energy efficiency industry.

In addition to investment capital and program administration, reduction in fuel demand may lead to an increase in unit fixed costs (as a fixed investment is spread over less fuel).

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Supermajority.

## Barriers to Consensus

To be determined.

## ESD-3a. Improved Building Codes

### Policy Description

This measure has two components. The first is a near-term option to allow for automatic updates of Vermont's Residential and Commercial Building Energy Codes based on updates to national energy codes (International Energy Conservation Code [IECC] or American Society of Heating, Refrigeration and Air-Conditioning Engineers [ASHRAE] 90.1). The second is a longer term measure to adopt a code to facilitate the greatly improved efficiency of buildings based on a set of targets such as the Architecture 2030 initiative that has been adapted to the state of Vermont's needs.[5]

### Policy Design

**Goals:**

Reduce the time it takes to update Vermont's Energy Codes to ensure that they reflect the most up-to-date version of the national energy codes (IECC or ASHRAE 90.1).

Develop a State of Vermont addendum for the Architecture 2030 initiative.

Ensure that the Energy Star benchmarking, target finder, and other valuable tools used to establish targets and goals and track progress are incorporated into everyday design.

Develop a "time-of-sale" energy requirement for exiting buildings ensuring that at the time of sale, they will be brought up to an improved efficiency level (which will continuously improve building efficiency).

**Timing:** Within 3 months after the national code update, Vermont's Energy Codes will be updated to reflect any increased efficiency requirements contained in the national update. Then 3 months after the Vermont update, the new Vermont Energy Code will go into effect, in total, a 6-month update cycle from release of the new national energy code.

**Parties Involved:** Vermont Department of Public Service, Efficiency Vermont, Vermont Gas Service, Burlington Electric Department, architects, engineers, contractors, builders, mortgage lenders, and legislators.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed, including an analysis of the impact of the time-of-sale provision on home ownership costs (purchase price and long-term operating costs) and the possibility of cost increases acting as a barrier to home ownership.

[5] http://www.architecture2030.org/

## Implementation Mechanisms

Vermont's Energy Codes legislation should be revised to allow for automatic updates of Vermont's Residential and Commercial Building Energy Codes based on updates to national energy codes (IECC or ASHRAE 90.1). When a new national energy code (IECC or ASHRAE 90.1) is updated, within 3 months the Vermont Department of Public Service will update Vermont's Residential and Commercial Building Energy Codes to reflect any increased efficiency requirements contained in the national update. Then, 3 months after the Vermont update, the new Vermont Energy Code will go into effect, in total, a 6-month update cycle from release of the new national energy code. An advisory board of regulators, architects, engineers and builders will guide the process as envisioned by the Commercial Buildings Energy Standards.

The time-of-sale energy requirement is currently on the books in the city of Burlington. The statewide requirement will be a part of the Vermont Energy Code to ensure that at the time of sale, existing buildings will be brought up to an improved efficiency level. The costs from the improvements can be borne by the seller (to improve the value of the building) or the buyer (to add as improvement costs in the mortgage).

The advisory board will also be tasked with the longer term measure as well. The advisory board will be responsible for adapting the Architecture 2030 initiative with an addendum to be consistent with the Vermont's localized issues such as the climate (e.g., temperature, humidity, and solar and wind opportunities), architecture (e.g., historic preservation, urban infill, and revitalizing efforts in towns), and funding (including constraints for state and federal government).

## Related Policies/Programs in Place

Vermont's Residential Building Energy Standards 21 V.S.A. (Vermont Statutes Annotated) § 266.

Vermont's Commercial Building Energy Standards 21 V.S.A. § 268.

US Environment Protection Agency's (EPA's) Energy Star Program.

City of Burlington time-of-sale energy requirement.

Burlington Electric Department and Efficiency Vermont provide statewide energy efficiency services that are funded by an EEC on electric utility bills. Burlington Electric Department and Efficiency Vermont can provide technical assistance and incentives to help the industry meet or exceed building codes.

Vermont Gas Service provides technical assistance and incentives to help the industry meet or exceed building codes.

## Type(s) of GHG Reductions

Reductions in GHG emissions primarily associated with the combustion of fossil fuels for heating buildings and generating electricity for consumption in buildings.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:**

The Department of Public Service Electric Energy Efficiency Potential Study, prepared by GDS Associates and the All-Fuels Study.[6]

Vermont's Commercial Building Energy Standards 21 V.S.A. § 268.

Burlington Electric Department and Efficiency Vermont provide statewide energy efficiency services that are funded by an EEC on electric utility bills. Burlington Electric Department and Efficiency Vermont can provide technical assistance and incentives to help the industry meet or exceed building codes.

Vermont Gas Service provides technical assistance and incentives to help the industry meet or exceed building codes.

**Quantification Methods:**

To estimate the GHG reductions and costs associated with this measure (and 3b and 3c), we have made the following assumptions:

1. We have taken an improvement of 50% over existing code to be cost-effective and feasible to phase in by 2015. (This level of cost-effective savings has been demonstrated and is in fact the threshold at which the 2005 EPAct [Energy Policy Act] authorizes EPA to provide a $2,000 tax credit to homeowners.)
2. We apply this level of improvement to new buildings, the baseline energy consumption of which we take to be the growth in demand over consumption in existing buildings, factoring in a 1.5%/year retirement rate of existing buildings.
3. To estimate costs, we first note that recent analyses from the New York State Energy Research and Development Authority (NYSERDA) (results of which were provided to the Energy Supply and Demand Technical Work Group [ESD TWG] by Vermont Energy Investment Corporation [VEIC]) find that 50% improvement over code is cost-effective. We conservatively estimate that the capital investment costs associated with the energy savings are comparable to the capital investment costs associated with fuel savings exploited by the DSM program for existing homes (see ESD-2 for details).

**Key Assumptions:** As above.

## Key Uncertainties

Energy price uncertainties are a key uncertainty, as are the costs associated with administering the policies required by ESD-3a, 3b, and 3c.

[6] http://www.publicservice.vermont.gov/pub/other/allfuelstudyfinalreport.pdf

## Additional Benefits and Costs

There are several additional benefits of energy efficiency that are not quantified here. As noted in the GDS Associates studies, these additional benefits include

- reduced building maintenance costs,
- improved comfort and public health (e.g., elimination of mold due to better ventilation),
- enhanced worker productivity,
- decreased local air pollution,
- economic stimulus of increased discretionary income,
- reduced fuel prices and price volatility,
- improved energy services for low-income households, and
- increased in-state jobs in the energy efficiency industry.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

# ESD-3b. Building Commissioning

## Policy Description

The State should assign an entity to develop and implement a comprehensive building commissioning, building recommissioning, energy tracking, and benchmarking program for builders, contractors, building managers, enforcement officials, and others.

## Policy Design

**Goals:**

To provide assistance to owners of buildings with more than 5,000 square feet.

To help building owners reduce energy usage in their buildings by ensuring that buildings are operating at peak efficiency.

To help building owners benchmark their buildings' energy use, identify high-use buildings, and allow prioritization of funds to improve energy efficiency where it is most needed.

To develop and implement an inspection for commissioning on a regular yearly basis or multi-year interval.

**Timing:** Policies could be implemented in a timely manner to place this option into operation in coordination with ESD-3a and ESD-3c.

**Parties Involved:** Vermont Department of Public Service, engineers, and architects.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed.

## Implementation Mechanisms

This entity can develop and deliver training on its own and work with other industry groups to assess ways to supplement or improve the training that already exists in the State.

The State should assign an entity to develop and institute a building commissioning, building recommissioning, energy tracking, and benchmarking program for builders, contractors, building managers, enforcement officials, and others.

## Related Policies/Programs in Place

Efficiency Vermont provides statewide energy efficiency services that are funded by an EEC on electric utility bills. Efficiency Vermont can provide funding for building commissioning and building recommissioning.

## Type(s) of GHG Reductions

Reductions in GHG emissions primarily associated with the combustion of fossil fuels for heating buildings and generating electricity for consumption in buildings.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** Efficiency Vermont provides statewide energy efficiency services that are funded by an EEC on electric utility bills. Efficiency Vermont can provide funding for building commissioning and building recommissioning.

**Quantification Methods:** See ESD-3a.

**Key Assumptions:** See ESD-3a.

## Key Uncertainties

See ESD-3a.

## Additional Benefits and Costs

See ESD-3a.

## Feasibility Issues

See ESD-3a.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-3c. Building Efficiency Codes, Training, Tracking

### Policy Description

The State should assign an entity to develop and implement an energy efficiency training and education program for builders, contractors, building managers, enforcement officials, and others. The objectives are to delivery high-quality training on various energy efficiency construction and energy management topics and to train building professionals to promote energy efficient construction and ensure ongoing energy management in buildings.

### Policy Design

See ESD-3a.

**Goals:** To develop and implement energy efficiency training and education programs for public and private sector actors who are involved in promulgation, implementation, and enforcement of building codes.

**Timing:** Policies could be implemented in a timely manner to place this option into operation in coordination with ESD-3a and ESD-3b.

**Parties Involved:** Vermont Department of Public Service, Efficiency Vermont, Vermont Gas Service, Burlington Electric Department, architects, engineers, contractors, builders, mortgage lenders, legislators, high schools, vocational schools, and adult education programs.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed.

### Implementation Mechanisms

The State should assign an entity to develop and implement an energy efficiency training and education program for builders, contractors, building managers, enforcement officials, and others. This training and education program should be expanded to include providers of non-electrical forms of energy that already have a program in place.

This entity can develop and deliver training on its own and can work with other industry groups to assess ways to supplement or improve the training that already exists in the State.

This entity can also be effective in assisting in the preliminary studies of energy optimization options and providing support for the design team and the owners.

This entity will submit a report to the Vermont Department of Public Service on a yearly basis to outline what has been accomplished and the goals for the following year. The Vermont Department of Public Service will also perform random inspections to ensure compliance by the entity.

## Related Policies/Programs in Place

Many trade groups for builders, architects, engineers, electricians, plumbers, and heating, ventilation, and air conditioning (HVAC) contractors provide training sessions for their members.

Many high schools or vocational centers offer training programs to the building trades.

Efficiency Vermont provides statewide energy efficiency services that are funded by an EEC on electric utility bills. Efficiency Vermont has provided training for contractors and builders on energy efficient construction.

## Type(s) of GHG Reductions

GHG emissions from fossil fuel combustion for residential and commercial energy services.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** See ESD-3a**.**

**Quantification Methods:** See ESD-3a.

**Key Assumptions:** See ESD-3a.

## Key Uncertainties

See ESD-3a.

## Additional Benefits and Costs

See ESD-3a.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-4. Evaluate Potential for Contracting Nuclear Power

### Policy Description

Nuclear power plants do not emit carbon dioxide ($CO_2$) during plant operation, and while there are carbon emissions during fuel processing, nuclear power emits considerably less carbon than fossil-fueled power sources. By obtaining a contract for nuclear power, Vermont utilities will be able to reduce $CO_2$ emissions from their generation portfolio. To the extent that additional power is produced from Vermont Yankee, which is not contracted to Vermont utilities, operation of Vermont Yankee will further reduce carbon emissions in the region.

Currently, Vermont's portfolio has heavy reliance on its single nuclear power plant, to the point where Vermont's utilities have concluded that insurance is warranted for protection in the event of an outage. A new contract with Vermont Yankee would likely be significantly smaller than the current obligation. Options for increasing nuclear power reliance would be to diversify the nuclear portfolio through additional contracts, trades, or swaps. These options can be developed by the purchasing utilities or by Vermont Yankee as its contract offer to Vermont. Including outage insurance in the contract could also help to mitigate exposure.

### Policy Design

Explore opportunities for engaging in replacement contracts with nuclear power generating stations or their owners to the benefit of Vermont consumers.

**Goals:** This option is examined in the form of two potential scenarios. In Scenario 1, nuclear power continues to contribute to Vermont's electricity supply on a scale similar to that of today, and in Scenario 2, nuclear power contributes roughly half what it contributes today.

**Timing:** The current Vermont Yankee contract expires in 2012. Vermont Yankee must also renew its operating license by 2012. The Vermont General Assembly is likely to vote before 2010 on whether or not the Vermont PSB should issue an order to approve or deny a new license for Vermont Yankee.

**Parties Involved:** Vermont legislature, Vermont PSB, Vermont Yankee, Vermont utilities, the public, and the Nuclear Regulatory Commission (NRC).

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed.

### Implementation Mechanisms

To implement this recommendation, several steps are necessary:

- The Vermont Yankee plant must receive a license extension from the NRC.
- Per agreement, the Vermont legislature must approve the license extension.
- The Vermont PSB must issue a certificate of public good for any continued operation of the facility.

- Vermont utilities must agree on contract terms that are acceptable to all parties and that provide sufficient benefit to justify continued operation of the plant.

Each of these steps is a significant undertaking by itself. Taken in combination, they require significant regulatory, legislative, and utility actions as well as acceptance by the public at each step.

Currently, about one third of Vermont's electricity requirements are supplied by this one plant. The Vermont Department of Public Service and others have long criticized Vermont's heavy reliance on one single plant. Should Vermont want to increase reliance on nuclear power above what is a reasonable amount for one plant to contribute, it will need to explore ways to mitigate this lack of diversification. This mitigation can be achieved through swaps with other nuclear plant owners (developed through efforts of the utilities or by Entergy) or by insurance mechanisms.

## Related Policies/Programs in Place

Integrated Resource Planning.

NRC relicensing procedures.

Legislative directives and approvals.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions from the electric sector, subject to interaction with the Regional Greenhouse Gas Initiative (RGGI).

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** NEPOOL (New England Power Pool) marginal emissions analysis. RGGI.

**Quantification Methods:**

The following two scenarios are considered:

**Scenario 1:** nuclear power continues to contribute to Vermont's electricity supply at a scale similar to that of today, which implies generation of approximately 2,000 GWh per year.

**Scenario 2:** nuclear power contributes roughly half what it contributes today, which implies generation of approximately 1,000 GWh per year.

The reference case alternative to the purchase of electricity from nuclear power is to purchase electricity from the ISO New England system. The net emissions impacts are the difference in life cycle emissions arising from nuclear generation appropriate for Vermont and the life cycle emissions associated with the avoided electricity purchases from the ISO New England system. For the purposes of the estimate calculated here, we take the nuclear emission rate as 0 $tCO_2$/MWh, and the regional ISO New England system rate is 0.63 $tCO_2$/MWh. Note that this figure is subject to all the uncertainties associated with the future expansion of the ISO New England electric sector. It may be higher or lower. However, since 0.63 $tCO_2$/MWh is the emission factor that is consistent with the inventory and forecast, it is the correct figure to use when assessing the effectiveness of the measure toward reaching the Vermont GHG reduction goals.

We do not make any assumptions about the relative cost of the nuclear power available to Vermont utilities. There are reasons to believe that Vermont utilities are in a good position to negotiate favorable rates with nuclear power generators relative to other potential sources of long-term contracted power. There are also reasons to believe that nuclear power might come with additional costs for ensuring high reliability and diversification.

We do assume that the current arrangement continues in which nuclear providers offer rate payers a price benefit equal to one half of the difference between the electricity price and a strike price of $61/MWh.

**Key Assumptions:** As above.

## Key Uncertainties

Energy prices are a key uncertainty, as is the nature of the contracting arrangement with the nuclear power provider.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Supermajority.

## Barriers to Consensus

The Plenary Group did not reach unanimous approval of this option because of concerns about Vermont’s continued reliance on nuclear power. Specifically, issues relating to nuclear reactor safety and nuclear waste storage were raised. This objection was further supported by the opinion that sufficient alternative sources of electricity exist to allow nuclear energy to be fully displaced.

## ESD-5. Support for Combined Heat and Power

### Policy Description

Identify and implement CHP where practical for meeting local heat requirements and generating power for local consumption and/or export to the grid.

Combined heating and power (CHP) (and, in some cases cooling as well) also known as co-generation, is a method of utilizing the thermal energy (heat) produced when generating electricity (power) in a single, coordinated process. CHP is more energy efficient than separate generation of electricity at a separate central electric plant and production of localized thermal energy for the end user. This distributed generation resource allows for recycling the heat, which is normally wasted to cooling towers or surface water at centralized electric generating stations, to meet onsite thermally driven demand, such as process and space heating, cooling, and dehumidification. This option is possible at locations where there is a year round demand for heat, cooling, and electrical power by organizations such as IBM, Fletcher Allen, University of Vermont, municipal district heating systems, and others to be identified.

### Policy Design

The proposed policy would encourage the adoption of CHP through a combination of regulatory improvements and expanded incentives and the adoption of output-based emission standards; it would also allow GHG-friendly business arrangements, such as third-party ownership of CHP-based generation.

**Goals:** Increase CHP generation in Vermont by 60 MW by 2028. This target can be met by using CHP systems for meeting local on-site heat demands and by using district heating systems for meeting municipal heat demands. CHP systems should be fueled only by energy sources that cause a net decrease in GHG emissions relative to separate electricity generation and heat production, given the characteristics of electric sector and fuel markets in Vermont.

**Timing:** As above.

**Parties Involved:** Pending.

**Other:** As with other proposed policies, further detailed analysis and evaluation of the recommended policy will be needed.

### Implementation Mechanisms

Identify locations within Vermont that would be suitable for utilization of CHP. Allow energy service companies to sell CHP output to third-party customers. Include consideration of CHP potential in decisions regarding expansion of natural gas in Vermont.

### Related Policies/Programs in Place

The policy design statements point to key related policies and programs that already exist at the national level in states such as California, Connecticut, New York, North Carolina, and Texas.

## Type(s) of GHG Reductions

Use of CHP in Vermont could reduce the overall GHG emissions from Vermont utilities and from fuel purchased for heating requirements.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:**

*Combined Heat and Power White Paper*, January 2006, Clean and Diversified Energy Initiative of the Western Governors' Association, www.westgov.org/wga/initiatives/cdeac/CHP-full.pdf

*A New Sustainable Energy Infrastructure for Brattleboro*, March 2007, Hervey Scudder and Morris A. Pierce.

**Quantification Methods:** We assume that the new 60 MW (electric) of CHP displaces electricity that would have otherwise been purchased from the ISO New England system. We assume that the electricity displaced has an emission factor of 0.63 $tCO_2$/MWh, consistent with the other ESD measures that displace ISO New England electricity. We assume the new CHP systems are fueled by a 50:50 combination of natural gas and biomass and that the heating fuel displaced is primarily fuel oil (90% of total), with the remainder being electricity and natural gas (5% each). Capital costs are $2,000/kW and $2,500/kW and non-fuel operations and maintenance (O&M) costs are $16/MWh and $20/MWh for natural gas and biomass systems, respectively.

**Key Assumptions:** As above.

## Key Uncertainties

None identified.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-6. Incentives and/or Mandate for Renewable Electricity

### Policy Description

This policy expands existing programs or adopts new incentives/mandates for expanding the role of renewable energy within the state and regional power mix. Currently, Vermont's electric sector is only a moderate contributor to carbon emissions in Vermont. Roughly 45% of Vermont's energy is attributable to low-GHG resources that include contracts for system power attributable to large hydro resources. However, Vermont's entitlements to many of its low-GHG sources are due to expire in the coming decade. To the extent that fossil-based generators would be needed to replace sources that are not renewed and to meet load growth, Vermont will need new low or non-emitting sources if it is to maintain its profile as a low emitter of GHG emissions in the electric sector.

### Policy Design

This policy has three elements: 1) expansion of voluntary green pricing programs; 2) continued reliance on or strengthening the Sustainable Priced Energy Enterprise Development (SPEED) Program, accounting for interactions with other states renewable programs; and 3) establishment of a renewable portfolio standard (RPS).

This option is designed to enable Vermont to back off all fossil-fueled generation (including those from system purchases). This objective is considered in two possible scenarios: in Scenario 1, nuclear and large hydro continue to contribute to Vermont's electricity supply at a scale similar to that of today; in Scenario 2, nuclear and large hydro contribute roughly half what they contribute today. (The level of generation from nuclear and hydro assumed in these two scenarios is based on two different possibilities regarding what will happen to their contribution, given that their contracts are due to expire over the coming decade. Efforts under ESD-4 and ESD-10, among other factors, will affect the eventual outcome.) The size of the RPS is shown in Table F-1.

**Goals:** In quantitative terms, the goals of the RPS are as shown in Table F-1.

**Table F-1. Size of the RPS**

| | Total RPS | | | |
|---|---|---|---|---|
| | **Current** | **2012** | **2028** | **GWh in 2028** |
| Scenario 1 | 15% | 17% | 25% | ~700 GWh |
| Scenario 2 | 15% | 20% | 45% | ~2000 GWh |

**Timing:** The RPS achieves its full level (25% or 45% for Scenarios 1 and 2, respectively) by the year 2020.

**Parties Involved:** Utilities, independent power producers, consumers, and other states (via their renewables requirements).

**Other:** As with other proposed policies, further detailed analysis and evaluation of the recommended policy will be needed.

## Implementation Mechanisms

The following are among the several implementation options for supporting renewable electricity.

### Renewable Portfolio Standard

An RPS is one such mechanism to ensure a certain amount of renewable energy in the sources serving Vermont customers. An RPS generally requires that a seller of electricity in Vermont maintain a certain percentage of renewable energy in its resource mix (generally as a percent of sales). The renewable component is demonstrated by the retirement of a renewable energy credit (REC), representing one MWh of renewable electricity generated. These credits are traded in the New England market through the NEPOOL Generation Information System (GIS). Under this system, Vermont could define its own standards for what constitutes a renewable generator and qualify generators meeting that criteria.

Individual state RPS targets in New England and the Northeast represent a potentially important reference point for Vermont. The market for electricity and the renewable resources needed to meet such a standard are primarily located in the region. Vermont is currently one of only two states in New England without an RPS.

States with an RPS have structured their targets in ways that differentiate embedded resources from new renewable resources. The target in Connecticut, for example, is 7% for "Class I" RECs on or after 2010. Massachusetts established a 4% standard for 2009, but allows the standard to grow by 1% each year until an administrative agency determination halts it. New York set a target of 25% but relied on approximately 19% of existing renewable resources when the target was established. Rhode Island's RPS is currently targeting 13% in 2017. Maine just recently established a 10% target for 2010. Like New York, Vermont already meets a significant portion of its demand—approximately 15%—with renewable electricity (including small hydro) and could use this as a starting point for a target. Vermont could set a target based on comparability to targets set by the region; alternatively, Vermont could establish a target based on a ground-up assessment of in-state potential with the recognition that it could be met with RECs should that prove more cost-effective.

The Vermont RPS could be met by 1) in-state renewable resources, 2) MWh from contracted out-of-state renewable resources, or 3) certificates purchased from the REC market.

### Voluntary Purchase Programs

Under this type of program, individual consumers are given the opportunity to designate a portion of their energy sources as renewable. The serving utility fulfills this obligation through the purchase of RECs in the same manner as the RPS. However, under a voluntary purchase arrangement, only participating customers are charged for the renewable premium.

**SPEED Program**

Vermont could continue and expand the SPEED goals for Vermont utilities to engage in long-term contracts for SPEED-eligible resources.

**Further Considerations**

*Cross-State Interactions*—It is necessary to assess how renewables programs enacted to meet a Vermont target interact with the renewables programs of other states. It will be necessary to ensure that renewable resources deployed to satisfy a Vermont goal do not have the effect of displacing renewables development in other states.

*Definitions of Renewable Resources*—It is important that the portfolio of renewables resources that are eligible under the ESD-6 measures are clearly defined. Because ESD-10 provides measures that are intended to support large-scale hydro, it is not considered necessary to also support large-scale hydro via the ESD-6 measures, which are aimed at reducing GHG emissions as well as facilitating markets for emerging renewable technologies and local renewable resources.

## Related Policies/Programs in Place

Following Acts 61, 74, and 208 of 2005 and 2006, Vermont has already embarked on a number of initiatives to encourage or reduce barriers to renewable sources of electricity including the establishment of new transparent and timely interconnection standards for small and renewable generation, the promotion of new contracts with renewable energy resources through the SPEED Program, the establishment of the Clean Energy Development Fund, and through various modifications to the net metering programs in Vermont and related tax policies.

Vermont has already had some success with its green pricing programs. Both of Vermont's largest investor-owned utilities have programs. The Central Vermont Public Service (CVPS) program "Cow Power" now has more than 2% of its customer base participating in the program (as of mid-2006). The Vermont legislature is now considering requiring that all utilities establish similar programs and make them available to all consumers.

Other efforts to promote the construction or purchase of electricity from renewable resources could come from strengthening the role of the SPEED Program and/or creating an RPS. At present, four of Vermont's New England neighbors and New York possess an RPS requiring that a certain percentage of sales be attributable to new renewable resources. Efforts are underway at the regional level to further harmonize the RPS requirements of states with an RPS.

Even beyond Vermont, the ISO New England region, from which Vermont purchases the bulk of its market energy, depends disproportionately on volatile fossil fuels. Efforts are underway to further diversify the regional resource mix, including strengthening transmission intertie capabilities between Canada and New England. The decisions that Vermont makes with respect to new resource contracts can, in turn, positively impact the character of decisions within the ISO New England region.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions from the electric sector (defined on a consumption basis).

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** ISO New England, Marginal Emissions.

**Quantification Methods:**

Two scenarios are considered for quantification.

**Scenario 1:** the assumption is made that nuclear power and large-scale hydro contribute to Vermont's electricity supply at a scale similar to today's. This scenario assumes that, despite the current status of contracts due to expire over the next decade, other factors, including efforts made under ESD-4 and ESD-10, are effective at keeping nuclear and hydro on the Vermont grid. Given the extent of the assumed electricity DSM, this implies a fairly modest level of incremental renewable electricity above Vermont's present level.

**Scenario 2:** the assumption is made that nuclear and large-scale hydro contribute to Vermont's electricity supply at roughly half the amount they contribute today. This scenario assumes that, despite the current status of contracts due to expire over the next decade, other factors, including efforts made under ESD-4 and ESD-10, are effective at keeping nuclear and hydro on the Vermont grid, although they are somewhat less effective than in Scenario 1.

For the purposes of estimating the cost of ESD-6, it is projected that the renewable requirement is primarily met in both Scenario 1 and Scenario 2 with a mix of 40%, 15%, and 45% of wind, hydro, and biomass respectively.

The reference case alternative to the purchase of nuclear power is to purchase electricity from the ISO New England system. The net emissions impacts are the difference in emissions between the life cycle emissions arising from renewable generation and the emissions associated with the avoided electricity purchases from the ISO New England system. The regional ISO New England system rate is 0.63 tCO2/MWh. Note, this figure is subject to all the uncertainties associated with the future expansion of the ISO New England electric sector. It may be higher or lower. However, since 0.63 is the emission factor that is consistent with the inventory and forecast, it is the correct figure to use when assessing the measure's effectiveness toward reaching the Vermont GHG reduction goals.

Cost and performance characteristics are taken from the analyses by the US Department of Energy (US DOE) Energy Information Administration (EIA) for their Annual Energy Outlook 2007 (AEO 2007) and the California Energy Commission's (CEC's) Comparative Costs of California Central Station Electricity Generation Technologies (CEC, June 2007), as shown in Table F-2.

For the purposes of estimating costs, it is assumed that for the first 7 years (2008–2014), the RPS is met through the purchase of RECs at a premium of $50/MWh. After 2014, the bottom-up engineering costs derived from the parameters in Table F-2 are used.

**Table F-2. Parameters used to derive engineering costs**

| | | Source of Electric Power | | |
|---|---|---|---|---|
| | | **Wind** | **Hydro** | **Biomass** |
| Capital cost | $/kW | $2,300 | $3,045 | $1,833 |
| Transmission | $/kW | $80 | $80 | $80 |
| Lifetime | Years | 20 | 25 | 30 |
| Capital recovery factor | % | 8.5% | 7.6% | 7.0% |
| Levelized cost | $/kW-year | 202.5 | 237.6 | 134.5 |
| Fixed O&M | $/kW-year | $27.6 | $15.3 | $50.2 |
| Fixed costs | $/kW-year | $230.1 | $252.8 | $184.7 |
| | | | | |
| Capacity Factor | % | 30% | 50% | 75% |
| Levelized capacity cost | $/MWh | $87.5 | $57.7 | $28.1 |
| Variable O&M | $/MWh | $– | $4.00 | $3.0 |
| Fixed + variable costs | $/MWh | $87.5 | $61.7 | $89.8 |
| | | | | |
| Fuel cost | $/MBtu | | | $4.51 |
| Heat rate | Btu/kWh | | | 13,000 |
| Fuel generation cost | $/MWh | | | $58.7 |

**Key Assumptions:** As above.

## Key Uncertainties

Energy prices are highly uncertain, as are capital costs and performance parameters, given the long time horizon associated with the policy measure. In addition, there is uncertainty associated with the demand for renewable resources and how the level of demand will affect prices.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Supermajority.

## Barriers to Consensus

To be determined.

## ESD-7. GHG Cap-and-Trade and/or GHG Tax

### Policy Description

This policy is designed to identify ways to constrain or internalize the cost of GHG emissions through complementary strategies to existing GHG emissions cap-and-trade structures.

This policy, then, addresses complementary mechanisms for internalizing the cost of GHG emissions beyond the large generating stations covered under the current RGGI structure and that participate in the Chicago Climate Exchange (CCX) (see Related Policies/Programs in Place below). The covered GHG sources would include transportation, home and commercial heating, and industrial processes that depend on sources of energy other than electricity.

### Policy Design

The major policy design options include

- A carbon tax for fossil fuel sources, with the revenue collected from a carbon tax targeted toward funding programs that reduce Vermont's overall carbon footprint; and
- Creation of a state-level GHG cap-and-trade program for other sectors of the Vermont economy with auctioning of permits and with revenues targeted toward funding programs that will reduce Vermont's overall carbon footprint.

The policy might also entail strengthened linkages between state GHG reduction policies and other programs such as RGGI and CCX, recognizing more non-electric sector initiatives as RGGI offsets, or allowing the trading of credits among RGGI-certified state GHG cap-and-trade programs.

**Goals:** The goals of the policy will be set to scale the revenues to be commensurate with the funding needs of the various measures included in the GCCC portfolio.

**Timing:** Consistent with the public funding requirements.

**Parties Involved:** All major emitting sectors.

**Other:** Not applicable.

### Implementation Mechanisms

The implementation mechanism would depend on whether a GHG cap or GHG tax mode is adopted. Further details are pending.

### Related Policies/Programs in Place

Vermont is already part of the 9-state RGGI currently located only in the northeastern United States. Vermont was also the first state to establish legislation adopting the implementing framework for RGGI.

In implementing the framework, Vermont has already allocated 100% of the revenues generated from the program toward consumer benefits, including directing program funds toward energy efficiency programs covered by ESD-1 or using funds in ways that may reduce rates or foster non-emitting resources.

While RGGI is structured to permit and even encourage adoption by other states and regions, RGGI is currently limited in scope both geographically and to just one sector of the economy. RGGI covers only the electric sector and is limited to large commercial generating stations over 25 MW in size.

Not addressed through RGGI are the carbon emissions from transportation, home and commercial heating, and industrial processes that depend on sources of energy other than electricity. Some carbon emissions are also capped for a number of organizations through the voluntary CCX.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions from reduced energy consumption due to energy price effects and corresponding policies (as per full portfolio of options).

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** RGGI, EIA, eGRID (EPA's Emissions & Generation Resource Integrated Database).

**Quantification Methods:** For the sake of quantification, this measure is considered a GHG tax, with the goal defined as generating a level of revenue that can contribute significantly toward meeting the funding requirements of the GHG reduction policies for which there are positive costs.

**Key Assumptions:** As above.

## Key Uncertainties

None identified.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete; referred to the GCCC as primarily a funding mechanism.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-8. Incentives for Clean Distributed Technologies for Electricity or Heat

### Policy Description

This option focuses on incentives for clean consumer technologies for electricity or heat. Conceptually this would include incentives to encourage clean technologies such as solar water heaters, rooftop photovoltaics (PV), and on-site wind generation, as well as support for switching to less carbon-intensive fuels (i.e., conversion of coal or oil applications to natural gas or biomass). The Residential, Commercial, and Industrial (RCI) sector is the second largest emitter of GHGs in Vermont, with heating fuels including oil, LPG, and kerosene being the predominate sources of emissions. To maximize the reduction of GHGs from this sector, the incentives should be designed to reduce residential, commercial, and industrial consumption of these fuels in favor of low-GHG options.

### Policy Design

**Goals:** Establish incentives to reduce or displace the use of oil in the RCI sector by encouraging clean consumer technologies and conversions to lower carbon fuels, including biomass, natural gas, and electricity as appropriate.

**Timing:** As soon as possible.

**Parties Involved:** Residential, commercial, and industrial applications.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed that includes an analysis of the natural gas rate implications.

### Implementation Mechanisms

Potential design elements include

- Incentives to support clean consumer technologies to displace oil usage, such as rebates, direct subsidies, and tax credits.
- Incentives to support the conversion to lower carbon fuels targeted at
  - Expansion of cleaner fuels in Vermont, and
  - Incentives for consumers to convert to lower carbon fuels.

### Related Policies/Programs in Place

To be determined.

### Type(s) of GHG Reductions

Reduction of GHG emissions associated with combustion of fossil fuels in residential, commercial, and industrial establishments.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:**

EIA data at http://www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_tot.html will provide specific data regarding the current fuel usage in Vermont.

EPA and Vermont Agency of Natural Resources (ANR) provide data on emissions for various fuel types.

**Quantification Methods:**

The potential for GHG savings and cost per $MtCO_2e$ from clean consumer technologies is quantified by analyzing two major options for reducing emissions in the RCI sector. This analysis is indicative, and the policy should be designed to allow other options to be deployed as well.

The first consideration is the use of solar water heaters. Deployment of solar water heaters to augment water heaters using fuels is already among the options considered in the GDS Associates All-Fuels Study (see ESD-2), but not solar water heaters to augment electric water heaters (ESD-1). This measure considers the latter only. We assume a capital cost of $5,300 per household, displacement of 65% of water heating energy requirements, and a penetration of 80% of households that are heating water with electricity.

The second consideration is the GHG savings and costs of expansion of the natural gas infrastructure to displace oil and LPG in six localities: Middlebury, Rutland, Bennington, Brattleboro, Newport, and Montpelier. The heating fuel requirements in these localities are estimated, and a penetration of 45% for oil and 75% for LPG is assumed to be achieved by 2015. The investment costs for each project are obtained from Vermont Gas (as shown in Table F-3), and the avoided fuel costs are taken from the Avoided Energy Supply Costs (2007) study (as are other avoided energy costs in the analysis of ESD options).

**Table F-3. Investment costs for each project**

| Locality | Estimated Capital Costs | Levelized Annual Carrying Costs* | Displaced Fuel Oil (MMBtu) | Displaced LPG (MMBtu) |
|---|---|---|---|---|
| Middlebury | $29,306,097 | $4,199,346 | 543,925 | 65,585 |
| Rutland | $68,219,316 | $9,775,320 | 1,565,487 | 176,122 |
| Bennington | $32,025,044 | $4,588,950 | 619,629 | 73,898 |
| Brattleboro | $32,042,085 | $4,591,392 | 936,904 | 86,295 |
| Newport | $34,696,601 | $4,971,765 | 754,136 | 115,034 |
| Montpelier | $44,525,080 | $6,380,113 | 1,319,953 | 324,162 |

**Key Assumptions:** As above.

## Key Uncertainties

Future fuel and avoided fuel costs and capital infrastructure costs.

## Additional Benefits and Costs

Additional benefits and costs related to clean consumer technologies (to be determined).

The following are additional benefits from the expansion of natural gas to displace oil usage in Vermont:

- Reductions in emissions from the transportation of alternative fuels.
- The availability of natural gas energy efficiency programs that reduce fuel use and further reduce emissions.
- The efficiency of natural gas equipment is higher than that of alternative fueled equipment, which reduces overall fuel usage and thereby further reduces emissions.
- Support of economic development in Vermont.
- Increased property tax base.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

# ESD-9. Wind-Specific Support Measures

## Policy Description

Financial and regulatory incentives that support wind generation in Vermont.

## Policy Design

**Goals:** To stimulate new investment in wind generation in Vermont and, at the same time, provide incentives to owners of existing resources to maintain their presence in the energy portfolio. The specific goal is to stimulate incremental wind generation sufficient to help meet the goals of two scenarios described under ESD-6 on the approximate schedule shown in Table F-4.

**Table F-4. Schedule for wind generation to meet goals in ESD-6**

| | Total Wind Generating Capacity | | |
|---|---|---|---|
| | **Current** | **2012** | **2028** |
| Scenario 1 | 4 MW | 19 MW | 94 MW |
| Scenario 2 | 4 MW | 54 MW | 279 MW |

**Timing:** As shown above.

**Parties Involved:** All developers of wind-generating facilities would be eligible to receive payments, develop projects under more expeditious regulatory and permitting regime, and receive credit under the RPS.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed.

## Implementation Mechanisms

In addition to the RPS, the following three mechanisms could be considered if additional incentives are necessary for developers:

1. Add a premium to the allowed return on equity for utility investment in wind generation and/or to the allowed return on equity for utility commitment to purchase non-utility–owned wind generation, so long as the total of the added investment and/or purchase equals 5% of the utility's load.
2. Amendment to Act 250 permit and Title 30, § 248 V.S.A. provisions requiring the wind generation permit and regulatory approval process to be completed within 9 months of submission of the application.
3. Utility investment in or contractual commitment to purchase wind generation, once approved by the Vermont PSB, is deemed prudent and useful for rate-making purposes.

Note that similar incentives should apply to investments in equipment that allows existing wind generating resources to operate or that extends existing contractual commitments to buy wind generation.

## Related Policies/Programs in Place

SPEED requirement that utilities commit to renewable resources.

Federal tax incentives for investment in wind-generating facilities.

Ambiguous rate-making precedent regarding recovery of power supply costs in rates after a supply resource commitment is made and approved.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions.

Every kWh of wind generation offsets a kWh of generation that would otherwise be purchased from ISO New England (most likely natural-gas–fired generation in the long term). Currently, only 6 MW of wind generation is available in Vermont, out of a total generating capacity of more than 1,100 MW in the state.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** Pending. (The Vermont Department of Public Service and others may have data pertinent to this issue.)

**Quantification Methods:** For quantification methods, including capital cost and performance characteristics, see ESD-6. In addition to those listed, we also take into account integration costs that increase depending on the level of penetration of wind according to the costs shown in Table F-5.

**Table F-5. Integrating costs for wind at various levels of penetration**

| Wind Capacity Fraction of System Peak | Average Wind Integration Cost ($/MWh of Wind Generation) |
|---|---|
| 0% | 0.0 |
| 5% | 3.0 |
| 10% | 6.0 |
| 20% | 8.0 |
| 30% | 12.5 |

Source: Northwest Wind Integration Action Plan, March 2007

**Key Assumptions:** As above.

## Key Uncertainties

None identified.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## ESD-10. Hydro-Specific Support Measures

### Policy Description

Financial and regulatory incentives that support hydroelectric generation in Vermont and contractual commitments to purchase hydroelectric generating capacity and energy by Vermont utilities.

### Policy Design

Resource strategies and incentives can be divided into two categories of hydro resource: smaller in-state resource potential and large hydro potential with Canadian partners. The barriers and incentives to develop these two categories of resources are distinct and can be encouraged in ways that recognize these differences.

#### Small In-State Hydro

Current estimates of additional hydro potential in Vermont vary considerably. Vermont currently relies on in-state hydro resources for almost 10% of its energy from 73 dams, 20 of which are from merchant generators managed through Vermont Electric Power Producers, Inc. (VEPPI). There are more than 1,000 dams in Vermont; however, this large figure belies the realizable potential. Only a fraction of the dams are likely to be permitted, given environmental permitting challenges and commercial viability. There have been many efforts to assess the additional hydro potential in Vermont. A recent survey of other studies concluded that 93 MW would represent a conservative estimate of potential. However, one respected veteran independent project developer estimates that the commercially feasible projects left in Vermont amount to only 10–15 MW of power.[7]

Vermont utilities are currently encouraged to invest in new small hydro resources or upgrades through legislative targets for SPEED resources or contracts with project developers. Small hydro resources have access to the Vermont Clean Energy Development Fund and to incentives through net metering. Small hydro projects also have access to regional renewable portfolio targets in neighboring states and, potentially, to include Vermont as proposed under ESD-6. The barrier to further development of hydro resources does not appear to be the lack of financial incentives.

One of the main concerns among the development community expressed at a recent ANR workshop was the high cost of environmental permitting and regulatory review. Projects that require Federal Energy Regulatory Commission (FERC) licenses or permits can take years and add considerably to project costs. One strategy for improving the development of these sites is to explore new ways to streamline the permitting process without undermining the basic environmental and other protections created through existing permitting.

[7] Vermont Council on Rural Development, The Vermont Energy Digest, April 2007 (p.53) refers to estimates by John Warshaw.

**Large Hydro**

While the resource potential for smaller hydro projects appears to be limited, there are large hydro projects (greater than 200 MW) beyond Vermont's borders that are in the planning and development stages. At least two Canadian provinces have new projects under development or in the planning stages. The winter peaking loads of at least one northern project complement our own summer peaking demand, allowing for power purchases by Vermont and other New England states during summer periods.

Vermont currently relies on large hydro facilities in Canada for roughly one third of its energy. Vermont also receives a small amount of electricity from the Niagara and St. Lawrence projects in New York. Currently, Vermont does not recognize large hydro resources above 200 MW as renewable energy in any of its goals for SPEED or an RPS. Yet large hydro exhibits the price stability and low-emissions profile of other renewables. By virtue of existing interties with Canada, New Hampshire, and New York, Vermont has the advantage of relatively good access to large hydro resources from its immediate neighbors. Through existing intertie capabilities with its neighbors, Vermont may also have access to new large hydro resources in New Brunswick and Labrador.

The ISO New England region, from which Vermont purchases the bulk of its market energy, depends disproportionately on volatile fossil fuels. Efforts are underway to further diversify the regional resource mix, including strengthening transmission intertie capabilities between Canada and New England. The decisions that Vermont makes with respect to its own new resource contracts can, in turn, positively impact the character of decisions within the ISO New England region as New England explores its intertie capabilities with Canada and looks for new strategies to diversify its current dependency on natural gas.

Negotiations are already underway to explore opportunities for replacing existing contracts with new contracts for large hydro resources. These contracts can be encouraged by establishing a supporting public and regulatory climate toward the development of such contracts and by recognizing the contribution that these resources can provide to Vermont's climate and economic performance objectives for electricity.

**Goals:** To stimulate new investment in wind generation in Vermont and, at the same time, provide incentives to owners of existing resources to maintain their presence in the energy portfolio. This option is examined in the form of two potential scenarios. In Scenario 1, large hydro continues to contribute to Vermont's electricity supply at a scale similar to today's. In Scenario 2, large hydro contributes roughly half what it contributes today. This goal also stimulates incremental hydro generation sufficient to help meet the goals of two scenarios described under ESD-6 on approximately the schedule shown in Table F-6.

**Table F-6. Assumed new small hydro objectives for ESD-10**

| | Additional Hydro | |
|---|---|---|
| | **2012** | **2028** |
| Scenario 1 | 4 MW | 21 MW |
| Scenario 2 | 12 MW | 63 MW |

Note that these estimates are based on incomplete information regarding hydro potential in Vermont. The potential used here is based on a state-by-state evaluation by the U.S. Department of Energy of hydro potential(see “Quantification Methods” below) but has been deemed by some to be an overestimate.

**Timing:** As shown in Table F-6.

**Parties Involved:** All owners and developers of hydroelectric generating facilities would be eligible to receive payments, develop projects under more expeditious regulatory and permitting regimes, and receive credit under the RPS.

**Other:** Further detailed analysis and evaluation of the recommended policy will be needed that includes analysis of in-state hydroelectric generating potential.

## Implementation Mechanisms

In addition to the RPS, the following four mechanisms, similar to those noted above for wind-specific support, have also been suggested for small hydro:

1. Adding premiums to the allowed return on equity for utility investment in new hydroelectric generation and/or the allowed return on equity for utilities committing to buying hydroelectric generation from another entity, so long as the total of the added investment and/or purchase commitment equals 25% of the utility’s load.
2. Amendment to Act 250 permit and Title 30, § 248 V.S.A. provisions requiring the hydroelectric generation permit and regulatory approval processes to be completed within 9 months of submission of the application.
3. Utility investment in or contractual commitment to purchase hydroelectric generation, once approved by the Vermont PSB, is deemed prudent and is useful for rate-making purposes.
4. State regulatory determination of water quality in federal hydroelectric relicensing proceedings must be completed within 9 months of submission of the application and must take into account economic and global warming impacts of approving or denying water quality certificates.

Note that similar incentives and regulatory streamlining provisions should apply to investments in equipment that allow existing hydroelectric resources to continue to operate or that extend existing contractual commitments to buy hydroelectric generation.

## Related Policies/Programs in Place

None identified.

## Type(s) of GHG Reductions

Net reduction in $CO_2$ emissions.

Every kWh of hydroelectric generation offsets a kWh of fossil-based generation. In New England, this most likely means that natural gas generation is displaced with renewable kWh.

Currently about 20% of Vermont's capacity and 5%–7% of its energy resources comes from in-state hydroelectric facilities, while nearly 40% of its supply portfolio is provided by out-of-state hydroelectric entitlements.

## Estimated GHG Savings and Costs per $MtCO_2e$

**Data Sources:** See below.

**Quantification Methods:**

The analysis of hydro relies on existing studies of hydro potential in Vermont, particularly the "Hydro Power Resource Assessment" by the US DOE (http://hydro2.inel.gov/resourceassessment/) and, in particular, the Vermont portion of the analysis contained in the Idaho National Laboratory's "INL Hydropower Resource Economics Database, April 29, 2003 at http://hydro2.inel.gov/resourceassessment/states.shtml. The identified hydro sites are listed in Table F-7.

This list is culled from a database of 27 sites totaling 150 MW of capacity, which is filtered down to 18 sites based on the following screens:

1. Nameplate capacity is greater than 1 MW.
2. An existing impoundment (i.e., would not be a new development).
3. No major environmental sensitivities or land use issues that would make development "unlikely" (as defined by the US DOE study).
4. Two sites (Vernon and Hart Island) have been excluded under the assumption that they would be developed as New Hampshire resources.

This leaves a total of 68 MW (of which 38 MW is from sites with > 0.5 MW capacity, and 18 MW is from sites that already have hydro power. This estimate is close to the "conservative estimate" from the "The Undeveloped Hydroelectric Potential of Vermont" study[8] recently commissioned by the Vermont Department of Public Service, though it is higher than the upper bound estimate (25 MW) provided by Rob Howland in consultation to Vermont Department of Public Service.[9]

[8] Lori Barg, The Undeveloped Hydroelectric Potential of Vermont, January 31, 2007 (available from the VT DPS).

[9] Rob Holand. Assessment of hydropower expansion (memo to Vermont DPS dated June 16, 2007).

**Table F-7. Small hydro sites in Vermont (according to US Department of Energy Hydro Power Resource Assessment, screened by above criteria**

| Name | Stream Name | Capacity (MW) | Total Development Cost ($/kW) |
|---|---|---|---|
| Fairfax Falls | Lamoille River | 1.1 | $1,741 |
| Weybridge | Otter Creek | 1.1 | $1,788 |
| American Woolen Mill | Winooski River | 1.2 | $2,941 |
| Saxtons River | Saxtons River | 1.2 | $3,022 |
| Newport 1,2,3 | Clyde River | 1.4 | $1,592 |
| Montpelier 4 | Winooski River | 1.5 | $2,809 |
| Wyoming Valley | Connecticut River | 1.6 | $2,772 |
| Garfield | Green River | 2.5 | $2,534 |
| Gorge 18 | Winooski River | 2.7 | $1,390 |
| Chace Mill Hydro | Winooski River | 3.0 | $2,345 |
| Pittsford | East Creek, Otter Creek | 3.1 | $1,398 |
| Essex(Gorge)19 | Winooski River | 3.6 | $1,293 |
| Harriman | Deerfield River | 5.2 | $1,272 |
| Jay Branch | Missisquoi River | 7.3 | $2,060 |
| East Georgia | Lamoille River | 14.0 | $1,826 |
| Bellows Falls | Connecticut River | 17.4 | $1,640 |
| | | 68 | |

The presumed average capacity factor is 49.7%, per the INL study.

**Key Assumptions:** As above.

## Key Uncertainties

The actual amount of hydro that can be developed is contingent on several factors, including cost-effectiveness, environmental limitations, and human habitat and recreation considerations.

## Additional Benefits and Costs

None identified.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

# Appendix G
# Transportation and Land Use Policy Recommendations

## Summary List of Policy Options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2028 (Million $) | Cost-Effective-ness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2008–2028 | | | |
| TLU-1 | Compact and Transit-Oriented Development Bundle | 0.26 | 0.99 | 10.88 | Net savings | | Pending |
| TLU-2 | Alternatives to Single-Occupancy Vehicles (SOVs) | 0.28 | 0.32 | 6.57 | Net savings | | Pending |
| TLU-3 | Vehicle Emissions Reductions Incentives | 0.11 | 0.63 | 7.73 | –$42 | –$10 | Pending |
| TLU-4 | Pay-as-You-Drive Insurance | 0.20 | 0.32 | 5.30 | Net savings | | Pending |
| TLU-5 | Alternative Fuels and Infrastructure (LCFS) | 0.12 | 0.42 | 5.75 | N/A | | Approved |
| TLU-6 | Regional Intermodal Transportation System – Freight and Passenger | 0.05 | 0.20 | 2.22 | N/A | | Pending |
| TLU-7 | Commuter Choice/Commute Benefits | 0.06 | 0.19 | 1.86 | –$1 | –$1 | Approved |
| TLU-8 | Plug-in Hybrids [part of TLU-5] | – | – | – | – | | Pending |
| TLU-9 | Examine GHG/Transportation Funding Mechanisms as part of a funding package after reductions policies are chosen | – | – | – | – | | Approved |
| | **Sector total before adjusting for overlaps** | 1.09 | 3.07 | 40.31 | N/A | N/A | Pending |
| | **Reductions from recent policy actions** | | | | | | Pending |
| | **Sector total plus recent policy actions** | TBD | TBD | TBD | TBD | TBD | Pending |

* LCFS = low-carbon fuel standard; N/A = not applicable; GHG = greenhouse gases; TBD = to be determined.

# TLU-1. Compact and Transit-Oriented Development Bundle

## Policy Description

Implement land use planning and development that supports protection of natural and cultural resources, strengthens communities, creates more compact development, and reduces growth in driving and emissions.

## Policy Design

**Goals:**

- Support and promote public and private planning and development practices, including smart growth planning and infrastructure provision, that reduce the number and length of trips and expand travel modes in Vermont.
- Ensure that vehicle miles traveled (VMT) in Vermont are equal to the amount driven in aggregate in the year 2000 by the year 2012 and are equal to the 1990 level by 2025.

  VMT was 5,838,000,000 in 1990 and 6,811,000,000 in 2000. Forecasts are in 5-year increments, so the Center for Climate Strategies (CCS) 2012 baseline is an interpolation: 8,858,000,000. 2025 baseline forecast is 10,300,000,000.

  Thus, these goals imply reductions from the baseline of

  2,047,000,000 VMT in 2012 and

  4,463,000,000 VMT in 2025.

**Timing:** To achieve 2012 VMT goals, need to begin implementing policies immediately.

**Parties Involved:** Municipal elected officials; local and regional planning commissions and staffs; state agencies which have programs/projects that have land use impacts; private developers and contractors; planning, land use, and engineering professionals; and public and private organizations with land use, transportation, and environmental interests.

**Other:** None noted.

## Implementation Mechanisms

Supporting state, regional, and municipal land use planning and development practices aimed at reducing the number and length of vehicle trips (VMT) and expanding travel mode opportunities is a multifaceted undertaking. There is no one program or policy mechanism, but several, which together over the long term will make a difference.

The present Vermont planning and regulatory legal framework encourages commercial, residential, and job growth in compact mixed use traditional cities, towns, villages, and new growth centers, the conservation of the surrounding landscape of farm and forest land, and the working of that land to support agricultural and forest-based economies. This legal framework and the programs and policies it supports are an excellent base upon which to build implementation mechanisms aimed at reducing VMT and significantly shifting travel modes to less polluting alternatives such as rail, transit, biking, and walking.

For these alternatives to be viable in the future, there must be a continuation of the existing compact mixed-use development patterns of historic cities, towns, and villages. New developments should include similar and even greater land use densities as well as a mix of uses. Alternative modes of transportation cannot effectively serve the scattered commercial and residential development typical of current growth in many areas of the state. Instead, growth needs to be redirected to Main Streets, downtowns, and existing and new nearby neighborhoods. This pattern has been shown to be livable and highly desirable, not only in Vermont but around the country. In addition, the growth of local economies, and thus jobs and housing, is an essential element of this vision for the future.

Implementation mechanisms for TLU-1 fall into the following categories:

1. **Providing technical and financial resources to municipalities to plan for the future by**
   - Implementing the Growth Center Law (Act 183) by carrying out the recommendations of the Growth Center Natural Resource Lands "working group" and staffing and supporting the Growth Center Planning Coordination Group.
   - Assisting municipalities in identifying and adopting planning principles and programs aimed at reducing GHG emissions including but not limited to appropriate growth center densities and growth management techniques.
   - Exploring additional incentives such as those currently in Act 183 to support municipalities that want to focus growth in their communities.
2. **Strengthening state-level planning, decision-making, and relevant programs in order to support municipalities with the necessary transportation, wastewater, and educational facilities, infrastructure and services to manage growth and reduce GHG emissions by**
   - Directing wastewater spending, school construction dollars, and transportation enhancement dollars to downtown areas and growth centers as described in current funding regulations and policies.
   - Maintaining to the extent possible existing state buildings and schools and locating new state buildings and schools in downtown and growth center locations.
   - Targeting downtown areas, growth centers, and commuter routes as transit priority areas.
   - Considering carbon-neutral requirements for all development projects receiving state funding.
   - Continuing funding for the Vermont Housing and Conservation Board at present statutory levels to develop housing in downtown and growth center locations and conserve farmland.

3. **Setting transportation policy aimed at balancing the rehabilitation and maintenance of existing highway infrastructure and planning for alternative modes in the future to help alleviate present and future capacity needs with practical new capacity projects and planning.**
4. **Breaking down silos among agencies; creating state–municipal and public–private partnerships; and working together on common goals related to areas such as transportation planning, resource protection, and housing and community development by**
   - Implementing the Act 200 planning process, which requires coordination among state agencies' and between the states', and regional and municipal plans and the development of accountable strategies in all plans to achieve the Act's planning goals.
   - Creating transportation plans focused on corridors served by transit and having a planning process that includes all stakeholders, especially landowners, developers and local decision makers, in order to promote growth center development. This may result in a program to encourage developers to help pay for transit or the examination of tax policy for land on versus off transit lines.
5. **Reforming the existing regulatory systems to support the growth of alternative modes, improve the review of energy impacts of new development, and consider the principles of carbon neutrality for development projects in the future by**
   - Strengthening Act 250 Criterion 5 (traffic) to support multi-modal options including site design standards that allow for transit and bike/pedestrian circulation.
   - Establishing a task force to examine how the smart growth planning principles identified in Act 183 and carbon neutrality concepts might be incorporated in the Act 250 review process.
   - Encouraging appropriate state agencies and other Act 250 statutory parties to establish project review guidelines and policies related to energy efficiency, smart growth and rural lands protection under criteria 9(b)(c) (off-site mitigation). H (the cost of scattered development), J (public utility services), and L (rural growth areas).
6. **Identifying a lead entity for each of the above actions.**

## Related Policies/Programs in Place

The following 14 policies, laws, rules, executive orders, and agency programs are already in place:

1. Act 250—State Land Use and Development Law.
2. Act 200 and the Municipal and Regional Planning and Development Law (Chapter 117).
3. Act 183—Growth Center Law. Through planning, regulatory, and financial incentives, and state investment policy, this 2006 law seeks to guide future development into designated growth centers so as to bring vitality to existing communities and enhance environmental quality in the countryside.

4. Downtown Law—Provides state assistance to communities to help with their downtown revitalization efforts. State agencies are required to give priority to downtowns in their subsidy programs.
5. Vermont's Agency of Natural Resources (ANR) Sewer Rule—State funding of sewage treatment projects to be used for projects that serve designated growth centers.
6. Brownfields Law—Designed to facilitate clean-up of vacant, contaminated sites and implement productive re-use projects.
7. VTrans Policies/Programs—Including Corridor Management Planning.
8. Chittenden County Metropolitan Planning Organization (CCMPO). Policies/Programs.
9. Vermont Housing and Conservation Board—Funds acquisition of farm/forest land, other open space lands, and policy on agricultural lands mitigation.
10. Vermont Economic Development Authority (VEDA)—Created to expand employment and raise per capita income through the creation and expansion of industrial sites, businesses, and farm assistance.
11. Vermont Economic Progress Council (VEPC) Programs—Administers several economic incentive programs (e.g., income tax credits, property-based tax incentives, and limited sales tax exemptions).
12. Development Cabinet Law (3 V.S.A. § 2293)—Established a mechanism to ensure collaboration among state agencies to support economic development while conserving and promoting Vermont's traditional settlement patterns, working and rural landscape, strong communities, and healthy environment.
13. Executive Order No. 15 (1985)—Requires state government to give priority for locating its activities in historic and other existing buildings.
14. Executive Order No. 7 (2001)—Requires that all state agencies, as appropriate, foster land conservation around interstate interchanges and work to ensure that any development around the interchanges be consistent with 24 V.S.A. § 4302.

## Type(s) of GHG Reductions

Primarily $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-1 | Compact and Transit-Oriented Development Bundle | 0.26 | 0.99 | 10.88 | Net savings | | Unanimous |

**Cost-Effectiveness:** Expected net savings.

**Data Sources:**

- **VMT impacts:** A wide variety of literature finds that integrated transportation and land use planning can substantially reduce VMT.[1] The appropriate percentage reduction depends on the scale at which policies are applied.[2] Given the methodology used here, a 35% reduction in VMT at the level of an individual development or neighborhood is an appropriate value. This is conservatively below the reductions of 50% and higher that have been empirically observed in neighborhoods planned to allow multi-modal access and compact, mixed-use development.[3]
- Note that VMT impacts for this policy option are driven in large part by how the suggested implementation mechanisms are implemented. The emissions impacts are driven by VMT impacts; for analysis purposes, the VMT impacts are driven by the 2012 and 2028 goals.
- **Costs:** A wide variety of literature finds that integrated transportation and land use planning produces *net savings* on total costs of buildings + land + infrastructure + transportation. Some portions of that total cost may be higher. A preponderance of literature suggests net savings overall.[4] A National Academy of Sciences/Transportation Research Board review found substantial regional and state-level infrastructure cost savings from more compact development.[5] These cost savings are shown in Table G-1.

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[1] *US EPA, Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality,* 2001 (available at: 2001. http://www.epa.gov/dced/built.htm).

[2] *US EPA, Guidance: Improving Air Quality Through Land Use Activities* (EPA 420-R-01-001, January 2001), and US EPA, *Comparing Methodologies to Assess Transportation and Air Quality Impacts of Brownfields and Infill Development* (EPA-231-R-01-001, August 2001).

[3] Cambridge Systematics, Inc., *Transportation Impacts of Smart Growth and Comprehensive Planning Initiatives: Final Report,* prepared for National Cooperative Highway Research Program, May 2004.

[4] Literature reviews include US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality*, 2001; and Robert Burchell, et al., *The Costs of Sprawl—Revisited (TCRP Report 39),* Transportation Research Board/National Research Council/National Academy Press, Washington, DC, 1998.

[5] Robert Burchell, et al., *The Costs of Sprawl—Revisited (TCRP Report 39)*, Transportation Research Board/National Research Council/National Academy Press, Washington, DC, 1998.

**Table G-1. Burchell findings of savings of compact growth vs. current or trend development**

| Area of Impact | Lexington, KY and Delaware Estuary | Michigan | South Carolina | New Jersey |
|---|---|---|---|---|
| Public–private capital and operating costs | | | | |
| Infrastructure roads | 14.8–19.7% | 12.4% | 12% | 26% |
| Utilities (water/sewer) | 6.7–8.2% | 13.7% | 13% | 8% |
| Housing costs | 2.5–8.4% | 6.8% | 7% | 6% |
| Cost–revenue impacts | 6.9% | 3.5% | 5% | 2% |
| Land/natural habitat preservation | | | | |
| Developable land | 20.5–24.2% | 15.5% | 15% | 6% |
| Agricultural land | 18–29% | 17.4% | 18% | 39% |
| Frail land | 20–27% | 20.9% | 22% | 17% |

The cost reduction percentages for Vermont's total infrastructure costs will be determined by how Vermont, its jurisdictions, and developers implement the 10 suggested implementation mechanisms. Even at the low end of the savings shown in Table G-1, the total savings would be significant.

**Quantification Methods:**

More compact development can reduce truck trip lengths, but the vast majority of the literature examines light-duty vehicles (LDVs) VMT only. We do the same. The analysis is top-down rather than bottom-up. That is, estimating and summing the impact of each of the many implementation mechanisms is beyond the scope of this effort. Reaching the 2012 and 2028 goals implies a 13% and 27% reduction in VMT from the baseline, respectively. Reaching these goals implies the following:

- 40% of total LDV VMT affected by these policies by 2012; 80% by 2028. So:
  - 2012 reduction = Statewide LDV × 40% of VMT affected × 35% reduction = **14%** reduction in total statewide LDV[6]
  - 2028 reduction = Statewide LDV × 80% of VMT affected × 35% reduction = **28%** of total statewide LDV
- Convert to $CO_2$

**Key Assumptions:**

The given VMT and emissions reductions assume that the planning described in "Implementation Methods" will produce the changes in growth patterns necessary to produce the goal.

[6] We express the final result in terms of percentage reduction in LDVs to provide for a common basis of comparison in terms of VMT. Since the ultimate output of interest is $CO_2$/GHGs, it may be argued that this intermediate step is unnecessary, but many people find VMT percentage reductions a useful yardstick.

## Key Uncertainties

Achieving the given VMT goal depends on a vigorous implementation of the policy initiatives at all levels of government.

## Additional Benefits and Costs

Benefits include reduced infrastructure costs noted above, avoided health care costs from reduced air pollution, increased walking/biking, and other quality-of-life aspects. Agricultural and open lands protection should benefit the tourism economy.

**Costs:** There will be front-end costs of program development and implementation, and a successful program requires dedicated resources.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## TLU-2. Alternatives to Single-Occupancy Vehicles

### Mitigation Option Description

Shift passenger transportation mode choice to lower emitting and clean alternatives including transit, ridesharing, bicycling, and walking. Transportation is the single largest contributor to GHG emissions in Vermont. Ensure that transportation modes are integrated with each other and with land use development plans. [See TLU-6 (intermodal connections) and TLU-1 (Compact and transit oriented development (TOD).]

### Mitigation Option Design

**Goals:**

- Expand transit routes and ridership numbers aimed at reducing home-to-work VMT and providing convenient, reliable, and frequent service.
- Expand/create regional connections/links within the state to maximize interregional ridesharing and transit commuting opportunities.
- Improve coordination of modes of transportation and transportation programs.
- Strategically increase the number and capacity of park-and-ride facilities. They should serve transit services, be integrated with bike and pedestrian facilities, and be available on the state highway system and at the regional, local, and neighborhood levels.
- Expand individual and place of employment participation in rideshare carpool and vanpool programs through increased marketing and incentive programs.
- VTrans will maintain or improve existing access and conditions for bicycles and pedestrians for all new roadway and "reconstruction" projects as well as paving and other facilities improvements when possible. ANR and VTrans will work together to address stormwater permitting issues that limit shoulder paving opportunities.

**Quantitative Goals:** Increase statewide non-SOV mode split:

- 40% by 2012
- 100% by 2028

Baseline: 1997 Crittenden County Metropolitan Planning Organization (CCMPO)-area mode split: SOV 92%, all other 8%. To increase non-SOV modes

By 40% = 11.2% non-SOV, and

By 100% = 16% non-SOV

Non-SOV mode split for the rest of the state is much lower. There does not appear to be at present a single source for non-SOV mode share outside the CCMPO area.

**Timing:**

- Vermont's present investments in transit and rideshare can be quickly enhanced/coordinated/expanded/re-directed to help reach emission reduction goals.
- Climate Change information and marketing of alternative modes to facilitate shift in choices/transportation behaviors can happen quickly.
- Infrastructure improvements and more complex policy initiatives will occur over a 2- to 5-year period.

**Parties Involved:** VTrans, regional planning commissions, CCMPO, municipalities, transit providers, human service transportation interests, interstate transportation services, rider organizations, bicycle and pedestrian advocacy organizations, and environmental groups.

**Other:** None.

## Implementation Mechanisms

The following mechanisms aimed at increasing transportation mode choice in Vermont build on existing and include new programs. Most require additional resources. The success of TLU-2 is linked to the goals and policies described in TLU-1, Compact and Transit-Oriented Bundle; TLU-6, Intermodal Connections; TLU-7, Commuter Choice; and TLU-9 Funding Mechanisms.

### Transit

Work to create a transit system that is easy to use and affordable and serves downtown, growth centers, major employers and major highway corridors with a goal of 15-minute headways throughout these areas and 30-minute headways elsewhere, as appropriate for each area.

Maximize the capacity of existing public transit programs by using performance evaluations of existing transit routes and cost of service data to guide and evaluate public transit services and invest or reinvest in services that have greatest potential to reduce VMT.

Use existing public transit organizations to evaluate, coordinate, and plan services that get more people on to one ride, whether that is a volunteer driver vehicle, a van, or a bus.

Investigate the feasibility of an energy tax credit or other mechanism identified in TLU-9 to fund transit operations.

### Rideshare

Continue and expand the state park-and-ride program and encourage park-and-ride use and facilities at the regional, municipal, and neighborhood levels.

Configure the state rideshare program to better promote and market both carpooling and vanpooling under a statewide coordinated interregional program.

Coordinate between and among Public Transit Provider Regions to deliver improved interregion VMT-reducing commuter services such as rideshare and vanpools.

**Biking and Walking**

Incorporate appropriate bicycle and pedestrian accommodations into VTrans projects, programs, and actions.

Sustain current state, regional, and municipal programs to encourage walking and bicycling as a means of transportation.

Promote the incorporation of pedestrian and bicycle considerations into municipal town plans and expand and/or implement regional bicycle and pedestrian plans.

**Planning, Marketing, and Public Outreach**

Provide incentives and fund Transportation Management Association and guaranteed ride home programs

Coordinate rideshare, transit, park-and-ride, bike–pedestrian, and interstate transportation planning and investment at the state, regional, and municipal levels.

Develop statewide geographic information system (GIS) database available to the traveling public that coordinates all transportation options, facilities, and programs. Include Web-based access to all modes and all inter-connection opportunities.

Develop and fund marketing strategies promoting alternative modes where modes are ready to accept additional usage (e.g., Way to Go Commuter Challenge).

Provide incentives to employers (such as the University of Vermont [UVM] and individuals who encourage or use rideshare, vanpool transit, and other alternative modes. **(More options are included in TLU-7.)**

## Related Policies/Programs in Place

- Vermont Rideshare Program is administered by VTrans and promotes carpooling and vanpooling statewide.
- VTrans Public Transit Section administers FTA 5311 and 5310 funding for provision of public transit services. VTrans also administers Congestion Mitigation and Air Quality (CMAQ) funding, which is primarily used to fund new commuter routes.
- Local Transportation Facilities Program is responsible for the development of Enhancement Projects, Bicycle and Pedestrian Facilities, Safe Routes to School Projects, Park-n-Rides, Scenic Byways, and “Local” Projects.
- Smart Growth laws passed in recent years (see TLU-1) are designed to promote and facilitate VMT reduction by development of projects and communities that are oriented toward use of public transit and other alternative modes.

## Type(s) of GHG Reductions

Primarily $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) 2012 | 2020 | Total 2008–2020 | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| TLU-2 | Alternatives to Single-Occupancy Vehicles (SOVs) | 0.28 | 0.32 | 6.57 | Net savings | | Unanimous |

**Quantification Methods:**

- Reductions from transit improvements: transit economics literature.[7]
- Reductions from TDM and transit promotion: TDM literature.[8]

**Costs:** Both of the above, and transit cost-benefit analysis guidance.[9]

**VMT reductions:**

Baseline: 1997 CCMPO-area mode split: SOV 92%. To increase non-SOV by 100%, then non-SOV = 16%, and SOV = 84%.

Apply reductions to urban LDV VMT only.

Convert to $CO_2$.

**Cost-effectiveness:** The cost-effectiveness of investments in transit and transit promotion will vary depending on how those investments are made, and the Option language gives the state and its constituents wide flexibility in making those investments. A given investment in transit and/or transit promotion may or not produce net benefits, so while this process needs to make general policy recommendations, it will remain the responsibility of the state and its constituents to maximize the cost-effectiveness of investments made.

For the purposes of this analysis, and to give the Plenary Group guidance, we ask whether those types of investments are *likely* to produce net costs or net savings. A wide variety of empirical experience suggests that the policies and investments listed in the Option Design and

[7] See Brian E. McCollom and Richard Pratt. 2004. "Transit Pricing and Fares." *TCRP Report 95*. Transportation Review Board, Washington, DC; and, Robert Cervero. 1990. "Transit Pricing Research." *Transportation* 17(2):117–140; and, Victoria Transport Policy Institute, "Public Transit Improvements" in *TDM Encyclopedia*, 2005.

[8] Including ICF Consulting, *Strategies for Increasing the Effectiveness of Commuter Benefits Programs: Transit Cooperative Research Program Report 87*, Transportation Research Board, Washington, DC, 2003; ICF Consulting, *Analyzing the Effectiveness of Commuter Benefits Programs: Transit Cooperative Research Program Report 107*, Transportation Research Board, Washington, DC, 2005; and ICF Consulting, "Commuter Connections Strategic Review," report to the Maryland Department of Transportation Office of Planning and Capital Programming, November 7, 2004.

[9] ECONorthwest, *Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners, Transit Cooperative Research Program Report 78*, Transportation Research Board/National Research Council/National Academy Press, Washington, DC, 2002.

Implementation Mechanisms sections are likely to produce substantial ***net savings***, as in the following four examples.

1. *Transit investments generally:* Nationally, transit produces net economic returns on investment: "For every $10 million invested, over $15 million is saved in transportation costs to both highway and transit users. These costs include operating costs, fuel costs, and congestion costs." These are in addition to the ancillary benefits summarized below.[10]

2. *Transit fare initiatives:* Unlimited Access transit at the University of California–Los Angeles costs $810,000 a year and has total benefits of $3,250,000 a year.[11] Similar programs at other universities show similar results.[12] Universities are in some senses unique institutions, but the general types of challenges (especially demand for and cost of providing parking), and the types of benefits enjoyed in response to commute benefits programs, are equally available to businesses, even businesses located in what would normally be thought of as locations unsupportive of transit use:

   > "Eco Passes also offer significant advantages for employers who offer free parking to all commuters, because those who shift from driving to transit will reduce the demand for employer-paid parking spaces. A survey of Silicon Valley commuters whose employers offer Eco Passes found that the solo-driver share fell from 76 percent before the passes were offered to 60 percent afterward. The transit mode share for commuting increased from 11 percent to 27 percent. These mode shifts reduced commuter parking demand by approximately 19 percent.
   >
   > "Given the high cost of constructing parking spaces in the Silicon Valley, each $1 per year spent to buy Eco Passes can save between $23 and $333 on the capital cost of required parking spaces."[13]

3. *Transit and non-SOV options information and promotion:* Per public dollar, a Transportation Management Organization (TMO) can accommodate seven times as many commuters as new highway investment.[14]

4. *Transit use:* Nationally,

   > "Households who use public transportation save a significant amount of money. A two adult "public transportation household" saves an average $6,251 every year, compared to an equivalent household with two cars and no access to public transportation service. We define "public transportation household" as a household located within ¾ mile of public transportation, with two adults and one car."[15]

   On net, each person trip by auto in the CCMPO area costs ~$3.09. Each person trip by transit costs ~$2.25 (operating costs).[16] For urban and suburban areas, the more transit

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[10] Cambridge Systematics, Inc., *Public Transportation and the Nation's Economy: A Quantitative Analysis of Public Transportation's Economic Impact*, 1999 (available at www.apta.com/research/info/online/documents/vary.pdf).

[11] Jeffrey Brown, Daniel Hess, and Donald Shoup, "Fare-Free Public Transit at Universities: An Evaluation," *Journal of Planning Education and Research* 23:69–82, 2003.

[12] Jeffrey Brown, Daniel Hess, and Donald Shoup, "Unlimited Access," *Transportation* 28:233–267, Kluwer, 2001.

[13] Ibid., 260.

[14] Minnesota Department of Transportation, Modal Options Identify Project, "Measurement and Evaluation", 2006.

[15] Linda Bailey, "Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil," ICF International, January 2007 (available at: http://www.icfi.com/Markets/Transportation/doc_files/public-transportation.pdf).

[16] Chittenden County Metropolitan Planning Organization, "Regional Indicators: Measuring Our Progress Toward Chittenden County's 20-Year Transportation Goals/Year 2025 Metropolitan Transportation Plan Update Working Paper #1, September 12, 2000 (available at: http://www.ccmpo.org/MTP/mtp_indr_2000.pdf).

trips, the greater the savings. Capital costs add complexity to this calculation, but net state and local costs can be low relative to other options given substantial flexibility in the use of federal transportation funds, and the demonstrated capability of transit to reduce the need for households to own multiple vehicles.

**Key Assumptions:** None cited.

## Key Uncertainties

None cited.

## Additional Benefits and Costs

There is a broad literature on the role of transit as part of a modern economy and as a key contributor to creating and maintaining certain aspects of quality of life. Overarching reviews of that literature are done only periodically, one of the most comprehensive being a publication by Cambridge Systematics, Inc. (CS) titled *Public Transportation and the Nation's Economy: A Quantitative Analysis of Public Transportation's Economic Impact*, 1999. It lists the following additional types of benefits from transit investments. We cite CS's bottom line estimate of transportation benefits, not to suggest that Vermont would necessarily see the same multipliers, but to support a finding that non-$CO_2$ benefits would, at a minimum, exceed costs:

- "Transit capital investment is a significant source of job creation. This analysis indicates that in the year following the investment 314 jobs are created for each $10 million invested in transit capital funding.
- "Transit operations spending provides a direct infusion to the local economy. Over 570 jobs are created for each $10 million invested in the short run.
- "Businesses would realize a gain in sales 3 times the public sector investment in transit capital; a $10 million investment results in a $30 million gain in sales.
- "Businesses benefit as well from transit operations spending, with a $32 million increase in business sales for each $10 million in transit operations spending. [….]
- "Business output and personal income are positively impacted by transit investment, growing rapidly over time. These transportation user impacts create savings to business operations, and increase the overall efficiency of the economy, positively affecting business sales and household incomes. A sustained program of transit capital investment will generate an increase of $2 million in business output and $0.8 million in personal income for each $10 million in the short run (during year one). In the long term (during year 20), these benefits increase to $31 million and $18 million for business output and personal income respectively.
- "Transit capital and operating investment generates personal income and business profits that produce positive fiscal impacts. On average, a typical state/local government could realize a 4 to 16 percent gain in revenues due to the increases in income and employment generated by investments in transit.
- "Additional economic benefits which would improve the assessment of transit's economic impact are difficult to quantify and require a different analytical methodology from that employed in this report. They include "quality of life" benefits, changes in land use, social welfare benefits and reductions in the cost of other public sector functions.
- "The findings of this report compliment studies of local economic impacts, which carry a positive message that builds upon the body of evidence that shows transit is a sound public investment. [L]ocal studies have shown benefit/cost ratios as high as 9 to 1."

## Feasibility Issues

Like any class of investment, the fact that empirically and on average it produces net returns does not guarantee that a given investment will do so. Transit investment and operation and transit promotion need to be tailored to the communities they serve and be well-planned, well-implemented, and well-run to produce the maximum return on investment (ROI).

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

# TLU-3. Vehicle Emissions Reductions Incentives

## Policy Description

The recent rise in gasoline prices—coupled with the introduction of fuel-saving hybrid electric vehicles—has caused many would-be car buyers to place more emphasis on fuel efficiency when making vehicle purchases. The New England states could further reinforce consumers' willingness to purchase more fuel-efficient vehicles by providing financial incentives.

One alternative is to finance incentives through fees charged to purchasers of less-efficient vehicles. This approach—known colloquially as a "feebate" plan—has been under discussion in Rhode Island, Maine, and Connecticut. Under such an approach, the state would calculate the fee or rebate a vehicle purchaser would pay or receive based on the vehicle's fuel efficiency or its emissions of GHG. Purchasers of the most efficient vehicles, such as hybrids, would receive the largest incentives; those purchasing the least efficient vehicles, such as large SUVs and sports cars, would pay the highest fees.

## Policy Design

**Goals:**

1. To reduce overall GHG emissions from new automobiles purchased in the state:
    - By having price signals reflect emissions levels and thus having emissions levels more directly enter buying decisions.
    - By sending a signal to manufacturers to produce increasingly low-emitting vehicles for the market.
    - Vermont new vehicle sales will have a $CO_2$ efficiency 20% above the Pavley/California Clean Car baseline.

2. To raise funds so that the State of Vermont will be able to finance transportation-related projects that reduce GHG through a mechanism that is directly tied to a significant source of GHG emissions from cars and trucks. Create a dedicated revenue stream for promotion of low- or no-emitting GHG transportation alternatives (e.g., hybrid tax credits and transit infrastructure).

**Timing:** Should be implemented as soon as possible.

**Parties Involved:**

- DMV
- Agencies that distribute and spend the revenue

**Other:** None

## Implementation Mechanisms

Feebate programs would work on two levels. First, the feebates would directly affect consumer choices for vehicle purchases as a result of the financial incentives. Second, the feebates could indirectly affect the types of vehicles and technologies that manufacturers offer.

For consumers to be well informed, it will be necessary to make information more readily available. Manufacturers currently are required to provide the certification level for the vehicle's emissions and the fuel economy rating clearly printed on the price label. While the fuel economy information is readily available, vehicle emissions certification is not as readily available or as visible. Vehicle emissions data can be compiled and converted to a score that provides an "index" of the vehicle's environmental and energy "footprint." This score would relate directly to a tax rate, which would also be advertised to consumers. This simple "index" and correlating tax rate information would allow for informed choices by consumers.

There are numerous issues that must be resolved for a state to implement an incentive program: specifically, which vehicles will receive incentives and how great those incentives will be, whether the incentive will be given out directly or passed along as a reduction in the vehicle sales tax, and whether the incentive will be given at the time of purchase or the time of registration.

Depending on whether vehicle manufacturers opt to provide more fuel-efficient choices for consumers in response to the program, the impact on overall fuel economy and vehicle emissions could be significant. A recent analysis conducted for the Rhode Island GHG stakeholder process estimated that a feebate program could reduce gasoline consumption (and therefore global warming emissions) from LDVs by between 5% and 31% below business-as-usual levels by 2020.[17]

Because the response of manufacturers to the program is critical, a regional or multistate vehicle incentive plan with consistent provisions and aggressive targets would likely be more effective than a piecemeal state-by-state approach. New England states should work together to devise an incentive program designed to significantly reduce gasoline use and $CO_2$ emissions from vehicles and to reward New Englanders who make vehicle choices that contribute to achieving the region's climate protection goals.

While recommending that the New England states should work together to devise an incentive program, this option assumes implementation only in Vermont.

Finally, the version of a feebate program proposed here would raise revenue. That is, not all fees on higher-emitting vehicles would be rebated to buyers of lower-emitting vehicles.

Example fee/rebate schedules are provided in Table G-2.

[17] Regional Economic Models, Inc., *Combined Economic Impact of Enacting a Feebates Program in Rhode Island, Connecticut, Massachusetts, Maine,* December 31, 2004.

**Table G-2. Alternative scenarios based on 2005 DMV information***

Alt #1

| | Surcharge | Number of Vehicles | Estimated Revenue |
|---|---|---|---|
| 40 mpg or better | –200 | 478 | –95,600 |
| 32–39 mpg | –50 | 8 | –400 |
| 25–31 mpg | 0 | 5,507 | 0 |
| 20–24 mpg | 100 | 13,598 | 1,359,800 |
| 19 mpg or less | 500 | 18,798 | 9,399,000 |
| Vehicles with gross vehicle weight rating of more than 8,500 lbs | 500 | 4,374 | 2,187,000 |
| TOTAL | | 42,763 | **12,849,800** |

Alt #2

| | Surcharge | Number of Vehicles | Estimated Revenue |
|---|---|---|---|
| 40 mpg or better | –100 | 478 | –47800 |
| 32–39 mpg | –25 | 8 | –200 |
| 25–31 mpg | 0 | 5,507 | 0 |
| 20–24 | 100 | 13,598 | 1,359,800 |
| 19 mpg or less | 250 | 18,798 | 4,699,500 |
| Vehicles with GVWR of more than 8,500 lbs | 500 | 4,374 | 2,187,000 |
| TOTAL | | 42,763 | **8,198,300** |

Alt #3

| | Surcharge | Number of Vehicles | Estimated Revenue |
|---|---|---|---|
| 40 mpg or better | 0 | 478 | 0 |
| 32–39 mpg | 0 | 8 | 0 |
| 25–31 mpg | 0 | 5,507 | 0 |
| 20–24 | 100 | 13,598 | 1,359,800 |
| 19 mpg or less | 250 | 18,798 | 4,699,500 |
| Vehicles with GVWR of more than 8,500 lbs | 500 | 4,374 | 2,187,000 |
| TOTAL | | 42,763 | **8,246,300** |

Alt #4

| | Surcharge | Number of Vehicles | Estimated Revenue |
|---|---|---|---|
| 40 mpg or better | 0 | 478 | 0 |
| 32–39 mpg | 0 | 8 | 0 |
| 25–31 mpg | 0 | 5,507 | 0 |
| 20–24 | 0 | 13,598 | 0 |
| 19 mpg or less | 100 | 18,798 | 1,879,800 |
| Vehicles with GVWR of more than 8,500 lbs | 200 | 4,374 | 874,800 |
| TOTAL | | 42,763 | **2,754,600** |

***** Data from the Department of Motor Vehicles (DMV); scenarios provided by Vermont Public Research Interest Group (VPIRG), 03-28-07.

## Related Policies/Programs in Place

Feebates have been proposed in many forms over the last 15 years but have not yet been implemented in the United States. While feebate proposals have been described in academic studies, there has been no implementation of a full feebate program to date in the United States. While there is a "gas guzzler tax" and tax incentives for hybrid vehicle purchases, there is not yet any history of an on-the-ground example of an implemented feebate program.

## Type(s) of GHG Reductions

Mainly $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-3 | Vehicle Emissions Reductions Incentives | 0.11 | 0.63 | 7.73 | –$42 | –$10 | Majority |

**Data Sources:** CCS Inventory and Forecast.

**Quantification Methods:**

- **Impacts.** Current analysis shows that 90% of the benefits of feebate programs are likely to arise from the manufacturing response, as manufacturers change the technology mix in the fleet, rather than the consumer response, in which consumers change the mix of purchasing decisions within the current for-sale fleet. And manufacturers are unlikely to substantially change their technology mix in response to a single state feebate program, especially one in a market as small as Vermont's. (These studies have spurred an interest in multistate feebate programs as a way to increase the size of the affected market and thus the incentive for manufacturers to shift technology mix.) *This policy option assumes only a Vermont-level policy.*

  Impacts were modeled by increasing the fuel efficiency of new cars in Vermont by 25% starting in 2010 and raising the penetration rate in the total fleet from 10% in 2010 to 100% in 2028.

  Although the above scenarios would raise substantial revenue for use in low-GHG emissions travel options, those benefits are not quantified here.

- **Costs.** A wide variety of economics literature finds that vehicle buyers do not buy all the efficiency technology that is cost-effective, taking into account the net present value of both the fuel savings and the additional technology cost. Feebate analyses, the most recent of which is cited above, find that the fuel savings that result from a feebate program would pay for additional costs, producing net cost savings:

> "The reduction in consumer surplus is more than compensated for by unvalued fuel savings that are realized. The benefits are positive for all rates up to $1000 but marginal costs begin to outweigh benefits between $500 and $1000. Adopting two or more classes reduces the benefits significantly while creating a relative subsidy for larger vehicles."

As a result, net benefits range from $40 per ton for a low feebate to $10 per ton for a high feebate. If Vermont has a stand-alone program, then it will have to have a high-feebate program to produce consumer response. We thus use the $10 net benefits per ton estimate.

> "If it is assumed that consumers already fully value fuel savings, then there are no unvalued fuel savings and the costs are in the range of $10 per ton."

## Key Assumptions

That the Vermont program is stand-alone.

**Key Uncertainties:** Which feebate schedule is chosen.

Until the United States has more experience with feebates, responses on both the consumer and producer side are uncertain. In a single-state program, most of the response would come from the consumer side, because the production mix is unlikely to change substantially in response to demand changes in a single-state market. Other analyses are pessimistic about the ability of consumer-side fee/rebates to produce consumer choice shifts of the magnitude estimated here.

## Additional Benefits and Costs

Net revenue is used to fund other GHG programs. Those benefits are not analyzed here.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Simple majority.

## Barriers to Consensus

Any program should not penalize individuals who need larger, lower mileage vehicles for work or family issues.

## TLU-4. Pay-As-You-Drive Insurance

### Policy Description

Pay-as-you-drive (PAYD) pricing converts a portion of insurance to a variable cost with respect to vehicle travel, so premiums are directly related to mileage. PAYD makes insurance more actuarially accurate and allows motorists to save money when they reduce their mileage. The less you drive, the more you save.

### Policy Design

**Goals:**

- Change fixed costs of automobile ownership to incremental costs directly related to mileage driven.
- Reduce the cost differential between an SOV trip and a public transit trip.
- Provide a direct financial reward for individuals who reduce VMT.

**Timing:** Direct the Commissioner of Banking, Insurance, Securities & Health Care to immediately develop regulations requiring companies offering auto insurance in Vermont to offer PAYD.

**Parties Involved:** VT Department of Banking, Insurance, Securities & Health Care Administration, Insurance Division; insurance companies.

**Other:** None cited.

### Implementation Mechanisms

Develop strategies for implementing PAYD insurance"

- Payment mechanism—How do policy purchasers pay for a product with a variable cost? Most current insurance policies involve a fixed payment at the beginning of the coverage period.
    - Fixed-fee up front, with a reimbursement (or additional payment) at the end of the policy period.
        - Shorter policy periods (1 month instead of 6 months to 1 year). Monthly insurance is billed similar to a utility.
        - Purchase insurance that is valid up to a certain mileage, instead of a particular date.
        - Review applicable technologies.
    - Insurance type.
        - Discrete premium levels—Premiums are set within specific ranges for mileage driven.

— Pay by the mile—Uses a linear rate that does not change as mileage increases

— Pay by the mile—Uses a non-linear rate that increase as mileage increases. This payment scheme must be carefully developed to ensure that when a person is faced with the choice of using 2 vehicles to make a trip that the logical and cost effective choice is the most fuel-efficient vehicle.

## Related Policies/Programs in Place

### GMAC and OnStar Offer Low-Mileage Discount Rates[18]

Since mid-2004, General Motors Acceptance Corporation (GMAC) Insurance has offered mileage-based discounts to OnStar subscribers located in certain states. The system automatically reports vehicle odometer readings at the beginning and end of the policy term to verify vehicle mileage. Motorists who drive less than specified annual mileage receive insurance premium discounts of up to 40%:

| | |
|---|---|
| 1–2,500 miles: | 40% discount |
| 2,501–5,000: | 33% discount |
| 5,001– 7,500: | 28% discount |
| 7,501–10,000: | 20% discount |
| 10,001–12,500: | 11% discount |
| 12,501–15,000: | 5% discount |
| 15,001–99,999: | 0% discount |

Value Pricing Program PAYD Pilot projects.[19]

This Federal Highway Administration's Value Pricing Pilot Program is now providing funding for PAYD insurance simulation projects in Georgia and Massachusetts.

### Distance-Based Program

Progressive Insurance[20] offers distance-based insurance in Oregon, Michigan, and Minnesota. The program uses a global positioning system (GPS) to track vehicle location and use.

### TripSense[SM]

"Safer drivers and people who drive less than average should pay less for auto insurance. That's why we created the revolutionary TripSense discount program, which measures your actual driving habits and allows you to earn discounts on your insurance by showing us how much, how

[18] See http://www.onstar.com/us_english/jsp/low_mileage_discount.jsp

[19] See http://www.fhwa.dot.gov/policy/13-hmpg.htm

[20] See http://www.progressive.com

fast, and what times of day you drive. TripSense gives you more control over what you pay for insurance, as your driving habits determine your discount." [21]

## Type(s) of GHG Reductions

Primarily $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-4 | Pay-As-You-Drive Insurance | 0.20 | 0.32 | 5.30 | Net savings | | Majority |

**Data Sources:**

The Arizona Public Interest Research Group (PIRG) Education Fund analyzed the potential GHG savings from a PAYD automobile insurance policy. The policy analyzed assumes that insurers are required to offer mileage-based insurance for certain elements of vehicle insurance, including collision and liability. The Arizona PIRG Education Fund assumes the PAYD policy is required, that it is phased in over time, and that all drivers in Arizona are eventually covered.

To calculate GHG savings, the Arizona PIRG Education Fund converted Arizona state automobile collision and liability insurance expenditures to an insurance cost per mile (6.4 cents per mile). If insurance consumers pay 80% of their collision and liability insurance on a per mile basis, then drivers would be assessed a charge of about 5.1 cents per mile. This per mile insurance charge would reduce VMT by about 8%.[22] (To put this charge in context, at 20 mpg, 5.1 cents/mile = ~$1/gallon of gasoline.)

CCS compared the Arizona PIRG Education Fund results for estimated reductions in vehicle miles of travel with other studies of PAYD policies, including those produced by the Economic Policy Institute and Resources for the Future (RFF). CCS found that the Arizona PIRG Education Fund estimates were comparable with other estimates, which ranged from 8% to 20%. The 8% reductions estimates CCS used for estimated reductions in VMT and GHG emissions reductions fell within the lower range of the comparable estimates.

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[21] See http://tripsense.progressive.com/about.aspx

[22] Elizabeth Ridlington and Diane E. Brown, *A Blueprint for Action: Policy Options to Reduce Arizona's Contribution to Global Warming*, Arizona Public Research Interest Group Education Fund, April 2006, pp. 25–26, http://www.arizonapirg.org/AZ.asp?id2=23683. See also: http://www.serconline.org/payd/links.html, which links to a wide variety of PAYD studies and materials.

**Quantification Methods:**

- **Impacts:**
  Pilot studies and empirical experience with other marginal costs of use find that PAYD can reduce VMT by between 8% and 20%. We assume a phase in/ramp up, then:

  Apply reductions to LDV VMT only:

  - 2010 reduction = Statewide LDV × 5% reduction
  - 2015–2028 reduction = Statewide LDV × 10% reduction
  - Convert to $CO_2$
- **Net present value/cost-effectiveness:**
  The success of the Progressive Insurance pilot in Texas suggests that there is an unmet demand for more choice in auto insurance. If PAYD 1) improves and increases consumer choice, and 2) allows insurance providers to more efficiently align risks and premiums, economic efficiency will increase.

**Key Assumptions:**

- State regulation of the Vermont automobile insurance industry requires insurance companies to offer PAYD insurance.
- PAYD insurance will eventually be applied to the whole Vermont light-duty fleet.

## Key Uncertainties

1. The specifics of the PAYD insurance programs are to be determined.
2. Until there is broader implementation beyond the current pilot programs, the effects of PAYD insurance on driver behavior are subject to significant uncertainty.
3. Until there is broader implementation beyond the current pilot programs, economic impacts on insurance companies are unclear. A common question is, "If distance-based pricing is better, why do insurance companies not offer it without a mandate?"

In general, as has been demonstrated repeatedly in other consumer sectors, individual firms may innovate and not be followed by other firms for a wide variety of reasons, but when the market is transformed through policy changes, the industry adapts and remains healthy, specifically for vehicle insurance:

"Individual insurers face several barriers to implementing distance-based pricing. An individual company faces relatively high administration costs to establish an odometer auditing system. Insurance regulators are often unsupportive of pricing innovations. An individual insurance company only captures a small portion of the total benefits, since most financial savings are passed back to customers or accrue to competitors. Insurers do not profit from reductions in uncompensated crash costs, congestion, infrastructure costs, or pollution, or benefit directly from increased equity.

"Insurance companies currently maximize profits by maximizing their gross revenue, because they are dependent on investment income. A pricing strategy that reduces total crashes could reduce profits if regulators or market competition required a comparable reduction in premiums. Although there are potential financial and marketing benefits, these longer-term saving which would have to offset an individual insurer's short-term revenue losses and risks. It is therefore not surprising that few insurers have implemented distance-based pricing."[23]

## Additional Benefits and Costs

### Equity Impacts

> "Current vehicle insurance pricing significantly overcharges motorists who drive their vehicles less than average each year, and undercharges those who drive more than average within each price class. Since lower-income motorists drive their vehicles significantly less on average than higher-income motorists, this is regressive. Distance-based insurance is fairer than current pricing because prices more accurately reflect insurance costs.
>
> "Distance-based pricing benefits lower-income drivers who otherwise might be unable to afford vehicle insurance, and who place a high value on the opportunity to save money by reducing vehicle mileage. It benefits lower income communities that currently have unaffordably high insurance rates…. Distance-based insurance would provide significant savings to workers during periods of unemployment, when they no longer need to commute."[24]

Other equity issues may be addressed through policy design.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Simple majority.

## Barriers to Consensus

Concern about impact on insurance companies and on their willingness to work in Vermont.

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[23] Todd Litman, "Pay-As-You-Drive Vehicle Insurance: Converting Vehicle Insurance Premiums Into Use-Based Charges," *TDM Encyclopedia*, Victoria Transport Policy Institute, March 2007 (available at: http://www.vtpi.org/tdm/tdm79.htm

[24] Ibid. This article discusses a wide variety of questions about PAYD in some detail and provides additional references.

## TLU-5. Alternative Fuels and Infrastructure

### Policy Description

This policy option seeks to increase market penetration of low-carbon fuels in Vermont via a low-carbon fuel standard (LCFS).

Rather than defining a policy that sets goals for a given fuel type, the LCFS would establish a full life cycle GHG rating system, apply it to available fuels, and set overall goals for the life cycle GHG emissions of the total statewide fuel mix. The benefits of this approach include allowing the market to choose the lowest cost way to pursue that overall GHG/carbon-intensity goal and allowing the market to vary the mix as technology changes.

### Policy Design

Decrease the net life cycle carbon in Vermont's total transportation fuels by 10% by 2028.

**Goal Levels and Timing:**

California has adopted the basic outlines of an LCFS and is developing the full system now. One option would be to develop an approach similar to California's, adapting as necessary for Vermont.

> Under the LCFS, fuel providers will have at least three different options with which to comply:
>
> - Blend or sell an increasing amount of low-carbon fuels (for examples, see Table G-3, below).
> - Use previously banked credits.
> - Purchase credits from fuel providers who have earned credits by exceeding requirements.
>
> One of the critical benefits of this performance-based approach is that it does not dictate the mix of fuels that fuel providers are obligated to deliver. Fuel providers will have flexibility to choose what types of fuels in what volumes they sell as long as their sales-weighted average meets the standard. In this way, the market will determine the least-cost and most consumer-responsive outcome for the fuel mix while ensuring decreasing GHG emissions.[25]

Table G-3 describes several possible low-carbon fuel (LCF) strategies.

[25] David Crane and Brian Prusnek. "The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy," Office of the Governor, California, January 8, 2007 (available at: http://gov.ca.gov/index.php?/fact-sheet/5155/)

**Table G-3. Possible low-carbon fuel strategies and descriptions**

| Low-Carbon Fuel Strategy | Description |
|---|---|
| E10 (10% ethanol, 90% gasoline by volume) | • Increase blending of ethanol from today's 5.7% by volume to 10%. |
| E85 (85% ethanol, 85% gasoline by volume) | • Sell high blend ethanol (85% ethanol, 15% gasoline) for use in flex fuel vehicles (FFVs). |
| Switch to low-carbon ethanol | • Switch to ethanol made from cellulosic materials (e.g., agricultural waste or switchgrass) that has 4 to 5 times lower GHG emissions than today's corn. |
| Electricity | • Either pure battery electric vehicle or in plug-in hybrid vehicle that can be recharged from the electricity grid. |
| Hydrogen | • Used in zero-emitting fuel cell vehicles or modified internal combustion engine cars. |
| CNG, LPG | • Compressed natural gas and liquefied petroleum gas burned in modified internal combustion engine cars. |
| Other biomass-based fuels | • For example, BP (British Petroleum) and Dupont are developing biobutanol as a possible additive, and Chevron is exploring petroleum-like products synthesized from biomass (so-called "biocrude"). |
| Other | • Future strategies to be developed by fuel providers and outside innovators. |

**Parties involved:**

- State of Vermont,
- Fuel retailers,
- Fuel wholesalers,
- Business owners,
- Municipal and institutional fleet managers,
- Car dealers,
- Biofuels producers,
- Vermont Biofuels Association, and
- Private vehicle owners.

## Implementation Mechanisms

To be successful and accepted, an LCFS would benefit from the following:

### Information and Education

Use information and education outreach to focus on voluntary methods of LC fuels expansion. Provide the public with information on the use of and effects of using ethanol and other alternative fuels in their existing vehicles. Target information and outreach about biodiesel use and effects to trucking and shipping companies, as well as smaller owner/operators in the State. Information should also be provided on where these vehicles can be purchased and their environmental and fuel-saving benefits.

**Technical Assistance**

Provide technical assistance through vehicle dealers, consumer technical support groups, fuels trade and advocacy groups, and public demonstrations.

Funding mechanisms, market-based mechanisms, and incentives:

Pursue US DOE and State funding for more renewable fuel pumps throughout the State and for introducing appropriate infrastructure throughout the State. Some federal tax incentives currently exist for the purchase of alternative fuel vehicles. When the federal incentives expire, examine the feasibility or need to continue such incentives for alternative fuel vehicles.

- *Reduce or eliminate the motor fuels tax on biodiesel and ethanol (E85).* Develop a system to provide for monthly credit for biodiesel and E85 blended fuel that would be equivalent to the state motor fuels tax owed on the non-biofuels portion of the fuel blend.

  Monthly tax credit would be claimed on the same form (Biodiesel and Fuel Alcohol Providers Form) as marketers currently file with VT DMV Motor Fuel Tax Division to pay fuel tax. This would reduce the pump price of biofuels because marketers would pass the bulk of credit on to consumers in order to be competitive. Credit could be paid for out of General Fund.

**Codes and Standards**

The LCFS should include a cost trigger, so that if the cost of alternative fuels exceeds conventional fuels by more than a specified amount, the renewable fuel standard (RFS) would be temporarily removed. The cost trigger should be based on costs over a period of time and not spot prices.

**Voluntary and/or Negotiated Agreements**

- Provide financial incentives for renewable fuels distributors.
- Provide state funds and/or loan guarantees for the construction of renewable fuels distribution facilities.

**Pilots and Demos**

- Show examples of existing multi-fuel pumps in Vermont that provide a model for dispensing three alternative fuels: B20 biodiesel, E85 ethanol, and E10 ethanol. The State's experience with these vehicles should be publicized.
- Ensure that the State invests in "VT-Green" Tourism through expanded use of Vermont-produced biofuels, linking producer farms with motor coach/bus tours using biofuels.

**Research and Development**

- Link in-state biofuels production from a variety of sources with expanded use of biofuels through public demonstrations.
- Ensure that the State advocates for significant federal funds for research and development to commercialize cellulosic ethanol technology and processes. This will be required for meeting the ethanol targets for 2020 and beyond.

- Analyze and quantify a range of cost-benefits that accrue to renewable fuels vehicle owners.
- Require research on the production of renewable electricity and hydrogen in order to implement a cost-effective process.

## Related Policies/Programs in Place

The Energy Policy Act of 2005 includes provisions that require an increasing volume of renewable fuel to be included in the gasoline sold in the United States. The Act instructs the US Environmental Protection Agency (US EPA) to establish an RFS program to oversee the increase. In April 2007, the EPA issued a rulemaking that requires refiners, blenders, and importers of motor vehicle fuels to increase the proportion of renewable fuel in their products.

Because of Vermont's peripheral position in relation to national fuel systems, as well as differences in policy design between the state and federal programs, the EPA's program is unlikely to have a large impact on Vermont's fuel production and distribution infrastructure.

## Type(s) of GHG Reductions

Primarily $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-5 | Alternative Fuels and Infrastructure | 0.12 | 0.42 | 5.75 | NA | | Unanimous |

**Quantification Methods:**

- **Impacts:** Modeled by decreasing the GHG intensity of the total fuel consumption by 2% in 2010, 5% in 2015, and 10% in 2000–2028.
- **Costs:** There are very few analyses of likely LCFS costs. There is substantial uncertainty both about the path of technology (e.g., the cost of cellulosic ethanol) and about how alternative fuels providers and buys may behave. The field is changing too quickly for CCS to be able to provide a credible estimate at this time.

**Key Assumptions:** None.

## Key Uncertainties

See above.

## Additional Benefits and Costs

To the extent that the LCFS is met with biofuels grown in Vermont, there will be economic benefits in Vermont. Depending on the origin of those feedstocks in Vermont (e.g., corn or wood), there may be concern about environmental effects (e.g., may increase conventional air pollutants, etc.), and effects on livestock feed prices.

## Feasibility Issues

California finds its 10% goal achievable.[26]

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous.

## Barriers to Consensus

None.

[26] Ibíd.

## TLU-6. Regional Intermodal Transportation System – Freight and Passenger

### Policy Description

The option addresses intercity rail and bus service, Vermont and regional rail and airfreight, commuter rail, and all intermodal connections for passengers and freight.

The option will decrease GHG emissions and the state and the region's VMT by increasing the access (location), frequency, travel time, and quality of service for passenger rail and intercity bus service. The options will also decrease GHG emissions by providing adequate intermodal connections—including bike, pedestrian, transit, shuttle service, and parking facilities at all nodes—and increasing the use of rail for both in-state and regional freight movement. The environmental benefits will help drive an adequate subsidy for all modes.

### Policy Design

**Goals:**

- Increase rail freight in Vermont by 100% by 2028.

  Background: From 1992 to 2002, freight rail traffic that originated and terminated in Vermont declined by 21 percent. Freight that originated in Vermont, however, increased from 430,000 tons in 1992 to 764,360 tons in 2002, which is primarily attributable to the increase in shipments from Omya, Inc. in Florence. It is projected that freight rail tonnage will increase between 44% and 55% between now and 2020 or approximately 2.4% annually during the next 5 years.

  State rail plan calls for a 2% annual increase; the baseline calls for a 29% increase by 2020.

- Increase passenger rail use by 200% by 2028.
- Increase other intercity passenger services substantially.

Achieve these goals by maintaining and improving intercity bus and rail, freight and commuter rail services, and the necessary intermodal connections and the efficiency and emissions cleanliness of equipment through the following policies, programs, and mechanisms:

- Replace Amtrak engines with more efficient diesel multiple units.
- Improve the frequency of service and travel time of Vermont's current Amtrak routes.
- Increase the marketing of the state's current Amtrak routes.
- Expand passenger rail service to Vermont's western corridor.
- Improve intercity bus service throughout the northeast region.
- Improve intercity bus service in the Rt. 7 corridor through public–private partnerships.
- Improve passenger rail connections to Montreal and Boston.

- Determine the demand necessary to justify commuter rail service in certain corridors and work to provide the service, including piggybacking commuter and intercity rail services.
- Provide adequate intermodal (e.g., transit, bike, pedestrian, and shuttle bus) connections at all railroad stations, airports, and bus stops.
    - Jitneys
    - Ski shuttles
- Target improved railroad station and airport intermodal connections for large institutions, companies, and the Vermont travel industry.
- Provide parking facilities at railroad and bus stations and airports.
- Improve rail infrastructure to serve all freight needs (e.g., double-stack on the western corridor).
- Identify and provide necessary freight modal transfer stations within Vermont and the region.
- Work with municipalities to plan and regulate land use to accommodate rail and bus infrastructure and service.

**Timing:** Begin immediately.

**Parties Involved:** VTrans, Amtrak, FTA, US Congress, Vermont transit providers, private bus companies, railroad owners, airport commissions and directors, municipalities, and private industry including tourism.

## Implementation Mechanisms

- Reexamine state rail plans.
- Examine possible funding sources for rail investment, including per-freight-car charges.
- Link to TLU-1 growth policies. Both freight and passenger traffic benefit from growth centers that can be served by intermodal transit.

## Type(s) of GHG Reductions

Mostly $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-6 | Regional Intermodal Transportation System – Freight and Passenger | 0.05 | 0.20 | 2.22 | NA | | Unanimous |

**Data Sources:** Vermont Agency of Transportation (VAOT) Forecast

**Quantification Methods:**

- **Impacts**: Reductions taken from heavy-duty and light-duty rural VMT only.
  - **Key Assumptions:** Moving a freight or passenger shipment/trip to intermodal each produce 50% of baseline GHG emissions compared to baseline:

| Extent of Implementation | 2012 | 2015 | 2020 | 2028 |
|---|---|---|---|---|
| VMT reached | 10% | 20% | 50% | 50% |

- **Costs:** The types of infrastructure investments and operating costs necessary to produce these results are unclear. Several states have successfully completed public–private freight rail investment partnerships that they have found cost-effective (for example, the Pennsylvania double-stack project with Norfolk Southern and Canadian Pacific Rail). Given truck damages to highways, shifts to rail can produce substantial savings in road maintenance costs. Without knowing what kind of or how many such partnerships may be available, there is no way to estimate net costs.

## Key Uncertainties

Given the transformation of the economy to rely on smaller, just-in-time shipments, whether substantial amounts of freight, in particular, can be shifted for within Vermont trips.

## Additional Benefits and Costs

Reduced truck traffic would bring various quality-of-life and safety benefits.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Barriers to Consensus

None.

# TLU-7. Commuter Choice/Commuter Benefits

## Policy Description

- Reduce emissions by focusing on the workplace and reducing SOV commutes by:
  - Reducing free parking,
  - Providing paid or pre-tax transit passes,
  - Providing a guaranteed ride home benefit,
  - Allowing (periodic) telecommuting, and
  - Joining a universal access program (institutional ID card = transit pass)
- Commute benefits need not imply transit use: employers can reward or provide incentives for any non-SOV commute.

## Policy Design

**Goals:**

- All Vermont employers with more than 50 employees offer commuter benefits (CB) programs,
- All colleges and universities offer CB,
- All government units, especially the state, offer CB,
- State adopts employee parking management and incentive programs, and
- Parking priority is provided for low-GHG vehicles (carpools, vanpools, and low-GHG SOVs).

**Timing:** Implement by 2010.

**Parties Involved:** VTrans, regional planning commissions, CCMPO, municipalities, large employers, and the state legislature.

## Implementation Mechanisms

- Provide employer education, and technical assistance, especially for large employers, including the State of Vermont.
- Improve broadband telecommunication facilities.
- Work to have towns revise parking policies and requirements (see TLU-1).
- Expand transit service and marketing (see TLU-2).

## Related Policies/Programs in Place

Similar programs are implemented by Transportation Management Associations (TMAs): Campus Area Transportation Management Association (CATMA), on behalf of the Hill Institutions in Burlington; and the Upper Valley Transportation Management Association (UVTMA) centered around the White River Junction (Vermont) and Lebanon (New Hampshire) area.

Chittenden County Transportation Association (CCTA) is providing Universal Access for Champlain College.

## Type(s) of GHG Reductions

$CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Mitigation Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effectiveness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-7 | Commuter Choice/Parking Cash Out | .06 | .19 | 1.86 | –$1 | –$1 | Unanimous |

**Data Sources:**

- Donald C. Shoup, "Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies," October 9, 1997, *Transport Policy*.
- Donald C. Shoup, *Cashing Out Employer-Paid Parking*, Report No. FTA-CA-11-0035-92-1. U.S. Department of Transportation. Washington, DC.
- ICF Consulting, *Strategies for Increasing the Effectiveness of Commuter Benefits Programs,* Transit Cooperative Research Program Report 87, 2003.[27]

**Quantification:**

| | | | | |
|---|---|---|---|---|
| Per participant reduction in VMT with full implementation | 12% | | | |
| | 2012 | 2015 | 2020 | 2028 |
| Extent of implementation | 25% | 50% | 50% | 50% |

**Key Assumptions:**

That reduced SOV commuting has collateral VMT reduction benefits as CB-recipients use transit more outside the commute.[28]

## Key Uncertainties

None cited.

## Additional Benefits and Costs

None cited.

[27] http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_87.pdf

[28] ICF, Analyzing the Effects of Commuter Benefit Programs on Transit Systems, Transit Cooperative Research Program Report 107, 2005 (available at: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_107.pdf)

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous.

## Barriers to Consensus

None.

## TLU-8. Plug-In Hybrids

Unanimously incorporated into the LCFS in TLU-5 as a compliance option.

## TLU-9. GHG-Related Transportation Funding Mechanisms

### Policy Description

Vermont (like the rest of the country) needs to find an alternative to a gas tax–based transportation funding system. The revised or replacement system should include a mechanism to also fund the low-GHG policy options in TLU 1-7.

### Policy Design

- The goal is not to use pricing to reduce emissions directly but to fund a low-GHG transportation system as part of a broader funding system.
- Option examples:
  - Per gallon
  - Feebates
  - Per mile
  - Per carbon unit
  - Per freight car
- Could be offset by reductions in property taxes

**Timing:** Existing per-gallon approach will almost certainly be gone or unsustainable by 2015.

**Parties Involved:** State and all fuel providers.

**Other:** None cited.

### Implementation Mechanisms

Fund the options detailed in TLU-1 through TLU-7.

### Related Policies/Programs in Place

Current tax system.

### Type(s) of GHG Reductions

Primarily $CO_2$.

## Estimated GHG Savings and Costs per $MtCO_2e$

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/$tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| TLU-9 | GHG-Related Transportation Funding Mechanism | – | – | – | – | | Approved |

**Quantification Methods:** None. This option funds other policies that produce reductions.

**Cost-effectiveness:** Cost-effectiveness depends on the use of revenues.

- Current discussion focuses on using the revenues to fund transit and other non-SOV travel choices. Cost-effectiveness in that case is the same as TLU-2: net savings.
- Depending on the chosen level of taxes or fees, more revenue may be raised than will be used to fund travel choices. At that point, revenue can be used to reduce other, more economically distortionary taxes. Two typical examples are personal income taxes and employer payroll taxes.[29] In one example of revenue-neutral "revenue recycling":

  > "This paper considers the distributional effects of imposing additional excise duties [taxes] on energy products according to carbon content. The assumed duties escalate from 1999 to 2010 and achieve levels reducing $CO_2$ emissions by 10 per cent below baseline by 2010 for 11 EU member states. *By 2010, real personal disposable incomes are 1.6 per cent above baseline and employment is 1.2 per cent above, assuming that the change is tax-revenue-neutral."*[30] [Emphasis added]

**Data Sources:** Economics literature, cited above.

**Key Assumptions:** None.

## Key Uncertainties

None cited.

## Additional Benefits and Costs

None cited.

## Feasibility Issues

Above.

[29] For example, Richard D. Morgenstern. May 1991. "Towards a Comprehensive Approach to Global Climate Change Mitigation," *The American Economic Review*, 81(2) 140–145.

[30] Terry Barker and Jonathan Köhler. 1998. "Equity and Ecotax Reform in the EU: Achieving a 10 percent Reduction in $CO_2$ Emissions Using Excise Duties," *Fiscal Studies*, 19(4):375–402.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous.

## Barriers to Consensus

None.

# Appendix H
# Agriculture, Forestry, and Waste Management Policy Recommendations

## Summary List of Policy Options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2007–2028 (Million $) | Cost-Effective-ness ($/t$CO_2$e) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2028 | Total 2007–2028 | | | |
| | **AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT** | | | | | | |
| AFW-1 | Programs to Support Local Farming / Buy Local | 0.004 | 0.02 | 0.2 | Not quantified | Not quantified | UC |
| AFW-2 | Agricultural Nutrient Management Programs | 0.08 | 0.10 | 1.6 | 4.2 | 3 | UC |
| AFW-3 | Manure Management Methods to Achieve GHG Benefits | 0.01 | 0.02 | 0.3 | 34 | 136 | UC |
| AFW-4 | Protect Open Space / Agricultural land | 0.06 | 0.11 | 1.8 | 56 | 31 | UC |
| AFW-5 | Forestry Programs to Enhance GHG Benefits | 0.01–0.04 | 0.06–0.18 | 0.6–2.0 | 4 | 3 | UC |
| AFW-6 | Increased Forest Biomass Energy Use | Quantified under ESD options | | | | | |
| AFW-7 | Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover | 0.4 | 2.0 | 22 | 34 | 2 | UC |
| AFW-8 | Expanded Production and Use of Durable Wood Products (especially from Vermont sources) | | | | | | UC |
| | A. Supply | 0.09 | 0.05 | 1.4 | —* | —* | |
| | B. Demand | 1E-4 | 2E-4 | 3E-3 | | | |
| AFW-9 | Advanced/Expanded Recycling and Composting | 0.16 | 0.88 | 9.1 | 37 | 4 | UC |
| AFW-10 | Programs to Reduce Waste Generation | 0.34 | 0.73 | 10 | Not quantified | Not quantified | UC |
| AFW-11 | Waste Water Treatment – Energy Efficiency Improvements | 0.004 | 0.01 | 0.14 | –19 | –133 | UC |
| AFW-12 | In-State Liquid Biofuels Production – Ethanol Production | 0.03 | 0.42 | 3.7 | 5.0 | 1 | UC |
| | In-State Liquid Biofuels Production – Biodiesel Production | 0.004 | 0.24 | 2.2 | 40 | 18 | |
| | **Sector Total After Adjusting for Overlaps**[†] | **1.2** | **4.7** | **54** | **210** | **4** | |
| | **Reductions From Recent Actions** | **0** | **0** | **0** | **0** | **0** | |
| | **Sector Total Plus Recent Actions** | **1.2** | **4.7** | **54** | **210** | **4** | |

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents; UC = unanimous consent; GHG = greenhouse gas; ESD = Energy Supply and Demand

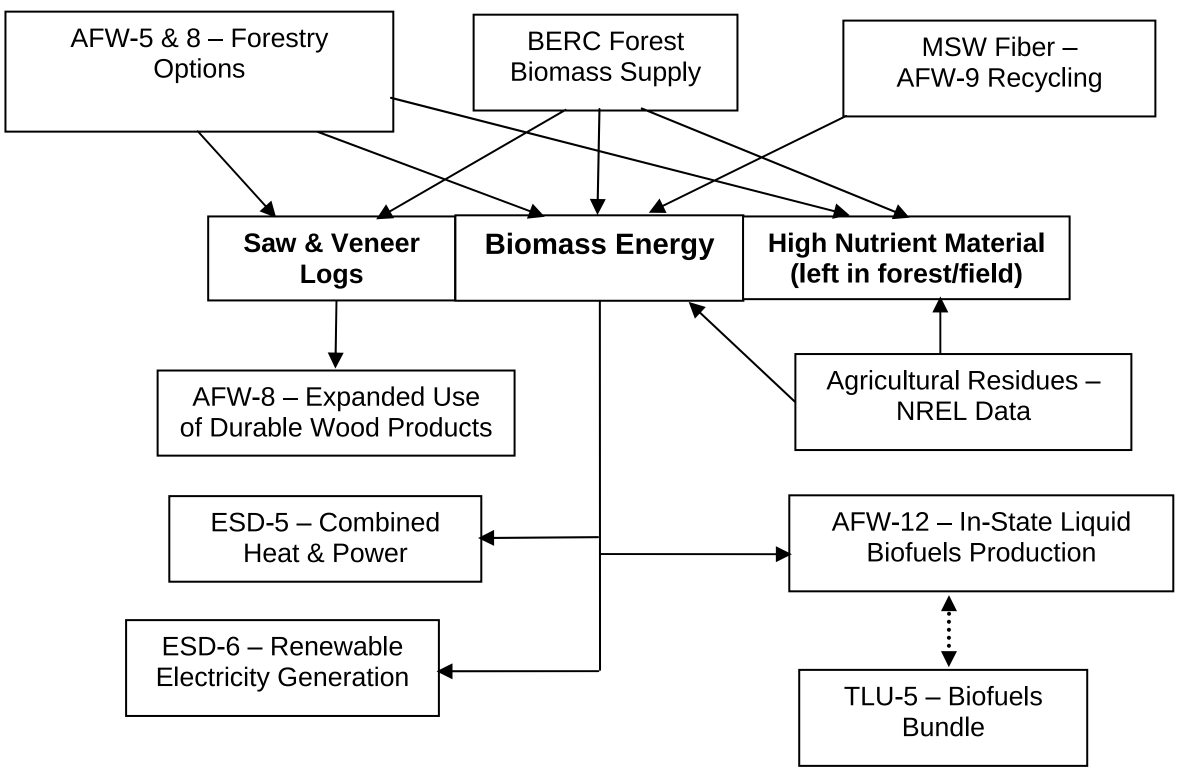
* Costs for the supply component of this option are captured under AFW-5. For the demand component, the costs could not be quantified.

[†] This energy efficiency option has overlap with policies in the Residential, Commercial, and Industrial (RCI) Technical Work Group (TWG); reductions and costs were removed from the AFW total.

## Biomass Resource Supply Assessment

Figure 1 provides a summary of the recommended Governor's Commission on Climate Change (GCCC) policies that relate to biomass supply and demand. Linkages are provided that show the sources of information on biomass supply for three biomass supply pools and the GCCC policies that require biomass. For forest biomass, both the analysis of AFW-8 and a recent report from the Biomass Energy Resource Center (BERC)[1] provided estimates on the amount of biomass available for energy purposes. Municipal solid waste (MSW) fiber from the analysis of AFW-9 covering advanced recycling and composting was included as a biomass resource. Data from a National Renewable Energy Laboratory (NREL) study was also reviewed for available information on biomass availability from crop residue.[2]

**Figure H-1. Vermont GCCC policy option biomass linkages**




The three resource pools are biomass energy (for either thermal conversion or production of liquid biofuels), saw and veneer logs, and high nutrient material (residue left in the forest/field to provide nutrients for regrowth). The last pool was not quantified in any of the assessments; however, for AFW-5 (Forestry Programs for Greenhouse Gas [GHG] Benefits), 61% of the

[1] The Vermont Wood Fuel Supply Study: An Examination of the Availability and Reliability of Wood Fuel for Biomass Energy In Vermont, prepared by BERC, prepared for the Vermont Department of Forests, Parks & Recreation and Vermont Department of Buildings & General Services, May 30, 2007.

[2] A Geographic Perspective on the Current Biomass Resource Availability in the United States, NREL/TP-560-39181, December 2005. This study found that there was no biomass resource supply in VT from crop residue.

biomass was assumed to remain in the forests following harvest (this includes both the remaining standing wood as well as nutrient material).

Figure H-1 also shows the GCCC policies that require biomass energy. TLU-5 (covering consumption of renewable fuels in the transportation sector) is shown as a linked policy option, since it will drive the demand needed by AFW-12, which covers liquid biofuels production programs.

Table H-1 provides a summary of the GCCC biomass resource supply and demand using the supply data sources above and the assessments of energy requirements from each GCCC policy. For forestry biomass supply, CCS used the three BERC harvesting results which represent conservative, moderate, and aggressive harvesting assumptions.[3] Using the BERC modeling results as the source of forestry biomass supply, the results at the bottom of Table H-1 show that there is a sufficient resource to meet the GCCC biomass policy recommendations, even under the conservative harvesting assumptions.

[3] Conservative assumptions—No harvesting on public lands and on privately owned lands fewer than 50 acres, 40% bole volume classified as low-grade and 0% tops and limbs; Moderate assumptions—very little harvesting on public lands and on privately owned lands fewer than 50 acres, 60% bole volume classified as low-grade and 50% tops and limbs; Aggressive assumptions—moderate harvesting on public lands and on privately owned lands fewer than 50 acres 70% bole volume classified as low-grade and 100% tops and limbs. In all cases, CCS estimated dry tons by converting BERC's green tons estimate assuming 50% moisture content.

**Table H-1. Summary of GCCC biomass resource supply and demand**

| Biomass Supply (black)/ Demand (red) | Dry Tons Available – For Energy 2012 | Dry Tons Available – For Energy 2028 | Dry Tons Available – Saw & Veneer Logs 2012 | Dry Tons Available – Saw & Veneer Logs 2028 | Notes |
|---|---|---|---|---|---|
| **Supply** | | | | | |
| VT BERC (conservative) | 193,745 | 193,745 | n/a | n/a | BERC 2007 Study. For comparison, total biomass is assumed to be available by 2012; NREL (2005) estimate is 496,000 for forest residues. |
| VT BERC (moderate) | 733,491 | 733,491 | n/a | n/a | |
| VT BERC (aggressive) | 1,171,027 | 1,171,027 | n/a | n/a | |
| AFW-8 Biomass Feedstocks | 30,801 | 45,654 | 133,330 | 133,330 | Energy feedstocks from AFW-8 reported under AFW-6 to illustrate supply potential |
| NREL Urban Wood Waste | 65,000 | 65,000 | n/a | n/a | 2005 NREL Study cited below. |
| AFW-9 Enhanced MSW Recycling | 4,500 | 25,000 | n/a | n/a | Refers to the incremental organics that would be directed to composting to meet diversion rate goals; does not include any additional available MSW fiber or Construction & Demolition Waste. Assumes 50% moisture content. |
| Agricultural Crop Residue | Not assessed–no AFW policy options targeting programs for crop residues | | | | NREL,2005Study.Thisstudyfoundthatnobiomassres ourcesupplyinVTfromcropresidue. |
| **Total Supply (BERC Conservative)** | 198,245 | 218,745 | 360,000 | 360,000 | Does not include urban wood waste, since this source was not included in AFW options. |
| **Total Supply (BERC Moderate)** | 737,991 | 758,491 | 360,000 | 360,000 | Does not include urban wood waste, since this source was not included in AFW options. |
| **Total Supply (BERC Aggressive)** | 1,175,527 | 1,196,027 | 360,000 | 360,000 | Does not include urban wood waste, since this source was not included in AFW options. |
| **Demand** | | | | | |
| AFW-6 Increased Forest Biomass Energy | Demand captured in ESD Options | | | | |
| ESD-5 Combined Heat and Power | 27,212 | 114,292 | | | |
| ESD-6 Renewable Electricity Generation | 82,781 | 467,554 | | | Based on high biomass scenario (Scenario 2) |

| Biomass Supply (black)/ Demand (red) | Dry Tons Available | | | | Notes |
|---|---|---|---|---|---|
| | For Energy | | Saw & Veneer Logs | | |
| | 2012 | 2028 | 2012 | 2028 | |
| AFW-8 Expanded Use of Durable Wood Products | | | 4,301 | 1,446 | |
| AFW-12 Cellulosic Ethanol Feedstock | 44,444 | 500,000 | | | |
| Total Demand | 154,437 | 1,081,846 | 4,301 | 1,446 | |
| **Biomass Balance** | | | | | |
| BERC Conservative | 43,808 | 64,308 | 355,699 | 358,554 | |
| BERC Moderate | 583,554 | 604,054 | 355,699 | 358,554 | |
| BERC Aggressive | 1,021,090 | 1,041,590 | 355,699 | 358,554 | |

## AFW-1. Programs to Support Local Farming / Buy Local

### Policy Option Description

Programs that promote the production, storage, processing, distribution and consumption of locally grown food products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embodied energy. For this policy, the term "local" should be construed to include the broader New York and New England region.

Food products consumed in the United States can travel thousands of miles before reaching a grocery or clothing store in the form of a final product (a typical food product can travel over 1,500 miles and change hands dozens of times). Vermont food buyers should focus the majority of their food product purchases from New England and New York markets.

In addition to Vermont production, storage and processing, the percentage of locally grown food consumed in Vermont should also be a priority as it will reduce fossil fuel use and its associated GHG emissions. Establishment and support of creative and effective multi-layered marketing programs including "a virtual marketplace for local farmers markets" (e.g., Local Foods Plymouth) has shown to boost consumption of local foods.

### Policy Option Design

**Goals:** To increase the production, storage, and processing of locally grown animal products, grains, vegetables and fruits and their consumption in Vermont *such that 30% of these products purchased by Vermonters are produced in the state.*

**Timing:** To increase sales *and consumption* of local farm products by 50% and increase storage and processing capacity of locally grown farm products by 20% by 2012 **above current levels**. *Increase purchasing of Vermont-produced agriculture products to 30% of total purchased agriculture products in Vermont by 2028.*

**Parties Involved:** Center for Sustainable Agriculture at the University of Vermont (UVM), Agency of Agriculture, VT Department of Economic Development, Vermont farmers and industry associations.

**Other:** Promote the use waste heat generated from farm or industry practices to increase the levels of year-round vegetable and fruit production.

### Implementation Mechanisms

Working together to further define, develop, implement and promote all local foods production, storage, processing and consumption will require several strategies:

- Establish and promote a "virtual farmers market" to help boost sales;

- Explore the barriers and obstacles on the production side;
- Expand meat production and self-sustaining cold and warm weather products;
- Support the location of food processing, storage, and distribution centers to serve the region's needs;
- Engage surrounding States in the region to develop a regional plan to increase regional production, processing, transport and consumption;
- Expand technical and financial assistance for mobile livestock processing and fruit and vegetable freezing facilities or other innovative approaches to process and store locally produced livestock, fruits and vegetables;
- Expand technical, financial, and economic development assistance to create year-round production facilities which use waste heat from industrial, commercial, utility, and farm production.

## Related Policies/Programs in Place

Vermont Sustainable Agriculture Council (www.uvm.edu/sustainableagriculture);

Vermont Sustainable Jobs Fund (VSJF), Vermont Fresh Network (VFN), Northeast Organic Farming Association of Vermont (NOFA-VT), Intervale Community Farm, Community Supported Agriculture (CSA), UVM, Shelburne Farms, North Country Framers, Rutland Area Food and Farm Link (RAFFL), Vital Communities—Sustainable Ag Network (SAN);

UVM efforts to define local products and work with Sodexo Food Services to include greater percentages of local food in campus dining rooms;

Local Foods Plymouth (http://lfp.dacres.org/);

NH Farmers Market Association (www.nhfma.org).

## Type(s) of GHG Reductions

- **$CO_2$ (carbon dioxide):** Reduction in $CO_2$ emissions due to a reduction in ton-miles required to bring out-of-state agriculture products to markets in Vermont. Although not quantified in this analysis, it is possible that processing of products in-state may yield additional GHG benefits, as electricity necessary for these products tends to be less carbon-intensive in Vermont than in some other states that primarily use coal for electricity generation.

## Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.004, 0.02.
- **Net Cost per $MtCO_2e$:** Not quantified.
- **Data Sources:** U.S. per capita food consumption was taken from the USDA Economic Research Service (ERS) Food Availability (Per Capita) Data System. Per capita consumption of each food type is shown in Table H-2. Per capita food expenditures were

also obtained from ERS.[4] Vermont local food expenditures for 2000 were obtained from the 2005 Report from the Vermont Sustainable Agriculture Council.[5] The average travel distance of imported food was taken from an Iowa study of food miles.[6]

**Table H-2. Per capita consumption of food types, by category**

| Food Category | US per capita consumption (lbs) |
|---|---|
| Red meat | 116 |
| Chicken | 86 |
| Turkey | 17 |
| Fish | 12 |
| Eggs | 33 |
| All dairy | 601 |
| Fats and oils | 87 |
| Peanuts | 7 |
| Tree nuts | 3 |
| Coconut | 1 |
| Fresh fruit | 122 |
| Canned fruit | 15 |
| Dried fruit | 2 |
| Frozen fruit | 5 |
| Fruit juice | 72 |
| Fresh vegetables | 184 |
| Canned vegetables | 108 |
| Frozen vegetables | 75 |
| Legumes | 6 |
| Dehydrated vegetables | 14 |
| Potatoes for chips, shoestrings | 16 |
| Grains | 192 |
| Coffee, tea, cocoa | 20 |
| Spices | 3 |
| Beverages | 116 |
| **Total** | **1,911** |

- **Quantification Methods:**

*GHG Benefits*

The Vermont Sustainable Agriculture Council has estimated that 12% of food purchased in Vermont is from in-state sources.[7] Total consumption of food was estimated for each year by

[4] USDA, Economic Research Service, Food CPI, Prices, and Expenditures: Per Capita Food Expenditures, http://www.ers.usda.gov/Briefing/CPIFoodAndExpenditures/Data/table15.htm

[5] Vermont's Agriculture: Generating Wealth from the Land, Vermont Sustainable Agriculture Council, 2005, http://www.uvm.edu/%7Esusagctr/CouncilReport05.PDF.

[6] Pirog, R., "Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions". Leopold Center for Sustainable Agriculture, 2003, http://www.leopold.iastate.edu/pubs/staff/files/food_travel072103.pdf

[7] Allen Matthews, Vermont Sustainable Agriculture Council personal communication with H. Lindquist, CCS, June 2007.

multiplying projected population by the per capita consumption data referenced above. Table H-3 shows the estimated food consumption and the amount of food imported from out-of-state sources with the policy goal and without the policy goal (business as usual; [BAU]).

**Table H-3. Estimated food consumption for states with and without BAU**

| Year | Population | % Locally Purchased Food | Food From Out-of-State (tons) | BAU Food From Out-of-State (tons) |
|---|---|---|---|---|
| 2007 | 639,592 | 12.0% | 577,664 | 577,664 |
| 2008 | 643,899 | 13.2% | 573,623 | 581,553 |
| 2009 | 648,205 | 14.4% | 569,476 | 585,443 |
| 2010 | 652,512 | 15.6% | 565,223 | 589,332 |
| 2011 | 656,643 | 16.8% | 560,715 | 593,064 |
| 2012 | 660,775 | 18.0% | 556,105 | 596,795 |
| 2013 | 664,906 | 18.8% | 554,463 | 600,527 |
| 2014 | 669,038 | 19.5% | 552,759 | 604,258 |
| 2015 | 673,169 | 20.3% | 550,990 | 607,989 |
| 2016 | 676,672 | 21.0% | 548,649 | 611,153 |
| 2017 | 680,176 | 21.8% | 546,254 | 614,318 |
| 2018 | 683,679 | 22.5% | 543,805 | 617,482 |
| 2019 | 687,183 | 23.3% | 541,302 | 620,646 |
| 2020 | 690,686 | 24.0% | 538,745 | 623,810 |
| 2021 | 694,281 | 24.8% | 536,205 | 627,057 |
| 2022 | 697,875 | 25.5% | 533,609 | 630,303 |
| 2023 | 701,470 | 26.3% | 530,958 | 633,550 |
| 2024 | 705,064 | 27.0% | 528,251 | 636,796 |
| 2025 | 708,659 | 27.8% | 525,490 | 640,043 |
| 2026 | 712,347 | 28.5% | 522,741 | 643,374 |
| 2027 | 716,035 | 29.3% | 519,936 | 646,705 |
| 2028 | 719,723 | 30.0% | 517,074 | 650,036 |

The reduction of food miles was estimated by taking the difference between the amount of food from out-of-state under BAU and under this policy and multiplying by average miles traveled by out-of-state food. This average was assumed to be 1,500 miles plus an additional 25% to account for trucks returning to their points of origin empty (1,875 miles).

Reaching 30% in-state food would require significant investment in infrastructure such as slaughterhouses, processing facilities, and distribution centers.[8] Therefore, the Center for Climate Strategies (CCS) assumed that much of the increased "local" food consumption comes from regional sources. The average miles traveled by food from regional sources was assumed to be 150 miles (the distance from Boston to central Vermont) plus an additional 25% to account for trucks returning to their points of origin empty (187.5 miles).

The food transport emission factor (0.162 lb $CO_2$/ton-mile) was estimated by assuming 23-ton payload trucks, 6 truck miles/gal diesel, and 22.4 lb $CO_2$/gal diesel.

[8] Allen Matthews, Vermont Sustainable Agriculture Council personal communication with H. Lindquist, CCS, June 2007.

*Costs*

- Overall costs for this policy option were not quantified. The Technical Work Group (TWG) was unable to determine the level of incentives needed in-state to address the envisioned regional approach to enhancing the overall food production system to increase consumption of local products. These include the additional costs to incentivize local year-round production of agricultural products, as well as regional storage, processing, packaging, and distribution.
- **Key Assumptions:** Reaching 30% in-state food would require significant investment in infrastructure such as slaughterhouses, processing facilities, and distribution centers. Therefore, CCS assumed that much of the increase in "local" food is from regional sources rather than in-state sources.

## Key Uncertainties

The largest source of uncertainty is whether the region can supply the variety of agricultural products needed to supply 30% of Vermont consumption. Significant work will be needed to identify and promote products that can be regionally produced to meet the goals of this policy.

## Additional Benefits and Costs

An increase in local jobs for farmers, food processors, and associated industries.

## Feasibility Issues

See Key Uncertainties above.

Information prepared by the Agency of Agriculture shown in Table H-4 suggests that the New York and New England regional agricultural industry has the potential to supply at least 37% of regional food consumption.[9] To estimate the total percent consumption of 37%, the production of potatoes was set equal to the consumption of potatoes (the region produces much more of this crop than is consumed). Note that regional production data for fish, fats/oils, and flour & cereal products were not available, therefore, 37% could be considered a low estimate of the region's ability to supply Vermont's needs.

[9] P. Benedict, VT Agency of Agriculture, personal communication with S. Roe, CCS, June 15, 2007. Data sources used include: New Engl. Ag.. Statistics, 2005 Annual Bulletin, USDA/NASS 2005-2006 New York Annual Bulletin, 2002 Census of Agriculture, U.S. Census Bureau Annual Estimates of Population for 2006 - www.ers.usda.gov/data/FoodConsumption/FoodAvailSpreadsheet.htm; excludes production for home consumption.

**Table H-4. Food production and consumption for New England and New York**

| New England & New York Food Item | Food Consumed (lb. per capita) | Total Consumption (million lb.) | Production (million lb.) | Percent of Consumption |
|---|---|---|---|---|
| Red meat | 161.6 | 5,426 | 133 | 2% |
| Poultry | 65.6 | 2,203 | 68 | 3% |
| Fish | 16.5 | 554 | N/A | |
| Eggs (number) | 253.9 | 8,525 | 3,325 | 39% |
| Dairy products, including butter | 591.8 | 19,870 | 16,278 | 82% |
| Fats/oils | 87.5 | 2,938 | N/A | |
| Fruits, selected | 271.4 | 9,113 | 1,436 | 16% |
| Vegetables, selected | 295.5 | 9,922 | 2,396 | 24% |
| Potatoes | 127.3 | 4,274 | 68,765 | 1,609% |
| Tree nuts | 3.6 | 121 | 0 | |
| Peanuts | 6.7 | 225 | 0 | |
| Flour and cereal products | 191.5 | 6,430 | N/A | |
| Sweeteners | 141.0 | 4,734 | 0 | 0.0% |
| Coffee | 9.6 | 322 | 0 | |
| Tea | 0.8 | 27 | 0 | |
| Cocoa | 4.8 | 161 | 0 | |
| **Totals** | | **74,845** | **27,910** | **37%** |

N/A = not applicable.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-2. Agricultural Nutrient Management Programs

### Policy Option Description

Use of conservation practices to increase the incorporation of organic green manures, implement grass-based rotations and cover-cropping, which will reduce soil erosion, maintain/increase soil organic matter level, and increase overall soil tilth. In addition, maximize the use of farm organic wastes to improve crop fertility and to lower the importation of oil-based synthetic fertilizers. This option is designed to increase the acreage using soil management practices that lead to higher soil carbon content and reduce nitrogen run-off which has the potential to reduce nitrous oxide emissions.

### Policy Option Design

- **Goals:** Implement Nutrient Management Plans (NMPs) aimed at increasing soil carbon levels and minimizing nitrogen run-off and subsequent nitrous oxide ($N_2O$) emissions on 75% of farm acreage by 2012 and 90% by 2028. Inject 10% of liquid dairy manure and processed waste water by 2012. Increase acreage managed under cover crop to 25% of annual cropland by 2012 and 50% by 2028.
- **Timing:** See goals above.
- **Parties Involved:** Vermont Agency of Agriculture, Vermont non-profit farming organizations, Agricultural Coops, eco-agriculture consulting companies, Vermont Farm Bureau, Vermont farmers, U.S. Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), Vermont natural resource agencies, environmental organizations, UVM and other Vermont Colleges.
- **Other:** NMPs would cover a wide variety of practices that will reduce nitrogen leaching and run-off and potentially increase soil carbon levels. These include: maximizing the use of on farm manure and processed waste water to reduce imported fertilizers; using crop rotation and increasing the use of cover cropping on annual crop land to minimize the loss of organic matter from soil erosion; and increasing the use of manure injector technologies on grass and no-till crop land. Additional practices for increasing soil organic matter include: planned grazing; biological subsoiling (using root crops and deep tap-rooted plants); composting and compost tea; pasture cropping, or double cropping; charcoal soil amendments (e.g., Amazon dark earths and the Epridra Process); biodynamic preparations; mineralization schemes, including rock dusts and sea minerals; microbial stimulants (e.g., effective microorganisms, indigenous microorganisms); cover cropping; green manures; mulches; seaweed products; recycled green wastes; biosolids; humic substances; dung beetle and earthworm reintroduction. Research and development is needed to determine the most cost-effective solutions for the many small dairies in Vermont, since some of the methods described above might best be implemented on medium to large operations.

## Implementation Mechanisms

- Fund and Implement the NRCS Grassland Reserve Program in order to increase carbon sequestration.
- Provide cost share assistance for farmers to purchase manure injection equipment to retrofit existing manure spreaders or purchase new equipment.
- Implement 590 NMPs (the NRCS Technical Practice Code) on large and medium livestock farms through agency permitting programs.
- Implement 590 NMPs on small livestock farms when they receive state or federal cost share to construct waste management systems.
- Provide cost share assistance for farms to develop NMPs and provide annual assistance so that existing plans continue to be implemented. Currently, the focus for matching funds for NMPs is on medium-sized operations (about 200). Around 800 smaller dairy farms need some type of plan but have no source of funding to develop one.
- Provide cost share assistance so that farms implement cover crops and other soil erosion and land cover practices.

## Related Policies/Programs in Place

- USDA's NRCS Grassland Reserve Program
- NRCS Environmental Quality Incentives Program (EQIP), a cost share program
- Vermont Best Management Practices cost share program
- Vermont Nutrient Management Plan Cost share program
- Vermont Farm Agronomics Practices cost share program
- Conservation District Technical Assistance Program
- UVM Extension Program

## Type(s) of GHG Reductions

- $N_2O$: reductions occur when nitrogen run-off and leaching are reduced. (Addition of nitrogen to water bodies leads to the formation and emission of $N_2O$.)
- $CO_2$: reductions occur as soil carbon levels in crop soils are increased above business as usual levels. Increasing the levels of carbon in soils indirectly sequesters carbon from the atmosphere.

## Estimated GHG Savings and Costs per MtCO$_2$e

- **GHG reduction potential in 2012, 2028 (MMtCO$_2$e):** 0.08. 0.10.

  *GHG savings only estimated for reduction in nitrogen run-off/leaching from fertilizer and manure application. Due to the nature of Vermont soils, the potential for soil carbon sequestration is judged to be minimal. Also, not captured in this analysis are the life cycle benefits associated with the production, transport, and application of commercial fertilizers that are reduced due to the application of NMPs.*

- **Net Cost per MtCO$_2$e:** $2

*Cost estimate includes the cost savings from lower fertilizer expenditures.*

- **Data Sources:** $N_2O$. Annual $N_2O$ emissions from synthetic fertilizer and manure applications (Table H-5) were taken from the Vermont Inventory & Forecast. The average reduction in fertilizer usage resulting from implementation of NMPs (15%) was taken from an EPA guidance document.[10] Cost information for synthetic fertilizers was taken from the USDA ERS.[11] The average cost of synthetic fertilizers in the United States in 2004 was $260/ton.

**Table H-5. 2002 emissions from fertilizer and manure applications**

| Source | $MMtCO_2e$ |
|---|---|
| Synthetic fertilizer | 0.279 |
| Direct | 0.047 |
| Indirect | 0.004 |
| Leaching and runoff | 0.227 |
| Manure application | 0.542 |
| Direct | 0.130 |
| Leaching and runoff | 0.412 |
| **Total** | **1.36** |

*Soil Carbon*

The Vermont Agency of Agriculture has had several discussions directly with the Chicago Climate Exchange (CCX). It is the CCX belief, that due to the inherent properties of Vermont soils (cold climate, naturally high percentage clay soils, and wet weather) local soils do not provide a significant opportunity for carbon sequestration because of the pre-existing relatively high organic matter (OM) content of Vermont soils.[12] On average, Vermont soils have OM content between 2% and 7%, and soil OM levels that increase above these levels can create soils with too much OM to support agricultural crops or grazing perennials. Soils with OM levels that are above accepted agricultural production guidelines can actually have a negative affect on carbon sequestration. As soil OM increases, the soil becomes more "muck-like" or saturated with OM and water. With a cold and wet climate OM build up is much more rapid (decomposition of OM is slow cold, wet climates), which is the case in most of Vermont, where many hay and corn fields would not be in production without tile drainage. When soils become muck-like they frequently become anaerobic during wetter parts of the year, and anaerobic soils emit a much larger amount of $CO_2$ into the atmosphere than productive agricultural soils with OM levels between 2% and 5% (Brady & Weil, 2005).

- **Quantification Methods:**

Estimates of GHG reductions and costs are provided below for the different management practices assumed to be implemented under this policy option.

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[10] "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters," http://www.epa.gov/owow/nps/MMGI/Chapter2/ch2-2c.html#Practices, Table 2-14.

[11] http://www.ers.usda.gov/Data/FertilizerUse/Tables/Table7.xls.

[12] Phil Benedict and David Weber, Vermont Agency of Agriculture, Food, and Markets, personal communication with H. Lindquist, CCS, June 2007.

*$N_2O$ Reduction in Lower Fertilizer Usage*

*GHG Benefits.* The reduction in $N_2O$ emissions was estimated by applying the NMP nitrogen reduction (15%) by the annual $N_2O$ emissions and then multiplying by the policy percentage of acreage under NMPs (75% in 2012, 90% in 2028) minus the BAU percentage of acreage under NMPs (estimated to be 13%).[13] It is assumed that the 15% reduction applies to both commercial fertilizer (through lower amounts applied annually) and manure application (through soil incorporation or other methods that reduce nitrogen leaching).

*Costs.* Incremental costs for staff, lab costs, and travel were estimated to be $250,000 per year. The cost of preparation of a guidance document was estimated to be $75,000 in the first year of the program. Costs for soil and manure tests were estimated to be $140,000 per year (12,000 soil tests at $15 and 2,000 manure tests at $35 per test).[14,15] The cost savings for reduced synthetic fertilizer usage were estimated by multiplying the annual synthetic fertilizer consumption by the percentage reduced in each year and the average cost of fertilizer ($260/ton). Overall costs were estimated as the net of costs and cost savings.

*Cover Crops*

Like manure injection, GHG benefits for cover crops were not estimated due to lack of data and the many variables involved. Cover crops can influence GHG emissions in numerous ways, such as weed suppression which reduces the need for herbicides and reduction in soil erosion. Nitrogen-fixation by a legume cover crop may reduce the need for fertilizers. However, other types of cover crops may require additional application of fertilizers. Some cover crops add biomass to the soil, increasing carbon sequestration, while other types remove carbon from the soil decreasing soil carbon stocks. The benefits from cover crops are highly dependent on the type of cover crop and local conditions.

- **Key Assumptions:** The nitrogen reduction is representative of agricultural practices in Vermont; a reduction in nitrogen use from commercial fertilizers will lead to a similar level of reduction in $N_2O$ emissions. No change in net soil carbon levels occur as a result of this option.

## Key Uncertainties

The effects of manure injection and cover crops on $N_2O$ emissions are highly uncertain due to highly variable conditions and lack of emissions data. While manure injection has been shown to result in lower ammonia ($NH_3$) emissions than manure broadcasting, the lower $NH_3$ volatilization may actually lead to higher $N_2O$ emissions. On the other hand, injection may result in higher fertilizer replacement value of the manure applied, leading to a reduction of mineral fertilizers and less nitrogen leaching on conventional farms (lower leaching of nitrogen could lead to lower $N_2O$). For this assessment, CCS has assumed that since most of the $N_2O$ emissions

[13] The state has contracted to have NMPs written for 92,000 acres out of 700,000 acres that may receive manure (100,000 cropland and 600,000 hay/pasture land).

[14] Estimated number of soil and manure tests provided by Phillip Benedict, Vermont Agency of Agriculture, Food & Markets, personal communication with H. Lindquist, CCS, May 2007.

[15] Soil and manure test costs from UVM, Agricultural and Environmental Testing Laboratory, http://pss.uvm.edu/ag_testing/?Page=forms.html.

are associated with leaching and runoff, these emissions can be reduced through NMPs that successfully address this issue (by retaining nitrogen in the soils).

Data to assess the additional GHG reductions associated with the production, transport, and application of commercial fertilizers was not identified in time to incorporate into the results of this analysis.

## Additional Benefits and Costs

Higher levels of soil organic carbon can lead to higher levels of crop productivity. Measures adopted that result in decreases in fossil fuel combustion will lead to lower GHG and other air pollutant emissions.

## Feasibility Issues

As stated above, due to the inherent properties of Vermont soils (cold climate, naturally high percentage clay soils, and wet weather) local soils do not provide a significant opportunity for carbon sequestration because of the pre-existing relatively high OM content of Vermont soils.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-3. Manure Management Methods to Achieve GHG Benefits

### Policy Option Description

The methane emissions inherent from the anaerobic decomposition process of manure and other wastes may be captured and used as an energy source. Methane and nitrous oxide emissions can occur at several different places in the manure management process. Management techniques aimed can reduce GHG emissions and, with energy recover, offset fossil-based energy. This option covers producer incentives to adopt programs to increase the number of methane capture and energy recovery projects or other manure management techniques that reduce methane and nitrous oxide emissions.

### Policy Option Design

**Goals:** Digest half of dairy cattle manure by 2028; Compost 50% of the poultry and livestock manure produced on farms by 2028; Implement nutrient management strategies which meet the NRCS Technical Practice Code 590 on 90% of the land which receives manure or processed wastewater by 2028.[16]

**Timing:** Increase the anaerobic digestion from 5% (in operation and under construction) to 15% of the dairy cattle manure in Vermont by 2012. By 2028, digest 50% of the dairy cattle manure in Vermont; Increase the percentage of manure composted on poultry and livestock farms to 25% by 2012 and to 50% by 2028; Implement nutrient management plans on 75% of the lands receiving manure and processed wastewater by 2012 and on 90% of this land base by 2028.

**Parties Involved:** Vermont Agency of Agriculture, Vermont Agency of Natural Resources, Vermont Department of Public Service, USDA Natural Resources Conservation Service, USDA Rural Development, Vermont Power Supply Companies, Vermont Farm Bureau, Rural Vermont, University of Vermont, Vermont Technical College-Business and Sustainable Technology, Vermont Center for Emerging Technology.

**Other:** Anaerobic digestion of half of Vermont's dairy manure could produce 15 megawatts of electric generation and 350 billion Btu's of heat energy per year.

### Implementation Mechanisms

- Implement 590 nutrient management plans on large and medium livestock farms through agency permitting programs.
- Implement 590 nutrient management plans on small livestock farms when they receive state or federal cost share to construct waste management systems.

[16] Natural Resources Conservation Service; Nutrient Management Code 590. For a 2005 "Statement of Work," providing a nutrient management component checklist, visit; http://efotg.nrcs.usda.gov/references/public/VT/VT-SOW_590_NutrientManagement_5-05.pdf.

- Provide cost share assistance for farms to develop nutrient management plans and provide annual assistance so that existing plans continue to be implemented.
- Provide cost share assistance so that farms implement cover crops and other soil erosion and land cover practices.
- Provide cost share assistance for the construction of waste management systems including methane digestion and composting facilities where appropriate.
- Provide technical assistance on the adoption of new technologies and support the development of service industries to maintain the new technologies.

## Related Policies/Programs in Place

- NRCS Environmental Quality Incentives Program
- Vermont Best Management Practices cost share program
- Vermont Nutrient Management Plan cost share program
- Vermont Farm Agronomics Practices cost share program
- Conservation District Technical Assistance Program
- University of Vermont Extension Program
- Vermont Clean Energy Fund
- CVPS Biomass Grants Program
- USDA Rural Development 2006 Renewable Energy Systems and Efficiency Grants Program
- EPA AgStar Program.
- Federal Renewable Electricity Production Tax Credit.
- USDA Farm Bill Renewable Energy and Energy Efficiency Loan and Grant Program—The Renewable Energy and Energy Efficiency loan and grant program was established under Section 9006 of the 2002 Farm Bill. It provides loan guarantees and grants to agricultural producers and rural small businesses for the purchase and installation of renewable energy systems or for energy efficiency improvements. Loan guarantees cover up to 50% of a project's cost, not to exceed $10 million. Grants are available for up to 25% of a project's cost, not to exceed $250,000 for energy efficiency improvements and $500,000 for renewable energy systems. These loans and grants are expected to reduce greenhouse gas emissions by 0.97 million metric tons, replace 821 million barrels of foreign oil and generate almost 2 million kilowatt hours of electricity annually. USDA has funded more than 800 loans and grants since the renewable energy program began in FY 2003.
- VT House Bill 520, Sect. 4: Section 4 updates the definition of a "farm," as it applies to the Bill, which establishes a goal of 25% renewable energy consumption in Vermont by 2025, "particularly from Vermont's farms and forests.

## Type(s) of GHG Reductions

- **$CH_4$:** methane is captured and typically combusted in an energy recovery system or flare. Small amounts of $N_2O$ and $CH_4$ are emitted from the combustion process.

- **$CO_2$:** carbon dioxide is reduced when the methane is converted to energy and that energy is used to offset fossil-based energy (e.g., electricity, natural gas, etc.). Small amounts of $N_2O$ and $CH_4$ are also reduced from the fossil-based energy that is offset. See ES-6 for estimates of $CO_2$ offsets.

## Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** Manure digesters: 0.007, 0.03; (including grid-based power offset), 0.006, 0.02 (including methane capture only);
- **Net Cost per $MtCO_2e$:** Manure digesters: $117 (including grid-based power offset), $136 (including methane capture only);

*Manure digester cost estimates include the reduction in capital costs associated with grants for renewable energy projects from the Federal Farm Bill but do not include the effects of other existing federal and state tax incentives.*

- **Data Sources:**

*Manure Digesters*

Manure management emissions estimates were taken from the VT GHG Inventory & Forecast. An electricity conversion factor of 10,000 Btu/kW-hr was taken from the Vermont Methane Pilot Project Resource Assessment.[17] Cost estimates were taken from a list of NYSERDA anaerobic digester projects[18] and a list of digester operations from the EPA AgSTAR program.[19]

*Composting*

Manure management emissions estimates were taken from the Vermont GHG Inventory & Forecast. Manure composting emission factors taken from a manure composting study by Hao et al.,[20]

- **Quantification Methods:**

*Manure Digester GHG Benefit*

Methane emissions data from the Vermont Inventory & Forecast were used as the starting point to estimate the GHG benefits of capturing and controlling the volumes of methane targeted by the policy. For 2012 and 2028, the GHG benefit for capturing methane was estimated by multiplying the methane emissions from dairy operations by the applicable goal (15% in 2012, 50% in 2028) minus the BAU percentage of dairy populations affected (5%), multiplying by an assumed collection efficiency of 75%,[21] and

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[17] Vermont Methane Pilot Project Resource Assessment, http://www.vermontagriculture.com/methresource.pdf

[18] Cornell Manure Management Program, NYSERDA Project List: Anaerobic Digestion, http://www.manuremanagement.cornell.edu/Lessons/List_anaerobicDigestion.aspx

[19] EPA AgSTAR, Guide to Operation Systems, U.S. Operating Digesters by State, http://www.epa.gov/agstar/operation/bystate.html

[20] X. Hao, C. Chang, F.J. Larney, and G.R. Travis, "Greenhouse Gas Emissions during Cattle Feedlot Manure Composting," Journal of Environmental Quality, 30:376-386 (2001).

[21] The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on methane collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).

converting to $CO_2e$. The benefit from offsetting grid-based power was estimated by multiplying the estimated annual MWh generated by manure digesters by the grid-based power emission factor (0.63 $MtCO_2e$/MWh) taken from the Vermont Inventory & Forecast.

*Manure Digester Costs*

Costs were estimated based on data from the NYSERDA and EPA AgSTAR project lists. The average capital cost per head was calculated for dairies with between 150 and 1,200 cows, resulting in a value of $674/head. (The highest capital cost/head value was removed because it was over 30% higher than the next highest value.) This capital cost was assumed to represent the "high" end of the range for capital costs. The "low" capital cost estimate was assumed to be $190/head for regional digesters (those serving multiple nearby operations), taken from a New Mexico Dairy Producers Association report.[22]

Annual costs were estimated based on data from the NYSERDA project list. The average of annual operating and maintenance costs minus benefits (excluding electricity and heat savings) resulted in an annual cost of $36/head.

CCS assumed that the 25% Farm Bill grant would be available to each project initiated as a result of this policy.[23] After adjustment of the capital costs, annualized costs per head were estimated assuming a 5% interest rate and a 15-year project life. The value of the electricity produced was assumed to be $0.073/kW-hr in 2012 and $0.064/kW-hr in 2028.[24] Additional incentives to the farmer from the Renewable Energy Production Incentives were not included but could have a small effect on the estimated costs (about $1/$MtCO_2e$ reduced). The annualized per head cost estimates were multiplied by the head of livestock to be controlled in each year to estimate total costs.

*Composting GHG Benefit*

Emission factors for $CH_4$ and $N_2O$ from manure management were estimated based on the Vermont Inventory & Forecast by dividing the estimated emissions by the total amount of manure for each livestock type (shown in Table H-6). The amount of manure was estimated from the amount of volatile solids (VS) estimated in the inventory by assuming 70% moisture and the following %VS values: dairy, 85%; feedlot cattle, 88%; and poultry, 75%. These emission factors were compared to emission factors taken from a manure composting study by Hao et al.,[25] who found that manure compost produces 0.0096 kg $CH_4$/kg of manure and 0.00047 kg $N_2O$/kg of manure. Comparison of these emission factors shows a substantial negative benefit for both pollutants and all livestock

[22] *DPNM Biomass Project 2005*, prepared by Agri-Energy and the Dairy Producers of New Mexico, no publish date provided.

[23] More information on the program is also available at: http://www.rurdev.usda.gov/rbs/farmbill/index.html. The application of this grant incentive was considered a reasonable assumption based on CCS discussions with EPA AgSTAR Program staff; Kurt Roos, personal communication with S. Roe, CCS, March 2007.

[24] Electricity costs come from the study "Avoided Energy Supply Costs in New England" prepared by ICF Consulting for the Avoided Energy Supply Component (AESC) Study Group. December 23, 2005.

[25] X. Hao, C. Chang, F.J. Larney, and G.R. Travis, "Greenhouse Gas Emissions during Cattle Feedlot Manure Composting", *Journal of Environmental Quality*, 30:376-386 (2001).

types except for $N_2O$ emissions from feedlot cattle. Benefits predicted for feedlot cattle from manure composting (including $CH_4$ and $N_2O$ emission) are less than 0.0001 $MMtCO_2e$.

**Table H-6. Manure management emissions and emission factors from the Vermont Inventory & Forecast**

| | 2002 $CH_4$ (kg) | 2002 Manure (kg) | kg $CH_4$/kg manure | % Reduction compared with that in Hao et al. |
|---|---|---|---|---|
| **Dairy** | 3,933,775 | 1,367,986,758 | 0.00288 | –234% |
| **Feedlot Cattle** | 520 | 530,079 | 0.00098 | –879% |
| **Poultry** | 17,317 | 7,555,687 | 0.00229 | –319% |
| | | | | |
| | **2002 $N_2O$ (kg)** | **2002 Manure (kg)** | **kg $N_2O$/kg manure** | **% Reduction compared with that in Hao et al.** |
| **Dairy** | 440,815 | 1,367,986,758 | 0.00032 | –46% |
| **Feedlot Cattle** | 601 | 530,079 | 0.00113 | 59% |
| **Poultry** | 2,365 | 7,555,687 | 0.00031 | –50% |

Because of the relative uncertainty associated with manure composting emissions and the potential for negative benefits, manure composting is not recommended as part of this option.

*Manure Composting Costs*

Not estimated due to the lack of GHG benefits estimated above.

- **Key Assumptions:** That the cost data for the studies cited is representative of actual costs; 75% collection efficiency for farm-level methane emissions for the digester. Farm Bill grant will be available to all projects in subsequent cycles of the Farm Bill through 2020. Composting emission factors are representative of all types of manure (dairy, feedlot, and poultry).

## Key Uncertainties

Significant research and development is needed over the next 10 years to develop digester technology for application to small dairy operations. Currently, it is uncertain to what extent regional digester projects could be implemented to serve groups of small dairies in the State.

CCS assumed that the 2007 Farm Bill (and subsequent versions of the Bill) would include the same capital cost share for digester projects offered by the 2002 Farm Bill. If this does not occur, the cost-effectiveness estimate for this option would be higher and additional cost share would likely be needed from the State. Another uncertainty is in the value of the electricity produced from these digester projects (either avoided cost by the farmer or the value of electricity sold to the grid). CCS assumed 7 cents per kW-hr in 2012 and 6 cents in 2028 based on a study cited above). Currently, Vermont farmers receive 11 cents per kW-hr, but in New York, dairy farmers only receive 3 cents per kW-hr.

## Additional Benefits and Costs

- *Air & Water Pollution Impacts*—Reductions in emissions of ammonia, volatile organic compounds, and odors (sulfur compounds) are achievable. Reductions occur when anaerobic digesters and energy utilization are used to capture emissions that would have occurred from the lagoon surface. Note that these reductions occur at the lagoon surface and that there is a potential for increased ammonia emissions during application of digester effluent to fields due to high ammonium concentrations, if measures are not taken to avoid these emissions. Ammonia emissions are important in the formation of fine particulate matter and nitrogen deposition to sensitive water sheds. Also, there will be an increase in emissions of nitrogen and sulfur oxides during the combustion of biogas. Both of these pollutants are also fine particulate matter precursors, and oxides of nitrogen are a precursor of ozone.

  Measures to reduce both air and water pollution impacts could include the use of nitrifying/denitrifying systems to reduce the ammonium concentration prior to application. In these systems, ammonium is converted to nitrogen which is released instead of ammonia (care must be taken to avoid excessive nitrous oxide emissions, however). The other option is to identify and produce marketable products for the digester effluent, which would have to be trucked off of the farm. The increased GHG emissions associated with transporting any such products have not been factored in to the analysis conducted for this option.

  A study of an anaerobic digester project for a dairy farm[26] demonstrated that these projects can substantially reduce total volatile solids (39.5%) and chemical oxygen demand (38.5%). These reductions translate directly into a lower potential for depletion of dissolved oxygen in natural waters. Although anaerobically digested manure is not suitable for direct discharge to surface or ground waters, these reductions still are significant due to the potential for these wastes to enter surface waters by nonpoint source transport mechanisms. The study also showed that mesophilic anaerobic digestion at an average hydraulic retention time of 29 days reduced the mean densities of the fecal coliform group of enteric bacteria by 99% and fecal streptococcus group by 90%;

- Economic benefits for the digester industry.

## Feasibility Issues

The TWG notes that additional infrastructure will be needed to fully implement this option. For example, to allow net metering, 3-phase wiring will be needed to the facilities involved, which could mean that new substations are needed. The cost analysis for this option does not include the additional costs for these potential new infrastructure needs.

## Status of Group Approval

Complete.

[26] "An Evaluation of a Mesophilic, Modified Plug Flow Anaerobic Digester for Dairy Cattle Manure," prepared by Eastern Research Group, prepared for the U.S. EPA AgSTAR Program, July 20, 2005.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-4. Protect Open Space / Agricultural Land

### Policy Option Description

Reduce the rate at which existing crop and pasture are converted to developed uses. The carbon sequestered in soils and aboveground biomass can be higher in agricultural lands than in developed land uses. Policies are needed to protect working farms and forests (see AFW-7) from unwise and unplanned development.

### Policy Option Design

**Goals:** To reduce the rate at which agricultural lands are converted to development by 50%.

**Timing:** Reduce the rate of conversion by 25% by 2012; achieve 50% reduction in the rate of conversion by 2020 and maintain this rate of conversion through the policy period.

**Parties Involved:** VT Department of Agriculture, non-government organizations, local planning departments, agricultural land owners.

**Other:** Vermont has established planning goals to protect the historic pattern of development which favors compact settlement surrounded by open and productive countryside. The state provides incentives to land owners to keep their property in the production of food, fuel and fiber for local consumption, but much more can be done. Vermont's landscape is susceptible to land development that will negatively impact the viability of farm and forestland unless land conservation programs are expanded and fully funded, and rural sprawl is controlled in a responsible manner.

### Implementation Mechanisms

1. Adequately fund the Vermont Housing and Conservation Trust Fund according to the formula set in statute.
2. Expand enrollment in Vermont's Use Value Appraisal (UVA) Program.
3. Encourage incentives for carbon sequestration on forest and agricultural land.
4. Encourage regional and local land use planning that promotes the viability of farms and forestland.
5. Strengthen incentives for landowners to pursue conservation easements by adjusting property tax rates for landowners who hold easements to reflect use value or a comparable rate.

### Related Policies/Programs in Place

Housing and Conservation Board, Use Value Appraisal Program, Forest Legacy Program, Land Trust activity, Regional Planning, Growth Centers Legislation, Act 200, Act 250, NRCS and other federal programs.

## Type(s) of GHG Reductions

- **$CO_2$:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass. Also, emissions are indirectly reduced to the extent that development patterns are influenced and vehicle miles traveled (VMT) are reduced (see TLU Option 1).
- **$CH_4$ and $N_2O$:** Are also indirectly reduced as VMT are reduced.

## Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** 0.06, 0.11
- **Net Cost per $MtCO_2e$:** $31

  *Note: The reductions and cost per Mt estimated for this option only refer to the direct benefits and costs associated with the estimated loss of soil carbon from agricultural soils due to development. They do not include the indirect benefits that occur as a result of more efficient development patterns that could result from this option (see TLU-1).*

- **Data Sources:** The annual rate of agricultural land in Vermont converted to developed uses is 10,000 acres per year based on 1982–1997 data from the National Resources Inventory.[27] The typical level of soil carbon in agricultural soils in Vermont was estimated by averaging soil carbon data for entisol and inceptisol type cultivated soils to depths of 30 cm,[28] resulting in a value of 0.016 MMtC/1,000 acres. The cost of establishing conservation easements on agricultural lands was estimated by averaging the project costs and NRCS funds for agricultural easements reported in the Vermont Housing and Conservation Board 2006 Annual Report.[29]
- **Quantification Methods:**

*GHG Benefits*

Studies are lacking on the changes in below and above-ground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top 30 cm of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of aboveground carbon stocks.

The benefit in each year was determined by 1) determining the amount of land protected in each year by multiplying the annual rate of agricultural land lost by the percentage of

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[27] Ray Godfrey, Resource Inventory Coordinator, VT USDA-NRCS, personal communication with H. Lindquist, CCS, March 13, 2007.

[28] Mann, L.K. 1986. Changes in soil carbon storage after cultivation. Soil Science 142(5):279-288, http://cdiac.ornl.gov/programs/CSEQ/terrestrial/mann1986/mann1986.html

[29] Vermont Housing and Conservation Board 2006 Annual Report, http://www.vhcb.org/pdfs/ar2006sm.pdf

agricultural land protected, 2) multiplying the soil carbon content on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost), and 3) converting the soil carbon lost to $CO_2$ by multiplying by 44/12. Table H-7 provides a summary of the estimates for each year.

**Table H-7. Land protection schedule and associated benefits**

| Year | % of Conversion Reduced | Ag Acres Protected | $MMtCO_2e$ Saved |
|---|---|---|---|
| 2007 | 0 | 0 | 0.00 |
| 2008 | 5 | 500 | 0.01 |
| 2009 | 10 | 1,000 | 0.02 |
| 2010 | 15 | 1,500 | 0.03 |
| 2011 | 20 | 2,000 | 0.05 |
| 2012 | 25 | 2,500 | 0.06 |
| 2013 | 30 | 3,000 | 0.07 |
| 2014 | 35 | 3,500 | 0.08 |
| 2015 | 35 | 3,500 | 0.08 |
| 2016 | 40 | 4,000 | 0.09 |
| 2017 | 40 | 4,000 | 0.09 |
| 2018 | 45 | 4,500 | 0.10 |
| 2019 | 45 | 4,500 | 0.10 |
| 2020 | 50 | 5,000 | 0.11 |

*Costs*

To estimate program costs in each year, CCS used multiplied the estimated agricultural acres protected from development by the conservation cost ($2,100/acre) minus the assumed contribution from NRCS ($873/acre). The resulting cost-effectiveness is $54/$MtCO_2e$. This estimate only accounts for the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in vehicle miles.

- **Key Assumptions:** No change in aboveground carbon stocks; 75% loss of soil carbon on 50% of developed land

## Key Uncertainties

As described above, these include the estimated above and below ground carbon stocks for agricultural and developed land uses.

## Additional Benefits and Costs

Supports the objectives of smart development and subsequent reductions in vehicle-miles traveled and related emissions.

## Feasibility Issues

Some TWG members did not fully agree with the implementation mechanisms for this policy option. This included a mechanism to “reduce and eliminate policies that promote sprawl in rural lands without appropriate environmental review. Options include eliminating Act 250 exemptions for utility lines and long roads that can promote indiscriminate rural development. Act 250 should be strengthened to conserve the integrity of farm and forestland resources."

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

# AFW-5. Forestry Programs to Enhance GHG Benefits

## Policy Option Description

Carbon dioxide is captured and stored in trees, soil and other forest biomass. Forest management activities that promote forest production have the potential to increase net carbon dioxide sequestration rates and enhance GHG benefits. Retaining forest management where it is currently practiced and expanding the area covered by management plans would stimulate the rate of production, both in terms of forest growth and the amount of biomass harvested. Carbon stored in harvested biomass is addressed in AFW-8. Use of biomass waste from forestry programs for energy purposes is covered under AFW-6.

## Policy Option Design

**Goals:** Increase net carbon sequestration in Vermont's forests by 3% per year by implementing forest management on 1–3 million acres by 2028.

**Timing:** Implement forest management on 47,619 to 142,857 acres per year from 2008 to 2028

**Parties Involved:** State of Vermont, Departments of Forests, Parks & Recreation and Taxes; foresters, landowners, wood products industry, towns.

**Other:** Forest management to produce high density, quality sawlogs can increase carbon sequestration in two primary ways. First it can increase forest growth rates, which would increase carbon sequestration within Vermont forests. In addition, this type of forest management objective can shift wood production from low-value, fast growing species to high-value hardwood species valued for durable products (such as maple, cherry, oak). In the long run, this will increase carbon sequestration by increasing the amount of carbon transferred from the forest into durable wood products where it is stored for long periods of time. The goal stated above relates specifically to increasing growth rates through forest management.

## Implementation Mechanisms

- Support and expand acres enrolled in the Vermont Current Use Program as a means of increasing acres of actively managed forest land, producing high quality wood products that provide GHG benefits, and improving incentives for forest landowners by increasing the value of wood harvested.
- Maintain existing programs that support sustainable forestry practices.
- Maintain existing programs that monitor and detect forest stress agents and issue management recommendations that promote forest health.
- Develop markets for durable wood products made from high-quality wood (e.g., Wood Products Development Program) and support new production technology by Vermont firms (see AFW-8).

- Develop a new forest management support program in Vermont that recognizes and compensates forest landowners for the ecosystem services (such as carbon sequestration and storage) produced on private forest land for public benefits.
- Promote landowner cooperatives as a means of enabling carbon trading and ecosystem services compensation in the market place.
- Work within existing municipal infrastructure (Conservation Commissions) to promote voluntary forest land carbon sequestration and storage programs.
- Expand education programs for foresters and landowners on GHG benefits provided by forests.
- Coordinate with broader land use planning efforts.
- Implement long-term monitoring to enable tracking and maintenance of benefits.
- Potential forest management strategies that could achieve the kinds of benefits envisioned under this option are provided here as additional guidance on implementation: 1) extended rotations/entry cycles; 2) post-harvest retention of trees (even-aged management) over at least one rotation period; 3) management for high quality, large dimension sawtimber; retention of very large tree sizes (uneven-aged management); 4) expanded use of judicious, carefully planned thinning.

## Related Policies/Programs in Place

- Use Value Appraisal Program
- Forest conservation easements and land acquisition: Forest legacy, The Nature Conservancy, the Vermont Land Trust.
- Forest Stewardship Program
- Forest Land Enhancement Program
- Agency of Natural Resources: Forest Resource Management Program, Forest Resource Protection Program, Urban & Community Forestry Program, Forest Marketing and Utilization Programs
- Green Mountain National Forest

## Type(s) of GHG Reductions

- Carbon sequestration in forest biomass

## Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** 0.03, 0.12
- **Cumulative GHG reduction potential ($MMtCO_2e$, 2008–2028):** 1.3
- **Data Sources:** US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program), US Forest Service Forest Inventory Analysis Program; Strong, T.F., “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329.

- **Quantification Methods:**

  There are approximately 4.5 million acres of forestland in Vermont (FIA 1997). The acres targeted by this option are based on expert judgment of the amount of forestland in Vermont potentially available for a change in forest management practices to yield carbon benefits. A range of values was discussed, from 1 to 3 million acres and the opinions were divergent on the most appropriate value (see more in Key Uncertainties Section). A compromise midpoint value of 2 million acres was chosen for the sake of analysis as illustrated below. A range of GHG reduction benefits are reported in the summary table (Table H-8), using 1 million acres and 3 million acres as upper and lower boundaries on the analysis.

  This analysis assumes the forest management is implemented on the three major forest types in Vermont, maple/beech/birch, spruce/fir, and white/red/jack, in proportion to their relative dominance. Table H-8 shows the cumulative number of acres that will have experienced a change in forest management since 2008 under this scenario, by forest type. Approximately 95, 38 acres per year would experience a change in management that is then maintained for the remainder of the time frame of analysis, such that by 2028 a total of 2 million acres of forest in Vermont have transitioned to a new state of forest management (see Implementation Mechanisms for guidance on potential types of forest management that could yield carbon benefits).

**Table H-8. Cumulative number of acres treated with improved forest management from 2008–2028, by forest type**

| Year | Maple/Beech/Birch | Spruce/Fir | White/Red/Jack | Total |
|---|---|---|---|---|
| 2008 | 71,429 | 11,905 | 11,905 | 95,238 |
| 2009 | 142,857 | 23,810 | 23,810 | 190,476 |
| 2010 | 214,286 | 35,714 | 35,714 | 285,714 |
| 2011 | 285,714 | 47,619 | 47,619 | 380,952 |
| 2012 | 357,143 | 59,524 | 59,524 | 476,190 |
| 2013 | 428,571 | 71,429 | 71,429 | 571,429 |
| 2014 | 500,000 | 83,333 | 83,333 | 666,667 |
| 2015 | 571,429 | 95,238 | 95,238 | 761,905 |
| 2016 | 642,857 | 107,143 | 107,143 | 857,143 |
| 2017 | 714,286 | 119,048 | 119,048 | 952,381 |
| 2018 | 785,714 | 130,952 | 130,952 | 1,047,619 |
| 2019 | 857,143 | 142,857 | 142,857 | 1,142,857 |
| 2020 | 928,571 | 154,762 | 154,762 | 1,238,095 |
| 2021 | 1,000,000 | 166,667 | 166,667 | 1,333,333 |
| 2022 | 1,071,429 | 178,571 | 178,571 | 1,428,571 |
| 2023 | 1,142,857 | 190,476 | 190,476 | 1,523,810 |
| 2024 | 1,214,286 | 202,381 | 202,381 | 1,619,048 |
| 2025 | 1,285,714 | 214,286 | 214,286 | 1,714,286 |
| 2026 | 1,357,143 | 226,190 | 226,190 | 1,809,524 |
| 2027 | 1,428,571 | 238,095 | 238,095 | 1,904,762 |
| 2028 | 1,500,000 | 250,000 | 250,000 | 2,000,000 |

A change in forest management is anticipated to increase the amount of carbon sequestered and stored in forest biomass as a result of enhanced forest growth rates. Forest carbon sequestration rates were based on published carbon stocks (tons carbon per acre in forest biomass) by age class for maple/beech/birch, spruce/fir, and white/red/jack stands in the Northeast region of the US (USFS GTR-343). A net positive increase in the total volume of carbon (i.e., carbon stock) in the forest over time results in net carbon sequestration (a decrease results in carbon losses, or net emissions). Table H-9 shows published carbon stock values for selected age classes, by forest types. In all forest types, forest carbon stocks increase over time, i.e., net carbon sequestration is expected to occur. The annual incremental change in carbon stocks or the annual rates of carbon sequestration (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 65-year-old stands from total carbon stocks in forest biomass of new stands and dividing by 65. USFS estimates of soil carbon stocks are constant over time. Therefore, this analysis assumes no net carbon sequestration in forest soils occurs under the baseline or policy scenarios.

It was assumed that a change in forest management would increase forest growth and hence carbon sequestration by 3%, based on expert opinion. This is also consistent with carbon sequestration rates published for average and high productivity Loblolly shortleaf pine stands in the Southeastern US, which show a 5% gain in carbon sequestration in the high productivity stands. Carbon stocks and annual carbon sequestration rates under baseline and policy implementation are shown in Table H-9.

**Table H-9. Forest carbon stocks and annual sequestration, by forest type, for baseline and forest management**

| | Baseline | | Forest Management | |
|---|---|---|---|---|
| | Biomass | Soils | Biomass | Soils |
| **Carbon Stocks, By Stand Age** | tons C/acre | | | |
| Maple/beech/yellow birch | | | | |
| 0 years | 25.0 | 28.1 | 25.8 | 28.9 |
| 35 years | 43.6 | 28.1 | 44.9 | 28.9 |
| 65 years | 63.8 | 28.1 | 65.7 | 28.9 |
| 125 years | 88.6 | 28.1 | 91.3 | 28.9 |
| Spruce/fir | | | | |
| 0 years | 22.7 | 39.7 | 23.4 | 40.9 |
| 35 years | 33.6 | 39.7 | 34.6 | 40.9 |
| 65 years | 52.0 | 39.7 | 53.6 | 40.9 |
| 125 years | 76.7 | 39.7 | 79.0 | 40.9 |
| White/red/jack | | | | |
| 0 years | 14.7 | 31.6 | 15.1 | 32.5 |
| 35 years | 32.8 | 31.6 | 33.8 | 32.5 |
| 65 years | 45.5 | 31.6 | 46.9 | 32.5 |
| 125 years | 62.2 | 31.6 | 64.1 | 32.5 |
| **Carbon Sequestration (0–65 years)** | tons C/acre/year | | | |
| Maple/beech/yellow birch | 0.60 | 0.0 | 0.61 | 0.0 |
| Spruce/fir | 0.45 | 0.0 | 0.46 | 0.0 |
| White/red/jack | 0.47 | 0.0 | 0.49 | 0.0 |

To assess net carbon sequestration within forests, both the annual amount of carbon sequestered from growth and the annual amount of carbon removed from the forest through harvesting are taken into account to calculate a net annual change in carbon stocks (i.e., the total carbon volume of removals are subtracted from annual increases in carbon stocks). Harvested wood is essentially counted as an emission from the forest in this analysis. In reality a portion of the carbon in harvested wood remains stored for a long time in durably wood products. Carbon stored in durable wood products from harvests in this policy option is accounted for in AFW-8. It was assumed that 1.3%/years of 95,238 acres (i.e., amount of forests coming into management each year) is harvested annually and that 39% of the biomass carbon stocks are removed. Research suggests that approximately 39% of forest biomass is removed during low impact harvesting (Strong 1997).

Annual carbon sequestration under policy implementation was calculated by multiplying the cumulative number of forest acres that have experienced a change in forest management since 2008 by the annual carbon sequestration rate for Forest Management in Table H-9. This accounts for annual carbon sequestration beginning in the first year that a change in management occurs and continuing through the duration of the timeframe of analysis (in this case until 2028) (see Column A). The trend of increasing carbon sequestration through time in Column A reflects the gradual implementation of forest management on additional acres each year until 2 million acres are reached.

Annual removals were calculated by multiplying the number of acres harvested each year (assumed to be 1,238 ac/years) by 39% of biomass carbon stocks in 65-year-old stands (Column B). Annual sequestration minus carbon removed during harvests was calculated to yield a net annual change in carbon stocks (i.e., "carbon flux"). Annual sequestration, removals, and net carbon flux under baseline conditions were calculated using the same area data and applying the baseline annual sequestration and 65-years carbon stocks values shown in Table H-9. The difference in net carbon flux between the policy and baseline cases is the total additional carbon sequestered within forests under this option. Results are shown in Table H-10.

In both the baseline and the policy case, net carbon sequestration is occurring from 2008–2028 because growth in biomass on the identified acres far exceeds the loss of biomass from harvesting (which occurs on a relatively small number of acres). The GHG impacts of the policy are based on the relative increase in carbon sequestration in the policy case over the baseline case (i.e., the baseline is subtracted from the policy scenario).

**Table H-10. Estimates of annual carbon sequestration, removals, and net carbon flux under baseline and policy scenarios**

| Year | Baseline | | | Policy Scenario | | | GHG Benefits | |
|---|---|---|---|---|---|---|---|---|
| | Annual Seq. (A) | Annual Removals (B) | Net Carbon flux (A+B) | Annual Seq. (D) | Annual Removals (E) | Net Carbon flux (D+E) | Additional Seq. (D+E)–(A+B) | Additional Seq., converted to $MMtCO_2e$ |
| | (tons C/year) | | | | | | | $MMtCO_2e$/year |
| 2008 | 53,645 | –28,990 | 24,655 | 55,254 | –29,859 | 25,395 | 740 | 0.003 |
| 2009 | 107,289 | –28,990 | 78,300 | 110,508 | –29,859 | 80,649 | 2,349 | 0.009 |
| 2010 | 160,934 | –28,990 | 131,945 | 165,762 | –29,859 | 135,903 | 3,958 | 0.015 |
| 2011 | 214,579 | –28,990 | 185,589 | 221,016 | –29,859 | 191,157 | 5,568 | 0.020 |
| 2012 | 268,223 | –28,990 | 239,234 | 276,270 | –29,859 | 246,411 | 7,177 | 0.026 |
| 2013 | 321,868 | –28,990 | 292,879 | 331,524 | –29,859 | 301,665 | 8,786 | 0.032 |
| 2014 | 375,513 | –28,990 | 346,523 | 386,778 | –29,859 | 356,919 | 10,396 | 0.038 |
| 2015 | 429,158 | –28,990 | 400,168 | 442,032 | –29,859 | 412,173 | 12,005 | 0.044 |
| 2016 | 482,802 | –28,990 | 453,813 | 497,286 | –29,859 | 467,427 | 13,614 | 0.050 |
| 2017 | 536,447 | –28,990 | 507,457 | 552,540 | –29,859 | 522,681 | 15,224 | 0.056 |
| 2018 | 590,092 | –28,990 | 561,102 | 607,794 | –29,859 | 577,935 | 16,833 | 0.062 |
| 2019 | 643,736 | –28,990 | 614,747 | 663,048 | –29,859 | 633,189 | 18,442 | 0.068 |
| 2020 | 697,381 | –28,990 | 668,391 | 718,302 | –29,859 | 688,443 | 20,052 | 0.074 |
| 2021 | 751,026 | –28,990 | 722,036 | 773,556 | –29,859 | 743,697 | 21,661 | 0.079 |
| 2022 | 804,670 | –28,990 | 775,681 | 828,810 | –29,859 | 798,951 | 23,270 | 0.085 |
| 2023 | 858,315 | –28,990 | 829,325 | 884,064 | –29,859 | 854,205 | 24,880 | 0.091 |
| 2024 | 911,960 | –28,990 | 882,970 | 939,318 | –29,859 | 909,459 | 26,489 | 0.097 |
| 2025 | 965,604 | –28,990 | 936,615 | 994,573 | –29,859 | 964,713 | 28,098 | 0.103 |
| 2026 | 1,019,249 | –28,990 | 990,260 | 1,049,827 | –29,859 | 1,019,967 | 29,708 | 0.109 |
| 2027 | 1,072,894 | –28,990 | 1,043,904 | 1,105,081 | –29,859 | 1,075,221 | 31,317 | 0.115 |
| 2028 | 1,126,538 | –28,990 | 1,097,549 | 1,160,335 | –29,859 | 1,130,475 | 32,926 | 0.121 |

## Cost Analysis

The costs per acre to implement forest management were assumed to be $3/acre based on expert opinion of the technical working group. The cost is relatively low especially when large areas are treated. This value takes into account future increases in gas prices as well. Costs were multiplied by the number of acres undergoing a change in management annually, yielding an annual cost of $285,714 per year. This implies that the change in forest management is a one-time treatment occurring in a single year with lasting impacts throughout the period of analysis. Annual discounted costs were then estimated using a 5% interest rate. Net present value, or the total cumulative discounted costs from 2008–2028 area estimated to be $3.8 million dollars. Cost-effectiveness ($/$MtCO_2e$), calculated by dividing the net present value by the cumulative GHG benefits from 2008–2028, is estimated to be $3/ton.

- **Key Assumptions:** Improved forest management increases carbon sequestration by 3%; approximately 2 million acres of Vermont forests will be treated with forest management by 2028 (see feasibility issues section for more); harvest rates are 1.3%/years;

## Key Uncertainties

Actual forest carbon sequestration will vary by site conditions, species classes, and specific management practices implemented. The analysis uses average values representative of the Northeast for three common forest types and therefore does not take into account site specific conditions.

The technical working group discussed a wide range of values for the potential number of acres available for implementing a change in management (1–3 million acres). The views were strongly divergent on which end of the range was most appropriate to analyze. The value of 2 million acres was chosen as a compromise for the sake of analysis. In addition, the analysis was run two additional times, using 1 million and 3 million as the total number of acres in forest management by 2028. Results provide an indication of the potential range in cumulative GHG benefits of this option for 2008–2028, on the order of 0.6 – 2.0 $MMtCO_2e$. This range is reported in the Summary List of Policy Options.

The analysis does not account for potential changes in fuel use related to a change in forest management or harvesting practices. Increased use of fuel under policy implementation could offset some portion of the GHG benefits estimated above.

## Additional Benefits and Costs

The effect of focusing only on greenhouse gas benefits may result in the potential suppression of other worthy goals and purposes for forest management.

Revenue generated from increased production of harvested wood products (not factored into cost analysis).

Increasing wood use efficiencies envisioned under this option (but not quantified) could reduce the amount of forest biomass available for energy production.

## Feasibility Issues

Preliminary investigations at the UVM Jericho Research Forest suggest that carefully planned harvests may be able to increase net sequestration potential in young to mature stands, but this potential is highly sensitive to assumptions regarding long-term forest carbon dynamics, the ability to produce higher grade timber on a given site, and the behavior of forest product markets.

Achievement of net carbon sequestration benefits will depend on: (1) specific choice of silvicultural system targeted under the program; and (2) opportunities to increase market consumption of durable wood products (see AFW-8).

Site limitations are not taken into account in the quantification analysis. Steep slopes, riparian buffers, wetlands, sensitive areas, unique wildlife habitat, and site specific growing conditions may limit actual opportunities to implement forest management to the extent envisioned under this option. Land ownership and current enrollment in related programs may affect the full extent of implementation as well. Approximately, 15% of Vermont forests are in public ownership, a portion of which are in active forest management. The UVA Program currently has approximately 38% of all privately owned forestland enrolled in the active forest management, however many enrolled parcels already have management plans, many of which provide for long harvesting rotations. Approximately 60% privately owned forestland is not enrolled in the UVA Program and it unclear how much of this land is available to boost productivity. Therefore, it is hard to estimate how much land is available in Vermont to boost productivity based on site specific limitations, the goals of existing and future land management plans, and the varied land management goals of landowners who are not enrolled in the UVA Program.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-6. Increased Forest Biomass Energy Use

### Policy Option Description

The goals of this option are to increase the use of low value wood material, including logging and mill residues, by appropriate processing centers for energy purposes (electricity, heating or liquid fuels). Offsetting fossil fuel use with biomass for energy, in applications such as distributed generation, combined heat and power and community energy systems will yield additional GHG emissions reductions benefits.[30]

### Policy Option Design

**Goals:** Increase production and use of forest biomass energy feedstocks in Vermont by 30% through sustainable harvesting practices.

**Timing:** Achieve 5% increase by 2010 and 30% increase by 2028

**Parties Involved:** VT Department of Forests, Parks & Recreation, forest products industry, forestland owners.

**Other:** Current levels of forest biomass feedstock production and use in Vermont are estimated at about 12.5% of annual forest growth (50% of annual growth is harvested each year, 25% of which goes to biomass energy). A biomass energy resource assessment is in preparation and publication anticipated in June 2007. Preliminary information from the assessment is being sought and may influence the above goal levels.

Sustainable harvesting practices should ensure sufficient biomass is left after harvest to provide the necessary nutrients to sustain forest growth (see Feasibility section for more details). The TWG will provide an estimate of the amount of annual growth that should be left in the forest after harvest.

*Note: The goal above focuses on the supply of forest biomass feedstocks. The TWG strongly encourages complimentary goals related to infrastructure development in the ES and RCI sectors. Specifically, the TWG recommends encouraging bioenergy production through retention and expansion of distributed generation sources, combined heat and power, promotion of district energy production, and establishment of forest biomass power plants. Development of small-scale biomass power generation, close to forest resources should be a priority.*

[30] Howard and Marland, application of GORCAM Model (1998)—will get the specific citation for research and modeling analysis for three Vermont community applications (i.e., combining biomass and district energy—economic and environmental benefits).

## Implementation Mechanisms

- Vermont is currently experiencing a market transition away from providing raw material for paper production. The biomass that would normally be used for paper production should be shifted over to use for energy production. Currently 12–15% of harvested biomass is going to paper production.
- Forest harvest volume increases in AFW-8 may also increase feedstock supply.
- Other implementation mechanisms might address the retention and use of wood pallets in Vermont.
- Investigate wood pellet industrial development with a strong landowner cooperative component to increase areas of wood availability.

## Related Policies/Programs in Place

None specified.

## Type(s) of GHG Reductions

Displaces emissions from fossil fuel combustion.

## Estimated GHG Savings and Costs per $MtCO_2e$

*Discussions with CCS facilitators for ESD indicate GHG reductions from biomass energy generation are calculated under options related to increasing energy generation from renewable energy sources (i.e., ESD-6: Incentives and/or Mandate for Renewable Electricity; ESD-8 Incentives for Clean Distributed Technologies for Electricity or Heat). Thus, reductions associated with the displacement of fossil fuels with biomass energy sources are accounted for in quantification of those options.*

**Supply Potential from AFW-8**

The methodology used in AFW-8 for estimating carbon sequestration in harvested wood products (HWP) also estimates the incremental amount of $CO_2$ emissions associated with combusting and capturing energy from the merchantable portion of harvested wood (see AFW-8 for details). The analysis suggests that AFW-8 would make available roughly 30,801 additional tons per year of biomass feedstocks for energy from merchantable wood by 2012 and 45,654 tons per year by 2028. (This estimate does not take into account fuelwood and intermediate thinning material used for energy.) The biomass tons are inferred from the additional biogenic emissions from biomass energy under full implementation of AFW-8 (based on the carbon stocks accumulated in the HWP pool “carbon emitted with energy capture”), converted to tons of carbon per year, and equivalent tons of biomass assuming a 50% carbon content in biomass. Table H-11 shows the estimated annual biogenic emissions under AFW-8 and the associated biomass equivalents.

**Table H-11. Inferred tons of biomass from the combustion of the merchantable portion of harvested wood products under AFW-8**

| Year | Biogenic Emissions from Wood based energy ($MMtCO_2e$) | Biogenic Emissions from Wood based energy (tons C) | Biomass Equivalent of the Biogenic Emissions (tons biomass) |
|---|---|---|---|
| 2009 | 0.04 | 12,227 | 24,455 |
| 2010 | 0.05 | 13,386 | 26,771 |
| 2011 | 0.05 | 14,438 | 28,875 |
| 2012 | 0.06 | 15,400 | 30,801 |
| 2013 | 0.06 | 16,246 | 32,492 |
| 2014 | 0.06 | 17,011 | 34,022 |
| 2015 | 0.07 | 17,728 | 35,456 |
| 2016 | 0.07 | 18,402 | 36,805 |
| 2017 | 0.07 | 19,050 | 38,101 |
| 2018 | 0.07 | 19,637 | 39,274 |
| 2019 | 0.07 | 20,034 | 40,069 |
| 2020 | 0.07 | 20,432 | 40,864 |
| 2021 | 0.08 | 20,830 | 41,659 |
| 2022 | 0.08 | 21,227 | 42,454 |
| 2023 | 0.08 | 21,625 | 43,249 |
| 2024 | 0.08 | 21,865 | 43,730 |
| 2025 | 0.08 | 22,106 | 44,211 |
| 2026 | 0.08 | 22,346 | 44,692 |
| 2027 | 0.08 | 22,586 | 45,173 |
| 2028 | 0.08 | 22,827 | 45,654 |

## Key Uncertainties

None specified.

## Additional Benefits and Costs

None specified.

## Feasibility Issues

Significantly intensified harvests for biomass fuels carry a potential risk to forest habitat values, primarily due to the removal of defective and dying trees ("cull") that have important ecological functions. Whole tree harvesting carries additional risk to long-term productivity and forest health if conducted on nutrient impaired sites.

These risks could be reduced through consistently applied standards and guidelines (e.g., retention standards for ecologically important elements of stand structure; procedures for evaluating the site-specific appropriateness and intensity of whole tree harvesting) for biomass fuel procurement.

Availability of feedstocks depends on forest capacity to produce biomass (AFW-5), as well as competition for wood from other policy options (AFW-12, AFW-8 for example).

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-7. Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover

### Policy Option Description

Reduce losses of forested lands and their carbon sequestration potential to development or other non-productive land uses. Forestland captures and stores carbon dioxide in trees, soil and other forest biomass. Developed areas contain lower amounts of biomass and its associated carbon. These developed areas also sequester less carbon dioxide than forested areas.

### Policy Option Design

**Goals:** Reduce the rate of forest loss by 50%

**Timing:** Reduce the rate of forest loss by 7% by 2010 and 50% by 2028.

**Parties Involved:** VT Department of Forests, Parks & Recreation, non-government organizations, local planning departments, forestland owners.

**Other:** Chittenden County alone experienced a 4.4% loss in forestland over the past 15 years. NRI data show a statewide 0.13%/years annual rate of forest loss from 1982–1997 for VT. Landsat Thematic Mapper (TM) classified satellite imagery data show a statewide 0.52%/years annual rate of forest loss from 1992–2002 (J. Jenkins and E. Quigley, UVM).

### Implementation Mechanisms

- Increase acres of forest land purchased for conservation or protected under conservation easements through existing or new programs.
- Increase enrollment in the Use Value Appraisal Program (see Related Policies/Programs in Place).
- Develop a new forest management support program in Vermont that recognizes and compensates forest landowners for the ecosystem services (such as carbon sequestration and storage) produced on private forest land for public benefits.
- Incentives to maintain forest cover in developed areas through land use regulations, planning assistance and storm water crediting.
- Incentives to reduce landowners dividing forests into small parcels.
- Maintain programs that educate about and encourage forest stewardship and best management practices.
- Expand education programs for foresters, landowners and the public on GHG benefits provided by forests.
- See also, Implementation Mechanisms for AFW-4

## Related Policies/Programs in Place

- Housing and Conservation Board
- Use Value Appraisal Program
- Forest conservation easements and land acquisition: Forest legacy, The Nature Conservancy, the Vermont Land Trust.
- Forest Legacy Program, Land Trust activity
- Regional Planning Commissions
- Growth Centers Legislation
- Act 200, Act 250
- Forest Stewardship Program
- Forest Land Enhancement Program
- Agency of Natural Resources: Forest Resource Management Program, Forest Resource Protection Program, Urban & Community Forestry Program, Forest Marketing and Utilization Programs
- Green Mountain National Forest
- Biomass Energy Resource Center.

## Type(s) of GHG Reductions

Avoided emissions from forest clearing

Maintenance of annual carbon sequestration from forest growth and long-term storage in biomass and soil

## Estimated GHG Savings and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** 0.4, 2.0
- **Cumulative GHG reduction potential ($MMtCO_2e$, 2008–2028):** 22
- **Net Cost per $MtCO_2e$:** $1.54
- **Data Sources:** Forestry: US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program). Data on forest conversion from NRCS National Resource Inventory and from Landsat TM satellite imagery analysis. Data on forest types from FIA, 1997.
- **Quantification Methods:** Carbon savings from this option were estimated from two sources: A. the amount of carbon that would be lost as a result of forest conversion to non-forest uses (i.e., “avoided emissions”); and B. the amount of annual carbon sequestration in the protected forest area. The area of forestland protected annually is based on a gradual implementation of the goals outlined above, so that a 7% reduction in forest conversion rates is achieved by 2010, and a 50% reduction by 2028. A current conversion rate of 22,635 ac/years was assumed based on satellite land cover data from 1992–2002, which show a 0.52%/years rate of forest loss. The percentages in the goals

represent a decrease from the current conversion rate of 1,584 acres/years in 2010 and 11,317 acres/years in 2028. This option assumes that maple/beech/birch forest types are those protected, based on the relatively high dominance of this forest type in Vermont.

The forest carbon stocks (tons carbon per acre) and annual carbon flux (annual change in tons carbon per acre) data are based on default carbon sequestration values for maple/beech/birch forest types in the Northeastern US (USFS GTR-343, Table A2). Average forest carbon stock for maple/beech/birch (including biomass and soils) is based on coefficients for 65-year-old stands. Annual rates of carbon sequestration (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 65-year-old stands from total carbon stocks in forest biomass of new stands and dividing by 65. An average for 65-year-old stands was used to take reflect the average age structure of Vermont's forests. Soil carbon density was assumed constant and is not included in the annual carbon flux calculations because default values for soil carbon density are constant over time in USFS GTR-343 (Table H-12).

**Table H-12. Carbon stocks and annual sequestration rates for maple/beech/birch forests in the northeastern United States**

| Carbon Stocks (tons C/acre) | Maple/Beech/Birch |
|---|---|
| Biomass | 63.8 |
| Soils | 28.1 |
| Annual Carbon flux (tons C/acre/year) | 0.60 |

Loss of forests to non-forest uses results in a large one-time surge of carbon emissions. In this case, it was assumed that 53% of carbon stocks in biomass and 35% of carbon stocks in soils would be lost in the event of forest conversion, with no appreciable carbon sequestration in soils or biomass following development. The biomass loss assumption is based on research that shows heavy levels of individual tree removal results in the harvesting of 53% of carbon in aboveground biomass (Strong 1997). The soil carbon loss assumption was based on a study that shows about a 35% loss of soil carbon when woodlots are converted to developed uses (Jenkins, personal communication). To estimate avoided emissions, the total number of acres protected in a year was multiplied by the percent-adjusted carbon stock value for loss of biomass and soil carbon stocks. Results were converted to units of million metric tons $CO_2$ equivalent ($MMtCO_2e$) and are provided in Table H-13.

Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration includes benefits from acres preserved cumulatively under the program. Annual carbon sequestration was calculated each year by multiplying the cumulative acres protected by the average annual carbon flux (Table H-13).

**Table H-13. Emissions avoided and maintenance of annual sequestration potential in forest land protected from conversion in Vermont**

| Year | Acres Protected | Avoided emissions ($MMtCO_2e$) | Annual Sequestration ($MMtCO_2e$) | Total C Savings ($MMtCO_2e$) |
|---|---|---|---|---|
| 2008 | 528 | 0.08 | 0.00 | 0.09 |
| 2009 | 1,056 | 0.17 | 0.00 | 0.17 |
| 2010 | 1,584 | 0.25 | 0.01 | 0.26 |
| 2011 | 2,125 | 0.34 | 0.01 | 0.35 |
| 2012 | 2,666 | 0.43 | 0.02 | 0.44 |
| 2013 | 3,207 | 0.51 | 0.02 | 0.54 |
| 2014 | 3,747 | 0.60 | 0.03 | 0.63 |
| 2015 | 4,288 | 0.69 | 0.04 | 0.73 |
| 2016 | 4,829 | 0.77 | 0.05 | 0.83 |
| 2017 | 5,370 | 0.86 | 0.06 | 0.92 |
| 2018 | 5,910 | 0.95 | 0.08 | 1.02 |
| 2019 | 6,451 | 1.03 | 0.09 | 1.12 |
| 2020 | 6,992 | 1.12 | 0.11 | 1.23 |
| 2021 | 7,532 | 1.21 | 0.12 | 1.33 |
| 2022 | 8,073 | 1.29 | 0.14 | 1.43 |
| 2023 | 8,614 | 1.38 | 0.16 | 1.54 |
| 2024 | 9,155 | 1.47 | 0.18 | 1.64 |
| 2025 | 9,695 | 1.55 | 0.20 | 1.75 |
| 2026 | 10,236 | 1.64 | 0.22 | 1.86 |
| 2027 | 10,777 | 1.72 | 0.25 | 1.97 |
| 2028 | 11,317 | 1.81 | 0.27 | 2.08 |

The cost of protecting forest land was estimated at $504.60/acre using average cost data from the State of Vermont, which is one of three main organizations that purchase forest conservation easements in Vermont. It was assumed that all of the forest land would be protected with conservation easements and that costs would be incurred one-time in the initial year that land is protected. The analysis does not take into account potential cost savings from forest products revenue on working forest lands that are protected under this policy. Annual costs were estimated by multiplying the number of acres protected by the cost per acre. Annual discounted costs were then estimated using a 5% interest rate. The cumulative cost-effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding $1.54/$tCO_2$e. The sum of annual discounted costs also provides an estimate of the Net Present Value of this option of $34 million dollars.

- **Key Assumptions:** 53% and 35% total forest biomass and soil carbon stocks, respectively, are lost when forests are converted to non-forest uses; no appreciable carbon sequestration occurs post-conversion. Distribution of forest types protected is assumed based on forest dominance.

## Key Uncertainties

The analysis is highly sensitive to key assumptions about the amount of carbon lost in soils and biomass as a result of land use change. The working group sought input from the research literature in formulating the assumptions and felt that they were generally conservative when compared with national and international defaults that suggest as much as 100% of biomass can be lost from development.

## Additional Benefits and Costs

This policy option weighs heavily on forest land protected regardless of future management objectives. Some of the additional forest land under conservation easements, purchased, or under the UVA or similar program will continue to be working forests where carbon is stored, but also removed during harvesting. This is not accounted for in these calculations, but is considered under AFW-5.

Protection of forest land for GHG benefits provides a multitude of other ecosystem service benefits such as air and water purification, wildlife habitat, watershed protection, aesthetics, and supply of raw materials.

## Feasibility Issues

This policy option will be much more likely to succeed if the other forestry policy options are also adopted. Collectively these options provide a variety of economically driven incentives to keep forest land from being developed, while providing an increase in the types of wood products that greatly benefit GHG.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-8. Expanded Production and Use of Durable Wood Products (Especially from Vermont Sources)

### Policy Option Description

This option covers increasing the supply and demand of wood products produced and used in Vermont. Increasing production of high density, quality sawlogs with subsequent use of these products in durable wood products (building materials, furniture, etc.) is important for ensuring net carbon benefits associated with the forest management envisioned in AFW-5. Improvements in the efficiency of wood utilization can enhance the amount of carbon stored in durable wood products. Development of markets for high value wood materials promotes the retention of forestland as actively managed, productive forests, thereby enhancing carbon dioxide sequestration. Wood products have lower embodied energy than many types of building materials (e.g., cement, steel). To the extent that wood products displace products with higher embodied energy, addition GHG benefits occur.

### Policy Option Design

**Goals:**

- Increase carbon sequestered in wood products by 40% per year by implementing forest management on 2 million acres by 2028.
- Increase the amount of wood from local and out of state production used in materials for residential, institutional and commercial buildings, and in other long lived wood products by 10% by 2028.

**Timing:**

- Implement forest management on 95,238 acres per year and harvest 1.3%/years from 2008 to 2028
- By 2012, increase wood products use by 2%; achieve 10% increase by 2028.

**Parties Involved:** Vermont Wood Products Marketing Council; Associated Industries of Vermont, Vermont Logger's Association, Vermont Forest Products Association, Vermont Wood Manufacturer's Association, and Vermont Woodland's Association.

**Other:** The increased supply of locally grown and produced durable wood products envisioned under this option comes in large part from the goals levels states under AFW-5. Forest management is anticipated to yield increases in forest growth and a higher density of large diameter trees, both of which can potentially lead to greater harvest volumes per acre without changing harvest frequency or intensity. Limited information was available to assess the extent to which harvest volume would increase and it was recognized that the actual value would be very site specific. This option quantifies the additional carbon stored in durable wood products assuming a 40% increase in harvest volumes is possible. A range of values was discussed with widely divergent views, as is reported in the key uncertainties section.

## Implementation Mechanisms

- Leveraging/expanding the Cornerstone Project and Vermont Sustainable Job Funds (see Related Policies/Programs in Place).
- Leveraging/expanding Use Value Appraisal Program.
- Develop a technology transfer center on wood products to promote and support new production technology use by Vermont firms.
- Promote branding and marketing approaches to encourage use of locally manufactured materials.

## Related Policies/Programs in Place

- The Cornerstone Project and Sustainable Jobs Fund: increase the use and production of wood products (e.g., furniture).
- Vermont Use Value Appraisal Program.

## Type(s) of GHG Reductions

Carbon from forest biomass is stored in durable wood products for long periods of time.

Displacement of life cycle emissions associated with production and use of industrial building materials (e.g., steel and concrete).

## Estimated GHG Savings and Costs per $MtCO_2e$

Each goal is quantified separately in the sections below. The first section (Part A) quantifies the additional amount of carbon stored in wood products as a result of increased harvest volumes per acre from forest management implemented under AFW-5. The second (Part B) quantifies the displacement of GHG emissions associated with a lower demand (and thus reduced production) of steel and concrete as a result of a shift in demand for wood as a building material.

**A. Carbon Stored in Durable Wood Products as a Result of Increased Harvest Volume**

*Annual Accounting Approach*

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** 0.14, 0.06
- **Cumulative GHG reduction potential ($MMtCO_2e$, 2008–2028):** 2.0
- **Cost-effectiveness:** costs captured under AFW-5

*100-year Accounting Approach (alternative)*

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** 0.04, 0.04
- **Cumulative GHG reduction potential ($MMtCO_2e$, 2008–2028):** 0.8
- **Cost-effectiveness:** costs captured under AFW-5

*Both HWP accounting approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case, may underestimate carbon storage (100-year accounting approach). The real benefits* *probably lie somewhere in between, so CCS reports the midpoint of the two estimates in the* Summary List of Policy Options.

- **Data Sources:** US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program), US Forest Service Forest Inventory Analysis Program; Strong, T.F., "Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem," USFS Research Paper NC-329.

*Note: Metric units are used in this analysis because default coefficients in the USFS methodology for quantifying carbon sequestration in harvested wood products are in metric units.*

Forest management under AFW-5 is also expected to increase the amount of high-density, high-quality wood available for harvest. The removal of biomass through harvesting transfers carbon stored in forest biomass to carbon stored in harvested wood products (HWP). Increased harvest volumes under this option will lead to more carbon transferred into HWP. The analysis below estimates the amount of additional carbon stored in HWP as a result of a 40% increase in harvest volume on 2 million acres of Vermont forests by 2028 (note these are the same acres treated with forest management under AFW-5).

Carbon sequestration in harvested wood products (HWP) was calculated following guidelines published by the US Forest Service. Details on each step of the analysis can be found in the guidelines, following the methodology referred to as "Land-based estimation." In general, forest production (harvest volume per acre) is used as a starting point and regional patterns in the disposition of carbon through various HWP pools are used to model carbon stock changes in HWP over time. The methodology calculates the transfer of carbon through four "pools" over time: wood in use (i.e., building materials, furniture), wood in landfills (i.e., products that were previously in use and have been discarded), wood burned for energy capture, and wood that has decayed or burned without energy capture. The difference in the amount of carbon entering the "in use" and "landfill" pools at the beginning of a year and the amount remaining in those pools one year later equals the annual change in carbon stocks (i.e., net annual carbon flux). If the annual flux is positive and more carbon is stored in products or landfills (where it decomposes very slowly) at the end of the year compared to the beginning, then carbon is sequestered in HWP that year. If the annual flux is negative, and the carbon stored in those pools declines during the year, then there are net emissions of carbon that year.

Data from the US Forest Service Forest Inventory Analysis program in 1997 were used to estimate current levels of harvest volumes for maple/beech/birch, spruce/fir, and white/red/jack in Vermont (Table H-14). Average harvest volume was calculated separately for each forest type by dividing the total growing stock volume in timberlands by the total area of timberland in 1997. Average harvest volume in maple/beech/birch, spruce/fir, and white/red/jack stands in Vermont was calculated to be 131, 128, and 185 cubic meters per hectare, respectively. Under implementation of this policy option, volume is expected to increase by 40%, therefore, volume on forests with forest management was calculated as a 40% increase over current levels (i.e., 183, 180, and 259 $m^3$/ha on maple/beech/birch, spruce/fir, and white/red/jack, respectively).

**Table H-14. Background information on average forest volume by forest type (FIA 1997)**

| Species | Area of timberlands (ha) | Growing stock volume ($m^3$/year) | Baseline Average Production ($m^3$/ha/year) | Average Production with Forest Management ($m^3$/ha/year) |
|---|---|---|---|---|
| Maple/beech/birch | 1,223,136 | 159,723,335 | 130.59 | 182.82 |
| Spruce/fir | 185,556 | 23,792,627 | 128.22 | 179.51 |
| White/red/jack | 198,760 | 36,790,658 | 185.10 | 259.14 |

There are several steps in the analysis where default coefficients for the Northeastern US region are applied to the starting point of average volume. First, for each forest type, average volume ($m^3$/ha/years) is apportioned into classes of wood harvested (i.e., softwood sawlog, softwood pulpwood, hardwood sawlog, hardwood pulpwood) and the per-area carbon volumes of each class are calculated. Next, the quantity that is processed into primary wood products is calculated (factoring out carbon in logging residue, fuelwood, and waste), using the following ratios: ratio of industrial roundwood to growing stock volume removed as roundwood; ratio of carbon in bark to carbon in wood; fraction of growing stock volume removed as roundwood; and the ratio of fuelwood to growing stock volume removed as roundwood. The results are approximate per-area carbon stocks (tons carbon per hectare) in industrial roundwood, excluding bark and fuelwood. Carbon stocks in industrial roundwood were estimated for the baseline case using current levels of volume as the starting point, and for the policy scenario using levels of volume under forest management as the starting point (Table H-15).

**Table H-15. Calculated carbon stocks in industrial roundwood**

| Product Pool | Baseline (MtC/ha) | Forest Management (MtC/ha) |
|---|---|---|
| Softwood saw log carbon in industrial roundwood | 29.15 | 40.80 |
| Softwood pulpwood carbon in industrial roundwood | 53.63 | 75.09 |
| Hardwood saw log carbon in industrial roundwood | 16.96 | 23.75 |
| Hardwood pulpwood carbon in industrial roundwood | 42.61 | 59.66 |

The average disposition pattern of HWP over time in the Northeast is provided by the USFS methodology. The disposition pattern is the flow of HWP between four pools over time: carbon in HWP in use, carbon in HWP in landfills, carbon emitted with energy capture, and carbon emitted without energy capture. Disposition patterns are provided separately for softwood and hardwood categories, each with sawlog and pulpwood subcategories.

Tables H-16 and H-17 show the disposition patterns used in this analysis for a single harvest. For example, in Table H-16, in the year following harvest, 57% of the carbon in softwood sawlogs goes into use, 24% is emitted with energy capture, 19% is emitted without energy capture, and none is placed in landfills. Over time the amount of carbon in use declines as it is transferred into the categories of carbon in landfills and carbon emitted to the atmosphere, such that by 100 years after harvest, approximately 10% of carbon remains in HWP in use, 22% is in landfills, and 68% has been emitted (note: carbon emissions from HWP are considered biogenic and are not counted as direct emissions).

**Table H-16. Disposition pattern of carbon in harvested wood products as a fraction of industrial roundwood for softwood in the Northeast**

| Year After Production | Sawlog | | | | Pulpwood | | | |
|---|---|---|---|---|---|---|---|---|
| | Fraction in Use | Fraction in Landfill | Fraction Emitted w/ Energy Capture | Fraction Emitted w/o Energy Capture | Fraction in Use | Fraction in Landfill | Fraction Emitted w/ Energy Capture | Fraction Emitted w/o Energy Capture |
| 0 | 0.569 | 0 | 0.24 | 0.19 | 0.513 | 0 | 0.306 | 0.181 |
| 1 | 0.542 | 0.014 | 0.246 | 0.197 | 0.436 | 0.025 | 0.334 | 0.204 |
| 2 | 0.517 | 0.027 | 0.252 | 0.203 | 0.372 | 0.046 | 0.359 | 0.223 |
| 3 | 0.495 | 0.039 | 0.257 | 0.209 | 0.317 | 0.063 | 0.381 | 0.239 |
| 4 | 0.474 | 0.05 | 0.262 | 0.214 | 0.271 | 0.077 | 0.399 | 0.253 |
| 5 | 0.455 | 0.06 | 0.266 | 0.219 | 0.232 | 0.088 | 0.415 | 0.265 |
| 6 | 0.438 | 0.069 | 0.27 | 0.223 | 0.197 | 0.098 | 0.429 | 0.276 |
| 7 | 0.422 | 0.078 | 0.274 | 0.227 | 0.167 | 0.106 | 0.441 | 0.286 |
| 8 | 0.406 | 0.085 | 0.277 | 0.231 | 0.139 | 0.113 | 0.452 | 0.296 |
| 9 | 0.392 | 0.093 | 0.281 | 0.235 | 0.114 | 0.118 | 0.463 | 0.305 |
| 10 | 0.379 | 0.099 | 0.284 | 0.238 | 0.093 | 0.123 | 0.472 | 0.313 |
| 15 | 0.326 | 0.126 | 0.296 | 0.252 | 0.037 | 0.128 | 0.497 | 0.338 |
| 20 | 0.288 | 0.144 | 0.304 | 0.264 | 0.021 | 0.122 | 0.505 | 0.352 |
| 25 | 0.259 | 0.158 | 0.311 | 0.273 | 0.016 | 0.114 | 0.509 | 0.362 |
| 30 | 0.234 | 0.168 | 0.316 | 0.281 | 0.014 | 0.107 | 0.51 | 0.369 |
| 100 | 0.095 | 0.223 | 0.338 | 0.344 | 0.006 | 0.0884 | 0.51 | 0.4 |

**Table H-17. Disposition pattern of carbon in HWP as a fraction of industrial roundwood for hardwood in the Northeast**

| Year After Production | Sawlog | | | | Pulpwood | | | |
|---|---|---|---|---|---|---|---|---|
| | Fraction in use | Fraction in landfill | Fraction emitted w/ energy capture | Fraction emitted w/o energy capture | Fraction in use | Fraction in landfill | Fraction emitted w/ energy capture | Fraction emitted w/o energy capture |
| 0 | 0.614 | 0 | 0.237 | 0.149 | 0.65 | 0 | 0.185 | 0.166 |
| 1 | 0.572 | 0.025 | 0.246 | 0.157 | 0.59 | 0.021 | 0.202 | 0.186 |
| 2 | 0.534 | 0.048 | 0.255 | 0.163 | 0.539 | 0.039 | 0.218 | 0.203 |
| 3 | 0.5 | 0.067 | 0.263 | 0.17 | 0.496 | 0.054 | 0.232 | 0.218 |
| 4 | 0.469 | 0.085 | 0.271 | 0.175 | 0.459 | 0.067 | 0.244 | 0.231 |
| 5 | 0.44 | 0.102 | 0.278 | 0.18 | 0.426 | 0.078 | 0.254 | 0.242 |
| 6 | 0.415 | 0.116 | 0.284 | 0.185 | 0.398 | 0.087 | 0.263 | 0.253 |
| 7 | 0.391 | 0.129 | 0.29 | 0.19 | 0.372 | 0.095 | 0.271 | 0.262 |
| 8 | 0.369 | 0.141 | 0.295 | 0.194 | 0.349 | 0.102 | 0.279 | 0.271 |
| 9 | 0.349 | 0.152 | 0.3 | 0.198 | 0.327 | 0.108 | 0.286 | 0.279 |
| 10 | 0.331 | 0.162 | 0.305 | 0.202 | 0.308 | 0.114 | 0.292 | 0.286 |
| 15 | 0.26 | 0.198 | 0.324 | 0.218 | 0.252 | 0.127 | 0.31 | 0.311 |
| 20 | 0.212 | 0.221 | 0.338 | 0.229 | 0.226 | 0.13 | 0.319 | 0.325 |
| 25 | 0.178 | 0.235 | 0.348 | 0.239 | 0.211 | 0.131 | 0.323 | 0.335 |
| 30 | 0.152 | 0.245 | 0.356 | 0.247 | 0.198 | 0.132 | 0.327 | 0.343 |
| 100 | 0.035 | 0.281 | 0.387 | 0.296 | 0.103 | 0.158 | 0.336 | 0.403 |

The disposition over time of carbon stocks was modeled using the carbon stocks in Table H-15 (separately for the baseline and policy cases) and the disposition patterns in Tables H-16 and H-17. The same pattern is used in the baseline and policy case. Thus, the analysis does not take into account any potential shifts in wood use efficiency, which would increase the proportion of wood going to use and decrease the portion emitted.) This provides per-acre estimates of carbon stocks (MtC/ha) remaining in each pool over time starting from a single harvest for both the baseline and policy scenarios. The total amount of carbon stocks, and their disposition over time, from a single harvest was calculated by multiplying the per-acre carbon stocks mentioned above by an average annual harvested area of 501 ha/years (i.e., 1.3% of the annual area of treated forest under AFW-5, equivalent to 1,238 ac/years). The net impact of carbon storage in HWP as a result of regular annual harvests over the period of analysis was modeled for the baseline and policy cases. The incremental increase in carbon stocks was calculated as the difference between the two scenarios. The analysis assumes instantaneous benefits of forest management on harvested volumes (i.e., volume increases occur the first year that forest management is implemented). In reality, the impacts would not appear until much later, most likely outside the time-frame of the analysis.

The results are summarized in Table H-18, which shows the amount of carbon stored in landfills and products in-use each year above what would have happened in the baseline, spanning the time period 2008–2028. While the amount of additional carbon in landfills and in products from a given harvest decreases each year (as it is emitted through decay or energy capture), additional wood is harvested each year, adding new carbon stocks to total HWP stream. Thus, for every year in the time series, the carbon stocks in the wood products pool are increasing. This analysis is carried out until 2028 and does not capture the continued disposition of carbon through the wood products pools in time.

The values in Table H-18 are incremental increases in HWP carbon stocks, with annual totals shown at the bottom. Carbon flux (sequestration or emissions) is calculated as the annual change in carbon stocks (subtracting stocks in year n from stocks in year n+1). The net sequestration rate (last row) is sensitive to the year of analysis because the transfer of carbon between HWP pools is dynamic over time. Total incremental annual sequestration in HWP remaining in use and landfills is estimated at 0.14 $MMtCO_2e$ in 2012 (from harvests during 2008–2011) and 0.06 $MMtCO_2e$ in 2028 (from harvests during 2008–2028).

Table H-18 shows the literal annual account of carbon fluxes in HWP starting with harvests in 2008 and extending until 2028. The flux is high initially because most carbon still remains in use. Over time, the carbon flux converges on a smaller value as the amount of carbon entering the HWP pool from new harvests each year is balanced by carbon emitted as a result of combustion or decay. This pattern is a function of the time frame of analysis. It is also important to note that this analysis assumes instantaneous increase in harvest volume when forests are treated with forest management. In reality, the gains would not be realized for several years into the future, outside of the timeframe of this analysis.

## Table H-18. Disposition of carbon in HWP over time, shown by tracking individual annual harvests from 2008 to 2028 ($MMtCO_2e$)

| Harvest Year | Incremental increase above baseline in carbon in use or in landfill by the end of this year | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **2028** |
| 2008 | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 2009 | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 2010 | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 |
| 2011 | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 |
| 2012 | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 |
| 2013 | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 |
| 2014 | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 |
| 2015 | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 |
| 2016 | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 |
| 2017 | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 |
| 2018 | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 |
| 2019 | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 |
| 2020 | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 |
| 2021 | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 |
| 2022 | | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 |
| 2023 | | | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 |
| 2024 | | | | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 | 0.14 |
| 2025 | | | | | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 | 0.16 |
| 2026 | | | | | | | | | | | | | | | | | | | 0.24 | 0.21 | 0.18 |
| 2027 | | | | | | | | | | | | | | | | | | | | 0.24 | 0.21 |
| 2028 | | | | | | | | | | | | | | | | | | | | | 0.24 |
| C stocks | 0.24 | 0.45 | 0.64 | 0.80 | 0.94 | 1.07 | 1.18 | 1.29 | 1.38 | 1.47 | 1.55 | 1.63 | 1.71 | 1.78 | 1.85 | 1.91 | 1.98 | 2.04 | 2.10 | 2.15 | 2.21 |
| C flux | | 0.21 | 0.18 | 0.16 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |

An alternative approach for estimating carbon stored in wood products is to estimate the amount of carbon remaining in products and landfills after 100 years and to apply that value to the year of harvest as an annual sequestration rate (GTR NE-343, 1605b technical guidelines). This approach essentially accounts for emissions occurring throughout the 100 years following a harvest in the year of the harvest and assumes that the carbon remaining stored in HWP after 100 years is stored permanently. This approach was developed to simplify annual reporting of carbon stored in wood products and to account for the long term dynamics of carbon flows in harvested wood products pools. Using this approach for HWP, the GHG benefits remaining 100-yearss after harvests are applied to the 2008–2028 timeframe. For comparison to the analysis shown in Table H-18, which tracks actual annual stocks and carbon sequestration during 2008–2028, assuming instantaneous impacts, the additional amount of carbon stored permanently above baseline levels 100-yearss after a single annual harvest is estimated to be 0.04 $MMtCO_2e$. Using the 100-years method, the total amount of incremental carbon permanently stored from harvests during 2008–2028 is 0.8 $MMtCO_2e$. This can be compared to the cumulative amount of carbon sequestration using annual accounting during 2008–2028 of 2.0 $MMtCO_2e$. Both approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case, may underestimate carbon storage (100-years accounting approach). Both results are presented here. The real benefits probably lie somewhere in between.

The primary cost to achieving the volume increases in this option relate to implementing forest management on the 2 million acres. These costs are accounted for under AFW-5 and are estimated to be about $285,000 annually. The cost-effectiveness is also factored into AFW-5 and thus is not calculated here. There are potentially additional costs required to harvest and process larger volumes per acre of wood. However, the additional revenue generated from the increased production of wood products likely offsets these costs.

**B. Displaced emissions from using wood in place of other building materials**

- **Estimated GHG Savings in 2012 and 2028:** 0.00012, 0.00018

  *Only a partial quantification of the full benefits of substituting wood for other materials building materials was possible given available data. The estimate captures only reductions associated with using more wood in place of steel and concrete in the framing of residential buildings. Additional reductions could be achieved in the commercial/industrial building sector and in long-lived consumer products sector (e.g., furniture). CCS could not identify any methodologies or GHG emission factors to assess the latter potential.*

- **Cost-Effectiveness:** Not Quantified. The costs for substituting high-GHG embedded building materials (concrete, steel, plastic) with wood have been assumed by some researchers to be zero. However, the implementation mechanisms described above include new State programs to promote use of wood building materials (especially those produced in-State) and long-lived consumer products. The TWG was unable to find information, such as similar programs implemented elsewhere to develop an estimate of the costs of these new programs.
- **Data Sources:** The Consortium for Research on Renewable Industrial Materials (CORRIM, Inc.) Phase I Research Report provided the GHG reduction potential for

substituting steel frames with wood frames in residential structures.[31] Data from the US Census Bureau was used to project the number of residential structures per year to be built in Vermont.[32] Data and GHG reduction estimates for industrial and commercial structures, as well as long-lived consumer products were not available at the time of this analysis.

- **Quantification Methods:**

  The CORRIM Phase I report modeled the life-cycle Global Warming Potential (GWP) for a steel-framed and wood-framed house in Minneapolis. Based on personal communication with an author of this report, it is reasonable to assume that a Vermont residential structure can be represented by the Minneapolis houses modeled by CORRIM.[33] For the wood frame house, 6% of the mass of building materials specific to the steel frame is replaced by wood fiber. As a result, the percentage of the house that is constructed from wood fiber increases from 8.6% to 14.6%. This is a 70% increase in the mass of wood fiber used in construction. The GHG reduction for a wood-frame house is shown to be 26%, compared to a steel-frame house.

  A conservative approach was used to determine the potential for emission reductions in the residential building sector. The baseline (BAU) GHG emissions for residential construction in Vermont were estimated based on the assumption that all new houses are going to utilize steel framing. Then, based on the targets of 2% increase in wood products by 2012 and 10% by 2028, the number of new wood-frame homes needed to meet the target is calculated. After calculating the number of wood-frame homes replacing steel-frame homes that are needed to meet the target, the GHG emissions are re-calculated based on a 26% improvement for wood-frame homes – and subtracted from baseline emissions to estimate the potential GHG reductions that can be achieved through this policy option. While this method provides a conservatively high estimate of benefits for residential frame construction, it does not capture reductions associated with other displacing high-GHG building materials in other elements of home construction (flooring, siding, etc.).

  The cost of this option could not be quantified. A key assumption of the CORRIM study was that the construction costs of the two homes (steel frame and wood frame) were equal. However, additional data were not available to substantiate this assumption and to extend it to the commercial/industrial sector and consumer products. There are also additional program elements specified under the implementation mechanisms that will bear some societal costs, which could not be quantified.

  Further data input is needed to accurately and comprehensively quantify the environmental and economic impacts of this option. It is clear that the current model,

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[31] J. Bowyer, D. Briggs, B. Lippke, J. Perez-Garcia, J. Wilson. *Life Cycle Environmental Performance of Renewable Materials in the Context of Residential Building Construction.* Prepared for CORRIM, Inc. http://www.corrim.org/reports/2006/final_phase_1/index.htm

[32] US Census Bureau, *Vermont: Selected Housing Characteristics: 2005.* http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=04000US50&-qr_name=ACS_2005_EST_G00_DP4&-ds_name=ACS_2005_EST_G00_&-_lang=en&-_sse=on

[33] B. Lippke, CORRIM, personal communication with B. Strode, CCS, May 31, 2007.

representing only the residential building sector, does not cover the benefits that can be realized by increasing the use of wood products in all sectors.

- **Key Assumptions:** regional patterns in the disposition of HWP represent conditions in Vermont; forest management results in instantaneous increases in volumes harvested per unit area of 40%. The second part of the analysis only applies to frames of residential buildings. It assumes that all new buildings are constructed of steel frames, which, while unrealistic, provides a sense of the potential for GHG benefits. It also doesn't capture GHG reductions in other elements of building construction. Based upon recent historical data of new housing structures in Vermont, the number of new structures is expected to decrease, further reducing the GHG benefits for each incremental target increase.

## Key Uncertainties

The actual achievable increases in harvest volume envisioned by this option are difficult to generalize. A range of values for the increase in harvest volume were suggested by the technical working group of 10–100%, with actual values depending on specific management practices and site conditions. The views of the TWG were widely divergent on what value to use in the analysis. The value of 40% was chosen as a compromise because it is a midpoint. To give a sense of the potential range, the HWP analysis was run two addition times, with a 10% and 100% assumption for increase in harvest volume. The result provide a rough range of the potential cumulative policy benefits of 0.5–5.0 $MMtCO_2e$ (or 0.2–2.0 $MMtCO_2e$ using the 100-years method).

The analysis does not account for potential changes in fuel use related to a change in forest management or harvesting practices. Increased use of fuel under policy implementation could offset some portion of the GHG benefits estimated above.

Both HWP accounting approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case, may underestimate carbon storage (100-years accounting approach). The real benefits probably lie somewhere in between, so CCS reports the midpoint of the two estimates in the Summary List of Policy Options.

There is a lack of data and established methodologies to assess GHG reductions and costs for offsetting high-GHG building materials in the commercial and industrial sectors and in long-lived consumer products. Cost information for making substitutions of wood for high-GHG embedded building materials was not identified for this analysis. The costs for implementing the programs described above for this option could not be estimated.

## Additional Benefits and Costs

- Revenue generated from increased production of harvested wood products (not factored into cost analysis).
- Increasing wood use efficiencies envisioned under this option (but not quantified) could reduce the amount of forest biomass available for energy production.
- Local job creation/retention in the forests products and finished wood products (e.g., furniture) sectors.

## Feasibility Issues

Feasibility of this option depends on forests shifting from low-value, less dense species to high-value hardwood species valued for durable products (such as maple, cherry, oak). This relates to AFW-5.

The implementation of this option is dependent on changes in fire and insurance codes that may prohibit (or effectively prohibit via costly requirements for heavy timber use) a switch from steel and concrete to wood as primary building materials. Technology has shown a progressive move away from solid wood products to lighter, less-expensive, plastics covered in a very thin layer of wood. This trend, along with the aforementioned regulatory barriers, may make it difficult to implement replacement of steel and concrete building materials with wood products from Vermont forests in the near future.[34]

Note the economic multiplier of this option: in addition to enhanced value of harvest for products, employing more people in forest-related jobs (e.g., in sawmills and wood production facilities) will contribute to local economies and sustain forests and thus the forest industry.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

[34] Input for the "Feasibility Issues" section was given by B. Shields, member of the public, to the TWG in an e-mail to B. Strode, CCS, June 12, 2007.

## AFW-9. Advanced/Expanded Recycling and Composting

### Policy Option Description

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).[35] 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. Use of waste materials as a fuel source can further reduce emissions by offsetting fossil-based energy sources.

### Policy Option Design

**Goals:** Increase per capita diversion to 50% (2005 actual diversion rate is 30%).[36]

**Timing:** 25% of the goal reached by 2012 (35% diversion rate); 50% diversion by 2028.

**Parties Involved:** Federal, state and municipal government, private solid waste and recycling service providers, commercial, industrial and institutional waste generators, Vermont Agency of Natural Resources Solid Waste Division.

**Other:** Per capita diversion as calculated by ANR Solid Waste Division.

### Implementation Mechanisms

Working together in further defining, developing, implementing, and promoting sustainable recycling practices will require an in depth understanding of the cost-effectiveness and environmental benefits of recycling.

- Develop advanced recycling infrastructure so that the entire state is able to participate in single stream recycling. Currently, only the Chittenden County area is served by single stream recycling.
- Develop an incentive/rewards based recycling infrastructure, coupled with single-stream hardware infrastructure (including material recovery centers), to encourage all Vermont residents and businesses to divert recyclable materials from the waste stream (Vermont's diversion rate is essentially unchanged in the last several years (2002: 30%, 2003: 31%,

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[35] It is important to note that VT ANR does not include the use of solid waste to produce energy or fuel products in its definition of recycling. Therefore, any wood waste diverted to the production of fuels (solid or liquid) would not be included in their calculations of the State's diversion rate. The potential for using municipal solid waste fiber as a feedstock for energy production is maintained in the description of this policy option to allow for the widest range of utilization of these materials (e.g. composted fiber often has limitations for use in the market place).

[36] Vermont, Agency of Natural Resources, *2005 Solid Waste Generation Report*, Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm. Note that the VT Solid Waste Plan calls for a 50% diversion to be achieved by 2011, so the goals stated in this option appear to be easily attainable.

2004: 29%, 2005: 30%[37]). This incentive/reward system could be expanded to include end of life electronics and promote the recovery, reuse and recycling of all obsolete electronic equipment.

- Develop additional processing capacity across the state for processing organic wastes (e.g., composting facilities) and expand the collection of commercially-generated organic waste materials.
- Develop a used clothing recycling program (curb-side and rural drop off model) for used clothing. Approximately 6% of the municipal solid waste stream is used clothing.[38]
- Develop an incentive/rewards based recycling infrastructure specifically for construction and demolition material to encourage all Vermont residents and businesses to divert recyclable construction materials from the waste stream (2005 C&D disposed of 99,654 tons).[39]
- Where the incentive-based methods mentioned above do not achieve progress toward the 2012 and 2028 goals, develop and implement appropriate mandates to achieve the goals (e.g., source-separated organics programs, disallow landfilling of organic wastes).

## Related Policies/Programs in Place

- Vermont Environmental Assistance Division – Business Environmental Partnership Program
- Vermont Food Rescue/Waste Division Grants for Organic Diversion
- Vermont Technology and Information Transfer and Exchange Program
- Vermont Construction & Demolition Waste Reduction Assistance Program
- Vermont ANR has just proposed the Center for Climate Change and Waste Reduction (CCWR). The document at the following link provides an overview of the goals of the CCWR – www.anr.state.vt.us/site/cfm/tvwf/CCWR.pdf.

## Type(s) of GHG Reductions

- **$CO_2$:** Upstream Energy Use Reductions – The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.
- **Methane:** Diverting biodegradable wastes from landfills will result in a decrease in methane gas releases from landfills.

## Estimated GHG Savings and Costs per $MtCO_2e$

- **Estimated GHG Savings in 2012 and 2028:** 0.16, 0.88.
- **Cost-Effectiveness:** $4

[37] Vermont, Agency of Natural Resources, 2005 Solid Waste Generation Report, Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm

[38] U.S. EPA "Waste Wise" retrieved from www.epa.gov/epaoswer/non-hw/reduce/wstewise/pubs/overview.pdf

[39] Vermont, Agency of Natural Resources, 2005 Solid Waste Generation Report, Summary, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm

*It should be noted that emissions associated with the production, packaging, and transport of products consumed in Vermont (e.g., embedded energy in product manufacturing occurring out of state) are not included in the Vermont GHG Inventory & Forecast. As a result, the PG might not include the reductions shown in this option in the calculation of progress towards meeting State GHG reduction goals.*

- **Data Sources:** Municipal solid waste (MSW) diversion data for 2005 is from the VT Agency of Natural Resources (ANR).[40] These data are shown in Table H-19.

**Table H-19. Municipal solid waste diversion data for 2005**

| MATERIAL | SOURCE OF MATERIAL | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | Recycling Facilities | Soft Drink and Beer Distributors(1)(2) (Broker Direct) | Economic Recycling(2) (Direct to Market) | Scrap Metal Facilities | Organics Composting | Reuse Facilities & Programs(2) | |
| FIBERS | 49,694 | 386 | 33,495 | | | 137 | 83,712 |
| CONTAINERS | 10,867 | 13,260 | 117 | | | 19 | 24,263 |
| SCRAP METAL | | | 251 | 34,830 | | 159 | 35,240 |
| ORGANIC WASTES | | | | | 32,726 | 0 | 32,726 |
| MISCELLANEOUS | 5,167 | | 14 | | | 2,167 | 7,348 |
| Total: | 65,728 | 13,646 | 33,877 | 34,830 | 32,726 | 2,482 | 183,289 |

| | |
|---|---|
| 2005 MSW DISPOSED (tons): | 431,230 |
| 2005 MSW DIVERSION RATE: | 30% |

- **Quantification Methods:** GHG Reductions:

*Non-Organics Recycling*

EPA's Waste Reduction Model (WARM) was used to estimate GHG reductions achieved via recycling.[41] The wastes in Table H-19 were aggregated into the applicable WARM material categories: mixed paper waste (fibers in Table H-19), mixed metals (scrap metals in Table H-19), and mixed recyclables (containers and miscellaneous in Table H-19). A baseline estimate of waste diversion and associated GHG reductions for 2005 (representing a 30% MSW diversion rate) was established by inputting the diverted quantities for each waste material.

The incremental benefit for 2012 and 2028 was then determined by inputting the additional quantities of waste that would be diverted in each year (35% overall in 2012 and 50% in 2028). These additional quantities of diverted waste also included organic

[40] C. Grodinsky, VT ANR, personal communication with S. Roe, CCS, April 24, 2007. Data were taken from the report: *Vermont Solid Waste Generation, Diversion & Disposal, 2005 Report*, Agency of Natural Resources, Department of Environmental Conservation, December 1, 2006.

[41] The WARM model and associated documentation can be downloaded from: www.yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html. Assumptions used in the WARM modeling included: landfill gas recovery for energy; 75% landfill gas collection efficiency; and default distances to landfill, recycling facility, and composting facility (20 miles each).

materials (addressed below). CCS assumed that the fractions of materials diverted remained the same as in 2005: mixed paper (0.56); mixed metals (0.23); and mixed recyclables (0.21). CCS also grew the waste generation in each future year using the 0.6%/years population growth as used in the GHG inventory and forecast. Table H-20 shows the resulting waste recycling amounts and rates in each year.

**Table H-20. Projected waste diversion rates for 2005–2028**

| | 2005 | 2010 | 2012 | 2028 |
|---|---|---|---|---|
| MSW Disposed | 431,230 | 444,323 | 449,671 | 494,837 |
| MSW Diversion (minus organics) | 150,563 | 178,405 | 199,393 | 406,012 |
| Organics Composted | 32,726 | 38,778 | 43,339 | 88,250 |
| Diversion Rate | 30% | 33% | 35% | 50% |
| Incremental Recycle Tons | 0 | 3,270 | 42,391 | 233,241 |
| Incremental Organics Composted Tons | 0 | 5,058 | 9,214 | 50,697 |

For the incremental tons recycled, WARM provided the results shown in Table H-21.

**Table H-21. Incremental tons recycled**

| Scenario | $MtCO_2e$ |
|---|---|
| Baseline WARM GHG Reduction | 556,520 |
| 2012 Incremental GHG Reduction | 155,893 |
| 2028 Incremental GHG Reduction | 857,738 |

*Composting of Organic Material*

By composting organic material, the $CH_4$ emissions that would have been generated via anaerobic decomposition in a landfill are avoided. Landfill methane avoided for the baseline (2005) organics material diversion was estimated using an estimate of the degradable organic carbon (DOC) content from the United Nations Framework Convention on Climate Change (UNFCC).[42] Since, landfill gas generated at operating landfills in Vermont is largely collected and controlled, the EPA default methane collection efficiency of 75% is applied. Also, the default assumption of 10% oxidation of $CH_4$ as it diffuses through the landfill soil cover is applied. The baseline landfill methane avoided is (see footnote for additional details):

$$\textbf{Baseline } CH_4 = (32{,}726 \text{ ton organics}) \times (0.21) \times (0.50) \times (0.907 \text{ Mt/ton}) \times (16/12) \times 21 \times (1-0.75) \times (1-0.10)$$

$$= 19{,}635 \ MtCO_2e$$

Using this method for calculating the GHG reductions and the incremental tons of organics to be recycled in 2012 (9,214) and in 2028 (50,697) as shown in Table H-20, the benefit of organic material recycling in 2012 is 5,528 $MtCO_2e$ and 30,417 $MtCO_2e$ in 2028.

[42] UNFCC, CDM – Executive Board, "Approved baseline and monitoring methodology AM0039," September 29, 2006. The average DOC content for lawn & garden, food, and wood/straw waste is 21%. Default $CH_4$ content of landfill gas is 50%. 16/12 is the ratio of molecular weights of carbon and methane. 21 is the global warming potential of methane.

Because GHG emissions also occur as a result of composting, these emissions need to be factored in to obtain a net GHG benefit for organics recycling. CCS used an average $CH_4$ emission factor of 1.12 lb/ton material from tests conducted by the South Coast Air Quality Management District in California.[43] $CH_4$ emissions from the incremental composting in 2012 are estimated to be 99 $MtCO_2e$ and in 2028 to be 540 $MtCO_2e$. Nitrous oxide emissions were estimated from tests done on composting of cattle manure[44] (no data on MSW organic materials were identified). The average $N_2O$ emission factor was 0.94 lb/ton of manure. Applying this emission factor to the incremental organic materials composted in 2012 and 2028 yielded: 731 $MtCO_2e$ and 4,020 $MtCO_2e$, respectively. The net GHG benefits for the incremental organics composting are shown in Table H-22:

**Table H-22. Net GHG benefits for incremental organics composting**

| Estimate | 2012 $MtCO_2e$ | 2028 $MtCO_2e$ |
|---|---|---|
| Landfill methane avoided | 5,528 | 30,417 |
| Composting methane | 99 | 540 |
| Composting nitrous oxide | 731 | 4,020 |
| Net GHG Benefit | 4,699 | 25,856 |

Therefore, the overall emission reductions for the policy option are 0.16 $MMtCO_2e$ in 2012 and 0.88 $MMtCO_2e$ in 2028.

**Costs:**

*Non-organics recycling.* CCS assumed that the policy would be applied to households in Rutland County (26,007 households), Bennington (15,061 households), and Windham County (18,760 households). Single-stream recycling service would cost $3–$4 per pick-up with each pick-up occurring every two weeks.[45] Further, households would fill a 96-gallon container with mixed recyclables. This resulted in an annual average cost per household of $91. The total annual operating cost for all households is $5.4 million.

The estimate for annual capital cost is based on an effective size plant that has a maximum throughput of 70,000 tons per year of single-stream waste. This plant would have the capacity to serve more than twice the current output from Vermont's three largest counties and cost an estimated $7.7 million. The capital cost analysis assumes that since initial recycling volumes are less than 50%, that a 50% cost share of the total capital costs is needed from the state. Therefore, the annual capital cost is equal the product of half the capital cost and a annualizing multiplier. The resulting capital cost is $0.4 million per year.

[43] Average of three facilities conducting composting of a variety of organic materials – digested biosolids, manure, wood waste, rice hulls, and green waste. Documented in Roe et al, 2004, *Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources*, Final Report, prepared for the U.S. EPA, Emission Inventory Improvement Program, April 2004.

[44] X. Hao, C. Chang, F.J. Larney, and G.R. Travis, "Greenhouse Gas Emissions during Cattle Feedlot Manure Composting," *Journal of Environmental Quality*, 30:376–386 (2001).

[45] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, April 26, 2007. Provided information on pick-up service costs, tipping fees, and additional information to derive assumptions for this analysis.

There are also societal cost savings associated with this option in that landfill tipping fees are avoided for the waste that is diverted. Tipping fees in Vermont are currently $103 per ton.[46] Using an EPA estimate of waste density (0.05 ton/yd$^3$), the volume of the recycle container, the number of annual pick-ups, and the number of households, the total waste to be diverted was estimated to be 37,333 tons/years. Using the tipping fee of $103 per ton, the avoided landfill cost is $3.8 million/years. The net cost for the non-organics recycling is $2.0 million/years. Using the GHG reduction estimates derived above, the cost-effectiveness for non-organics recycling in 2028 is $2.0 million/ 857,738 $MtCO_2e$ = $2.33/$MtCO_2e$.

*Organics Composting.* The cost of organics composting is based on the total quantity of organic material composted under the business as usual (BAU) scenario, less the total quantity of organics composted after the adoption of the targets imposed by this action. The per-ton cost was largely derived from capital and operation and maintenance (O&M) cost estimates provided via personal communication.[47] The cost estimates used in this analysis are provided in the Table H-23.

**Table H-23. Cost estimates used for analysis**

| Annual Volume (tons) | Capital Cost (2007$,000) | Operating Cost ( $/ton) |
|---|---|---|
| <1,500 | 75 | 25 |
| 1,500–9,999 | 200 | 50 |
| 10,000–29,999 | 2,000 | 40 |
| 30,000–50,000+ | 8,000 | 30 |

The capital costs were annualized using the cost recovery factor method. This method takes the product of the total annual capital cost and a factor that includes assumptions of a 15 year project life and a 5% interest rate. The annualized capital cost is added to the annual O&M cost and the tipping fee is subtracted to determine the total annualized composting costs. This value does not take into account any revenue raised from the sale of compost.

As reported above, the current tipping fee in Vermont is $103 per ton. Therefore, since the total annual cost-per-ton is greater than the tipping fee, composting projects are expected to have a net cost. The net present value of costs—assuming a constant $103 tipping fee—related to composting is $11.77 million.

- **Key Assumptions:** Assumptions used in the EPA WARM modeling include the use of the "current mix" of recycled and virgin material inputs to production (i.e., new products are not produced with 100% virgin materials); landfill gas is recovered for energy purposes; 75% collection efficiency for LFG; default distance to the landfill and recycling facilities (20 miles). Another key assumption is the ability of the $N_2O$ composting emission factor to represent emissions from MSW organic materials composting.

[46] Taylor, Holly, Intervale Compost Project, Personal Communication with B. Strode, CCS, May 29, 2007.

[47] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007. Transmitted via e-mail to B. Strode by S. Roe.

It can be assumed that one ton of organic compost input is equal to about one cubic yard of finished compost. This compost may net $4–6 per cubic yard after transport. However, if trucking costs are high due to remote location of compost facility, the net profit from compost sales may equal zero.[48]

## Key Uncertainties

While Chittenden County is the only solid waste district with a single stream material recovery facility (MRF), many of the solid waste districts bring their recyclables to this MRF. Most of the other districts do not have the population base to support a more expensive all in one MRF. Additionally, at least one hauler in another county brings single stream materials to a MRF in Canada. A full accounting of benefits and costs would need to take these details into account; however a sub-State- (e.g., county-) level analysis was beyond the scope of the assessment conducted here.

There is also an overlap between this option and AFW-10 (Programs to Reduce Waste Generation). To the extent that AFW-10 achieves source reduction during the policy period, there could be less material available for recycling under this option. The extent of this overlap was beyond the scope of the analysis conducted for this option.

## Additional Benefits and Costs

- Lower emissions of landfill gas for the decomposable waste that would be landfilled without this policy option. In addition to methane, landfill gas contains other air pollutants, such as volatile organic compounds and toxic air pollutants.
- This policy could result in lower revenue for landfill operators due to lower quantities of waste being landfilled.

## Feasibility Issues

Post consumer organic waste diversion. Vermont currently composts only separated organic waste.[49] Broadening the range of wastes composted to include mixed MSW may not be feasible at small-scale facilities due to equipment requirements, higher capital costs, and poor marketability of compost residue (whereas the end product from organic composting may be sold as fertilizer).

Co-operating a landfill with an organic composting operation necessitates additional equipment for odor control. The capital costs of odor control equipment vary, depending on the size of the operation and the available buffer zone between the landfill sites and surrounding communities.[50] For some wastes—particularly heavy nitrogenous or wet wastes—bulking agents are necessary to properly manage the composting operation. These bulking agents are major factors in operations and maintenance (O&M) costs of composting facilities.[51]

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[48] Ibid

[49] Taylor, Holly, Intervale Compost Project, Personal Communication with B. Strode, CCS, May 29, 2007.

[50] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007. Transmitted via e-mail to B. Strode by S. Roe.

[51] Ibid.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-10. Programs to Reduce Waste Generation

### Policy Option Description

Institute programs to reduce waste generation at the source to reduce downstream emissions at the waste management site and for transporting these materials to the site. Reducing waste generation can also reduce the emissions associated during manufacturing of the original products.

### Policy Option Design

**Goals:** Reduce the rate of municipal solid waste generation to 50% below 2005 actual rate of 5.40 pounds per person per day.[52]

**Timing:** 25% by 2012; 50% by 2028.

**Parties Involved:** Residential, commercial, industrial and institutional waste generators, Vermont Agency of Natural Resources Solid Waste Division

**Other:** Not applicable.

### Implementation Mechanisms

The policy should aim to develop accessible, cost-effective and sustainable policies, strategies and educational/media campaigns that will promulgate cultural and behavioral changes across the state with the ultimate goal of reducing the amount of waste generated. The policy should reflect the principles of the waste hierarchy and reduce the generation of all waste.

- Develop prototype residential and commercial waste prevention programs that will validate costs savings realized by the waste prevention.
- Develop a communication portal that will keep all constituents apprised of waste reduction/minimization initiatives and actively promote waste minimization efforts, including the results of prototype programs and specific case studies.
- Develop sector-specific waste minimization strategies (schools, hotels, hospitals, restaurants, retail, banks, etc.). Develop these strategies in collaboration with other organizations and the local community.
- Develop an assistance program to provide engineering support to businesses to: 1) reduce product packaging and shipping materials 2) select product packaging and shipping materials that are highly recyclable.
- Encourage manufacturers to provide end-of-life management solutions that reduce the environmental impact of waste (e.g., "cradle-to-cradle" responsibility of waste).

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[52] Vermont, Agency Natural Resources, *2005 Solid Waste Generation, Diversion, and Disposal,* Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm.

- Develop and implement a green purchasing program for all state operations, and use that program as a model and encourage adoption of that model by all municipalities and businesses.

## Related Policies/Programs in Place

- Vermont Department of Environmental Conservation "Beyond Disposal & Recycling Waste Prevention Stakeholders Forum" (along with Agency of Natural Resources is developing the Vermont Waste Prevention Plan).
- Vermont Agency of Natural Resources Environmental Assistance Office Partnership.
- Vermont ANR has just proposed the Center for Climate Change and Waste Reduction (CCWR). The document at the following link provides an overview of the goals of the CCWR – www.anr.state.vt.us/site/cfm/tvwf/CCWR.pdf.

## Type(s) of GHG Reductions

- **$CO_2$:** Upstream Energy Use Reductions – The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.
- **Methane:** Diverting organic wastes from landfills will result in a decrease in methane gas releases from landfills.

## Estimated GHG Savings and Costs per $MtCO_2e$

- **Estimated GHG Savings in 2012 and 2028:** 0.34, 0.73
- **Cost-Effectiveness:** Not quantified. The TWG was unable to determine the costs associated with the implementation mechanisms described above (programs developed and implemented by the State and waste generators to reduce generation. These program costs would be offset to some extent by savings from reduced tipping fees; however the extent of this was not possible to quantify with existing data.

  *It should be noted that emissions associated with the production, packaging, and transport of products consumed in Vermont (e.g., embedded energy in product manufacturing occurring out of state) are not included in the Vermont GHG Inventory & Forecast. As a result, the PG might not include the reductions shown in this option in the calculation of progress towards meeting State GHG reduction goals.*

- **Data Sources:** These include the 2005 Vermont Solid Waste Generation, Diversion & Disposal Report,[53] data on the amounts of waste recycled in 2005,[54] and a 2002 report on

[53] *Vermont Solid Waste Generation, Diversion & Disposal, 2005 Report*, Agency of Natural Resources, Department of Environmental Conservation, December 1, 2006.

[54] C. Grodinsky, VT ANR, personal communication with S. Roe, CCS, May 16, 2007, spreadsheet provided via e-mail.

municipal solid waste (MSW) composition in Vermont,[55] and the EPA Waste Reduction Model (WARM).[56]

- **Quantification Methods:** WARM provides estimates of the life cycle GHG emissions avoided via source reduction, recycling, and composting. The 2005 Vermont waste generation rate was 614,519 tons (5.4 lb/person-day). Waste composition data from the 2002 study cited above were used to provide inputs to the WARM model, as shown in Table H-24.[57] This table shows an assumed baseline for 2012. The tons generated in 2012 are those estimated for 2005 and adjusted for population growth. The tons recycled, combusted and composted were held static from 2005.

[55] *Final Report, Vermont Waste Composition Study*, prepared for the Vermont Department of Environmental Conservation, Solid Waste Program, prepared by DSM Environmental Services, Inc., June 2002.

[56] The WARM model and associated documentation can be downloaded from: www.yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html. Assumptions used in the WARM modeling included: landfill gas recovery for energy; 75% landfill gas collection efficiency; and default distances to landfill, recycling facility, and composting facility (20 miles each).

[57] For all waste categories, the data in Table 7a of the 2002 waste composition study cited above were used. The August urban and rural values were averaged; then the November urban and rural values were averaged; finally the average values obtained for August and November were averaged to represent an “annual average” waste percentage by weight.

**Table H-24. Waste composition data from 2002 study**

| Material | Tons Generated | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|
| Aluminum Cans | 5,790 | 1,981 | 3,809 | | NA |
| Steel Cans | 26,379 | 1,404 | 24,975 | | NA |
| Copper Wire | | | | | NA |
| Glass | 17,372 | 13,719 | 3,653 | | NA |
| HDPE | 30,517 | 916 | 29,601 | | NA |
| LDPE | 23,337 | - | 23,337 | | NA |
| PET | 5,984 | 1,968 | 4,016 | | NA |
| Corrugated Cardboard | 57,906 | 36,366 | 21,540 | | NA |
| Magazines/Third-class Mail | 18,659 | 881 | 17,778 | | NA |
| Newspaper | 31,526 | 21,281 | 10,245 | | NA |
| Office Paper | 42,465 | 585 | 41,880 | | NA |
| Phonebooks | | | | | NA |
| Textbooks | 4,504 | 18 | 4,486 | | NA |
| Dimensional Lumber | | | | | NA |
| Medium-density Fiberboard | | | | | NA |
| Food Scraps | | NA | | | |
| Yard Trimmings | | NA | | | |
| Grass | | NA | | | |
| Leaves | | NA | | | |
| Branches | | NA | | | |
| Mixed Paper (general) | - | - | - | | NA |
| Mixed Paper (primarily residential) | | | | | NA |
| Mixed Paper (primarily from offices) | | | | | NA |
| Mixed Metals | - | | - | | NA |
| Mixed Plastics | - | - | - | | NA |
| Mixed Recyclables | | | | | NA |
| Mixed Organics | 193,021 | NA | 160,295 | | 32,726 |
| Mixed MSW | 174,361 | NA | 124,690 | 49,671 | NA |
| Carpet | | | | | NA |
| Personal Computers | 11,581 | - | 11,581 | | NA |
| Clay Bricks | | NA | | NA | NA |
| Aggregate | | | | NA | NA |
| Fly Ash | | | | NA | NA |

* Plastics composition was estimated as follows using information in the 2005 solid waste report: high density polyethylene (HDPE) – 51%; polyethylene terephthalate (PET) 39%; other plastics, assumed to be primarily low density polyethylene (LDPE) – 10%. Steel cans includes ferrous cans and all other ferrous waste. Newspaper includes newspaper/inserts as well as half of the “dirty paper” identified in the solid waste composition study; office paper includes “mixed paper” and the other half of the “dirty paper” identified in the solid waste composition study.

Table H-25 shows an alternative solid waste management scenario for 2012 assuming that waste in all categories has been source reduced by 25%. The recycled and waste combusted amounts were held constant from 2005 levels. Composting levels were increased to reflect a 25% reduction in organics being landfilled (while this is not technically source reduction it does reduce the landfill emissions that would occur from this organic waste; also, WARM does not have the capability to model source reduction of organics). For mixed MSW, WARM also does not have the capability to estimate the benefits of source reduction. Therefore, CCS reduced the amount of waste being landfilled for that category in 2012 to reflect the waste not landfilled due to source reduction. While this captures the reduction in landfill emissions, it does not capture the rest of the life cycle emissions. Hence, the benefits are slightly underestimated as a result.

**Table H-25. Alternative solid waste management scenario for 2012**

| Material | Baseline Generation | Tons Source Reduced | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|---|
| Aluminum Cans | 5,790 | 1,448 | 1,981 | 2,361 | | NA |
| Steel Cans | 26,379 | 6,595 | 1,404 | 18,380 | | NA |
| Copper Wire | - | | | | | NA |
| Glass | 17,372 | 3,653 | 13,719 | - | | NA |
| HDPE | 30,517 | 7,629 | 916 | 21,972 | | NA |
| LDPE | 23,337 | 5,834 | - | 17,503 | | NA |
| PET | 5,984 | 1,496 | 1,968 | 2,520 | | NA |
| Corrugated Cardboard | 57,906 | 14,477 | 36,366 | 7,063 | | NA |
| Magazines/Third-class Mail | 18,659 | 4,665 | 881 | 13,113 | | NA |
| Newspaper | 31,526 | 7,882 | 21,281 | 2,363 | | NA |
| Office Paper | 42,465 | 10,616 | 585 | 31,264 | | NA |
| Phonebooks | - | | | | | NA |
| Textbooks | 4,504 | 1,126 | 18 | 3,360 | | NA |
| Dimensional Lumber | - | | | | | NA |
| Medium-density Fiberboard | - | | | | | NA |
| Food Scraps | - | NA | NA | | | |
| Yard Trimmings | - | NA | NA | | | |
| Grass | - | NA | NA | | | |
| Leaves | - | NA | NA | | | |
| Branches | - | NA | NA | | | |
| Mixed Paper, Broad | - | NA | - | | | NA |
| Mixed Paper, Resid. | - | NA | | | | NA |
| Mixed Paper, Office | - | NA | | | | NA |
| Mixed Metals | - | NA | | | | NA |
| Mixed Plastics | - | NA | - | | | NA |
| Mixed Recyclables | - | NA | | | | NA |
| Mixed Organics | 193,021 | NA | NA | 112,040 | | 80,981 |
| Mixed MSW | 174,361 | NA | NA | 81,100 | 49,671 | NA |
| Carpet | - | | | | | NA |
| Personal Computers | 11,581 | 2,880 | | 8,701 | | NA |
| Clay Bricks | - | | NA | | NA | NA |
| Aggregate | - | NA | | | NA | NA |
| Fly Ash | - | NA | | | NA | NA |

WARM estimated a 0.34 $MMtCO_2e$ reduction in 2012 due to the 25% source reduction shown above. A similar assessment was done for 2028 with the goal of achieving a 50% reduction in waste generation. For 2028, a GHG reduction of 0.73 $MMtCO_2e$ was estimated.

- **Key Assumptions:** The increased wastes to be recycled as a result of this option will be recycled in the same relative quantities to those currently being recycled. Since some recycled materials have higher life-cycle GHG benefits than others, changes to the proportions of different wastes recycled could have either a positive or negative effect on the reductions estimated.

## Key Uncertainties

There is an overlap between this option and AFW-9 covering enhanced recycling. To the extent that this option achieves the source reduction goals during the policy period, there could be less material available for recycling under AFW-9. The extent of this overlap was beyond the scope of the analysis conducted for this option.

## Additional Benefits and Costs

These can include reduction in fossil energy use and related emissions associated with the production of new products that are avoided as a result of source reduction.

The option could potentially result in lower revenue for landfill operators due to lower quantities of landfilled waste.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-11. Water and Wastewater Treatment – Energy Efficiency Improvements

### Policy Option Description

Energy efficiency programs at water and wastewater treatment plants (WWTPs) can reduce GHG emissions by reducing consumption of electricity to run pumps, fans, and other electrical equipment. Included in this option is a review of the potential for installing anaerobic digesters for biosolids and subsequent use of the methane as an energy source for generating electricity (e.g., using internal combustion engines or microturbines).

### Policy Option Design

**Goals:** Develop an energy conservation, management and efficiency plan to increase energy efficiency of plant operations by 25%; Use wastewater digester gas to produce energy where feasible.

**Timing:** 15% by 2012; 25% by 2028.

**Parties Involved:** Municipal and private/investor-owned water and wastewater treatment operators, Vermont Agency of Natural Resources Wastewater Treatment Division

**Other:** Not applicable.

### Implementation Mechanisms

An evaluation of the potential for energy efficiency and energy production improvements in municipal and private/investor-owned water and wastewater treatment sector is needed. Energy costs can account for 30% of the total operation and maintenance costs of WWTPs. WWTPs account for 3% in electric load in the United States.[58]

Goals of the assessment are to:

- Quantify the energy consumed in Vermont's municipal and private/investor-owned water and wastewater treatment sector annually, to establish a baseline for the sector.
- Assess the potential for energy savings for the sector.
- Assess the potential for energy production using digester gas (in anaerobic plants).

Near-term opportunities for energy savings:

- Lighting retrofits from T12 systems to T8;
- Heating retrofits from electric heat;

[58] EPA, Wastewater Management Fact Sheet – Energy Conservation, July 2006.

- Installation of high-efficiency influent and effluent pumps, high-efficiency motors and variable frequency drives;
- Evaluate the costs and benefits to second-stage activated sludge mixing and aeration;
- Identify opportunities for peak demand reduction and optimizing load profiles.

Mid-term opportunities for energy savings:

- Co-generating electricity and thermal energy on-site; capturing and using anaerobic digester gas.

## Related Policies/Programs in Place

None identified.

## Type(s) of GHG Reductions

- **$CO_2$:** A portion of electricity used by WWTPs in Vermont is generated through the combustion of fossil fuels, a process that releases $CO_2$ into the atmosphere. Additionally, methane combusted on-site for the purposes of flaring or energy generation releases $CO_2$, as well as small amounts of $CH_4$ and $N_2O$. However, since $CO_2$ has a lower global warming potential (GWP) than $CH_4$, the practice of combusting methane at WWTPs results in a net reduction of GHGs when expressed in $CO_2e$.
- **Methane:** WWTPs that utilize anaerobic digestion as a method of wastewater treatment emit methane. However, as this analysis will show, there is a potential for facilities to capture this methane and combust it to produce heat and electricity.

## Estimated GHG Savings and Costs per MtCO$_2$e

- **Estimated GHG Savings in 2012 and 2028:** 0.004, 0.011
- **Cost-Effectiveness:** $–133
- **Data Sources:** This analysis relied on data from EPA's Clean Watershed Needs Survey (CWNS).[59] This survey reports the existing flow, projected flow, and population receiving treatment from the year 2000. These data were applied to aggregate Vermont population data from the Draft Vermont Inventory & Forecast.[60] Data regarding the cost and efficiency of specific technologies were compiled from various sources; mostly case studies. There is a lack of data regarding specific energy requirements for WWTPs in Vermont, so many of the estimates provided in this analysis are based upon as few as one data point, reducing the accuracy of the quantification.
- **Quantification Methods:**

  *GHG Reductions:* The first step in quantifying the GHG reduction potential and cost-effectiveness of this assessment was to estimate the electricity demand for WWTPs and the emission factor of electricity in Vermont. Electricity demand for WWTPs was measured using the CWNS 2000 data to determine what the million gallons per day

[59] US EPA. CWNS 2000 DATA; Ask WATERS Simple Query Tool. http://www.epa.gov/cwns/2000data.htm.

[60] Primary source for 2000-2020 projections: http://www.census.gov/population/projections/SummaryTabA1.xls. Linear extrapolation used to estimate population after 2020.

(MGD) discharge rate was for all residents served by the surveyed facilities. Next, the energy use per million gallons was determined from the median of a survey of 12 WWTPs.[61] The annual BAU WWTP electricity consumption was estimated by taking the product of the per-capita discharge rate, the projected population, and the electricity usage (in kWh/MG treated). The emission factor ($MMtCO_2e$/kWh) was calculated by dividing the projected emissions[62] by the projected Vermont electricity sales from the Vermont Inventory & Forecast. The avoided emissions from electricity savings were determined by multiplying the annual efficiency improvement targets by the annual BAU WWTP electricity consumption and the annual electricity emission factor. The cumulative (2008–2028) $CO_2$ emission reduction from achieving the energy efficiency targets defined by this option is 0.15 $MMtCO_2e$.

GHG reduction from the conversion of methane to $CO_2$ was calculated by first examining the CWNS data to determine which WWTPs had combined heat and power (CHP) potential, identifying the fraction of Vermont wastewater capacity that can utilize anaerobic digestion to produce methane for CHP, and multiplying that fraction by the annual WWTP methane emissions provided by the Vermont Inventory & Forecast. The resulting GHG emission reduction from the conversion of methane to $CO_2$ was minimal; on the order of $10^{-7}$ $MMtCO_2e$.

*Cost:* As mentioned in the Data Sources section, most of the cost estimates for the implementation of energy efficient technologies at WWTPs in Vermont resulted from case study data and were often based on only one data point. For example, if it is known that a particular technology has reduced a facility's energy use by 1,000,000 kWh/years, and the capital cost $10,000, then the cost per kWh used in this analysis would be the annualized capital cost[63] divided by either the kWh reduced or the total BAU kWh used in the process to which the technology in question is applied. Each efficiency-improving technology is applied to the specific process in which it is implemented. Meaning that if a variable frequency device can improve the efficiency of an influent pump by 25% and the influent pump uses 4.5% of the WWTPs electricity, then the efficiency improvement is assumed to apply to the entire 4.5%, or 0.25*0.045*BAU WWTP electricity use. Table H-26 displays the fractions of electricity used by WWTP processes.

[61] Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities, prepared for Pacific Gas and Electric, prepared SBW Consulting , Inc., February 2002.

[62] Projected from EIA Historical Data (1990-2004).

[63] The cost for each technology in this analysis is annualized utilizing the Cost Recovery Factor method.

**Table H-26. Fractions of electricity used by WWTP processes**

| **Fraction of Electricity used by WWTP** | |
|---|---|
| Influent Pumping | 0.045 |
| Solids Dewatering | 0.07 |
| Clarifier & Sludge Pumping | 0.156 |
| Aeration | 0.556 |
| Heating | 0.033 |
| Lighting | 0.0606 |
| Other | 0.0794 |

After the net cost per kWh is determined, the option that is the most financially attractive (i.e., greatest cost savings) were fully implemented. Additional technology options were added on until the targets for 2012 and 2028 were met. Hence, this method calculated the best-case net cost scenario for this set of efficiency targets.

Since the capital cost of the equipment was annualized over ten years, cost savings are quickly realized due to the high cost of electricity in Vermont and the large potential for low-cost efficiency improvements at WWTPs. The levelized and discounted cost-effectiveness of this action is $–133/Mt$CO_2$e.

- **Key Assumptions:** The large cost savings realized by this option is largely due to the assumption that capital cost may be annualized over ten years. Also, it is assumed that the efficiency improvements for a given technology apply to the full fraction of WWTP electricity usage for each process. Additional assumptions include:
  - The technology cost and efficiency data from case studies are used as averages that represent the population of WWTPs in Vermont.
  - This analysis assumes that WWTPs will meet and not exceed the efficiency targets.

## Key Uncertainties

None identified.

## Additional Benefits and Costs

Reductions in energy consumption and associated air pollutant emissions.

## Feasibility Issues

None identified.

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

## AFW-12. In-State Liquid Biofuels Production

### Policy Option Description

This option covers incentives needed to increase biodiesel and ethanol production in Vermont. Use of biodiesel offsets the consumption of diesel fuel produced from petroleum (petrodiesel). Since biodiesel has a lower GHG content than petrodiesel, overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user. Also, feedstocks for biodiesel production (e.g., vegetable oils) produced from GHG-superior sources than the current dominant feedstock (soybean oil) can produce additional significant reductions. An example of a superior feedstock would be cultivated algae, which is capable of sequestering considerable quantities of $CO_2$ in its life cycle and converting it to oil and protein meal.

This option also seeks to offset fossil fuel use (gasoline) with in-state production of ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content. Incentives are needed for the research and production of ethanol, especially from GHG-superior cellulosic crops, forest sources, animal waste, and municipal solid waste.

*Note: This option is linked with TLU Option 5 on Alternative Fuels and Infrastructure. This option seeks to achieve incremental GHG benefits beyond the TLU option by promoting in-state production of biodiesel and ethanol using feedstocks with greater GHG benefits than the likely business as usual national production methods. In addition, Vermont consumption of biodiesel and ethanol produced in-state will produce better GHG benefits than these same fuels obtained from a national market due to lower embedded $CO_2$ associated with transportation of biodiesel and ethanol or its feedstocks from distant sources.*

### Policy Option Design

**Goals:** The goal levels and timing for increasing production of biofuels in Vermont are shown in Table H-27.

**Table H-27. Goal levels and timing for increasing production of biofuels in Vermont**

| Phase | Year | Gallons of biodiesel produced in Vermont | Represents percentage of total distillate used in state (in 2006) | Gallons of cellulosic ethanol produced in Vermont | Represents percentage of total gasoline used in state (in 2006) |
|---|---|---|---|---|---|
| 1 | 2010 | 1,000,000 | 0.4% | 0 | 0% |
| 2 | 2015 | 14,500,000 | 6% | 10,000,000 | 3% |
| 3 | 2028 | 50,000,000 | 21% | 50,000,000 | 15% |

**Timing:** See Table H-27.

**Parties Involved:** State of Vermont, farmers, biofuels producers, fuel retailers, fuel wholesalers, business owners, and relevant agriculture and trade associations.

**Other:** The goals above are incremental to business as usual (BAU) production, which include the planned Biocardel plant described in the Feasibility Issues section below.

## Implementation Mechanisms

- Incentives in the form of grants or tax breaks (sales and/or income) for incurred capital costs for feedstock producers (oil crops, methanol/ethanol).
- Streamlined permitting of production facilities. Technical assistance for new producers.
- Incentives and grants for expanded research for oilseed production and processing (including canola and other crops not typically grown in Vermont).
- Active solicitation of new producers.
- Expanded consumer education to drive demand.
- Expanded producer education to develop skilled workforce.

## Related Policies/Programs in Place

- House Bill 520, Section 4 establishes the definition of a farm, to which H520 applies (see AFW-3 for additional explanation).
- House Bill 520, Section 39 recommends targets that increase the use of biodiesel blends in state office buildings, state garages, and the state vehicle fleet. The targets are to use (wherever possible) blends that are at least 5% biodiesel (B5) by 2008 and 10% biodiesel (B10) by 2012.

## Type(s) of GHG Reductions

**$CO_2$:** Life cycle emissions are reduced to the extent that biodiesel and ethanol is produced with lower embedded fossil-based carbon than conventional (fossil) fuel. Feedstocks used for producing biodiesel and ethanol can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon).

The primary feedstocks for biodiesel are vegetable oils (soy, canola, sunflower, algal, etc.) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),[64] biodiesel from soybeans contains 93% more useable energy than its petroleum equivalent and reduces life cycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the life cycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded $CO_2e$ of biodiesel compared to importation of out of state vegetable oil supplies.

[64] Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," *Proceedings of the National Academy of Sciences*, 103:11206–11210, July 25, 2006.

There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., corn stover), forestry waste, purpose grown crops (e.g., switchgrass), and municipal solid waste. Local production of ethanol also decreases the embedded $CO_2$e of ethanol compared to importation from the current U.S. primary ethanol producing regions. Current research indicates cellulose-based ethanol production provides up to 72–85% reduction in GHGs compared to gasoline, whereas an 18–29% reduction is measured from starch-based ethanol production compared to gasoline.

## Estimated GHG Savings and Costs per Mt$CO_2$e

- **GHG reduction potential in 2012, 2028 (MMt$CO_2$e):** Biodiesel: 0.004, 0.24; Ethanol: 0.03, 0.42
- **Net Cost per Mt$CO_2$e:** Biodiesel: $18; Ethanol: $1
- **Data Sources:**

  The $CO_2$e emission factor for fossil diesel used in the inventory and forecast is 10.04 Mt/1,000 gallons. The life cycle fossil diesel emission factor is 12.3 Mt/1,000 gallons (Hill et al., 2006; cited in the footnotes).

- **Quantification Methods:**

*Biodiesel GHG Reductions*

A new study on life cycle GHG benefits for biodiesel production and use was used to estimate the $CO_2$e reductions for this option (Hill et al, 2006; cited in footnotes to this option). This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the US and is assumed to remain that way for the purposes of this analysis (it is also the predominant source of vegetable oil production in Vermont). Life cycle $CO_2$e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al to be 41%.[65] This value is being used by the TLU TWG to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks production with the focus on vegetable oils and algal oil.

For this option, the incremental benefit of in-state production is derived from the lower embedded GHG content of biodiesel feedstocks (vegetable oil and algal oil) avoided from having to transport the feedstocks from their likely source region. For this assessment, the likely source regions for soybean or canola oil are the U.S. mid-west or northern plains regions. Using South Dakota as a potential source region, rail transport would require shipments to central Vermont of about 1,700 miles.[66] Rail fuel consumption is about 400

[65] Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," Proceedings of the National Academy of Sciences, 103:11206–11210, July 25, 2006.

[66] U.S. National Atlas, at http://nationalatlas.gov/natlas/Natlasstart.asp

ton-miles/gallon.[67] The density of vegetable oil is about 3,700 tons/MMgal. From these inputs, a GHG emission rate of 158 $MtCO_2$/MMgal oil was calculated.

When combined with the other feedstocks needed to produce biodiesel (e.g., either methanol or ethanol), a gallon of vegetable oil will produce slightly more than one gallon of biodiesel. For the purposes of this estimate, each gallon is assumed to produce one gallon of biodiesel.

In addition to soybean oil, other oil feedstocks included in this analysis include canola, sunflower, waste vegetable oil (WVO), and algal oils. For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the life cycle soybean emission factor (7,261 $MtCO_2e$/MMgal from the Hill et al. study). As mentioned previously, the benefits of the biodiesel component of the TLU biofuels option is based on displacement with soybean-based biodiesel. Hence, this analysis was designed to only account for the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. These include vegetable oils that produce greater volumes of oil per unit of energy input (e.g., canola), and, in the future, algal oils.

Canola produces 127 gallons of oil per acre compared to soybeans at 48 gallons/acre.

Assuming canola production energy inputs are not significantly greater than soy, the life cycle emission rate for canola would be 7,261 x 48/127 or 2,744 $MtCO_2e$/MMgal. So the incremental benefit of canola over soy is 7,261 – 2,744 = 4,517 $MtCO_2e$/MMgal. Sunflower produces 102 gallons of oil per acre resulting in an incremental benefit of sunflower over soy of 3,488 $MtCO_2e$/MMgal. For waste and algal oils, CCS assumes that these have negligible embedded energy. So, the incremental benefit over soy equals the life cycle fossil diesel EF (12,306 $MtCO_2e$/MMgal) minus the soybean based EF (7,261 $MtCO_2e$/MMgal), which is 5,045 $MtCO_2e$/MMgal.

To meet the in-state production goals for 2012, 2015, and 2028, Table H-28 provides the mix of oil feedstocks assumed in this analysis. The assumed mix relies heavily on new technologies (e.g., algal oil) to produce feedstocks in the post-2010 period. The net production data summarized below exclude BAU production, which is estimated to be 8 MMgal/years.

GHG reductions were estimated by multiplying the production of each oil feedstock by the applicable incremental benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type.

[67] U.S. National Atlas, at http://nationalatlas.gov/articles/transportation/a_freightrr.html

**Table H-28. Net production data for mix of oil feedstocks**

| | | | |
|---|---|---|---|
| 2012 | Oilseed | 500,000 | 33% Soy, 33% Sunflower, 33% Canola |
| | WVO | 500,000 | |
| | | 1,000,000 | |
| 2015 | Oilseed | 2,000,000 | 33% Soy, 33% Sunflower, 33% Canola |
| | Algal oil | 12,000,000 | |
| | WVO | 500,000 | |
| | | 14,500,000 | |
| 2028 | Oilseed | 4,500,000 | 33% Soy, 33% Sunflower, 33% Canola |
| | Algal oil | 45,000,000 | |
| | WVO | 500,000 | |
| | | 50,000,000 | |

*Biodiesel Costs*

Costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[68] The value of incentives needed is assumed to be equivalent to the difference in the costs of producing fossil diesel and soy-based biodiesel ($0.34/gallon). This value is very close to the incentive offered in a State of Missouri incentives program.[69] This program offers production incentives of $0.30/gallon to producers up to 15 million gallons of production/years. The incentive grants last for five years. CCS assumed a similar incentive structure and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates are based on multiplying the amount of biodiesel produced in each year by the production incentive. This assumes that all production occurs at production facilities of less than 15 million gallons/years. The production incentive runs out after five years of production.

*Ethanol GHG Reductions*

The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (BAU) starch-based production in the U.S. As per the policy design, all ethanol production targeted by this policy is assumed to occur via cellulosic technology. Feedstocks for the fiber needed by this policy could come from crop residue, forestry biomass, or municipal solid waste fiber.

[68] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.

[69] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.

Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Lab study.[70] These emission factors incorporate the GHG emissions during the entire life-cycle of fuel production (e.g., for gasoline: extraction, transport, refining, distribution, and consumption; for ethanol: crop production, feedstock transport, processing, distribution, and consumption). These life-cycle emission factors are referred to as "well-to-wheels" emission factors:

Fuel Emission Factor (grams $CO_2$e/mi):

- Reformulated gasoline 552
- Starch-based ethanol 451
- Cellulosic ethanol 154

Based on the emission factors shown above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 66% (reduction of $CO_2$e by offsetting gasoline consumption). This value was used along with the life cycle emission factor for gasoline[71] and the production in each year to estimate GHG reductions. The assumed production schedule is provided in Table H-29.

**Table H-29. Assumed production schedule**

| Year | MMGal Ethanol Capacity Needed | Cellulosic Feedstock Needed | Ethanol Yield[72] |
|---|---|---|---|
| 2008 | – | – | 70 gallons/dry ton biomass |
| 2009 | – | – | 70 gallons/dry ton biomass |
| 2010 | – | – | 70 gallons/dry ton biomass |
| 2011 | 2 | 28,571 | 70 gallons/dry ton biomass |
| 2012 | 4 | 44,444 | 90 gallons/dry ton biomass |
| 2013 | 6 | 66,667 | 90 gallons/dry ton biomass |
| 2014 | 8 | 88,889 | 90 gallons/dry ton biomass |
| 2015 | 10 | 111,111 | 90 gallons/dry ton biomass |
| 2016 | 13 | 145,299 | 90 gallons/dry ton biomass |
| 2017 | 16 | 179,487 | 90 gallons/dry ton biomass |
| 2018 | 19 | 213,675 | 90 gallons/dry ton biomass |
| 2019 | 22 | 247,863 | 90 gallons/dry ton biomass |
| 2020 | 25 | 253,846 | 100 gallons/dry ton biomass |
| 2021 | 28 | 284,615 | 100 gallons/dry ton biomass |

[70] Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions, General Motors, Argonne National Lab, and Air Improvement Resource, Inc., May 2005.

[71] In the study mentioned above, the average fuel economy used was 21.3 miles/gallon or 100 miles/4.7 gallons. Multiplying this value by the emission factor of 552 grams/mile yields 11,745 grams/gallon.

[72] J. Ashworth, NREL, personal communication with S. Roe, CCS, 4/06/07.

| Year | MMGal Ethanol Capacity Needed | Cellulosic Feedstock Needed | Ethanol Yield[72] |
|---|---|---|---|
| 2022 | 32 | 315,385 | 100 gallons/dry ton biomass |
| 2023 | 35 | 346,154 | 100 gallons/dry ton biomass |
| 2024 | 38 | 376,923 | 100 gallons/dry ton biomass |
| 2025 | 41 | 407,692 | 100 gallons/dry ton biomass |
| 2026 | 44 | 438,462 | 100 gallons/dry ton biomass |
| 2027 | 47 | 469,231 | 100 gallons/dry ton biomass |
| 2028 | 50 | 500,000 | 100 gallons/dry ton biomass |

*Ethanol Costs*

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The DOE EIA estimated that the cost to produce starch-based ethanol is $1.10/gal compared to $1.29/gal, or a difference of $0.19/gal (in $1998).[73] In 2006 dollars, the difference is $0.23/gal. These incentives are considered necessary in the near term (up to 2015) to help commercialize technologies that produce ethanol from cellulose or produce starch-based ethanol using renewable fuels. The incentives should also help to establish the infrastructure to deliver biomass to bio-refineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that there is currently federal legislative proposal to offer cellulose an incentive of $0.765/gallon compared to the $0.51/gallon currently offered for ethanol production.[74] If enacted, this $0.255/gallon premium could cover the additional incentives that are assumed to be needed by the State of Vermont. Obviously, the federal incentives do not assure that production facilities would locate in Vermont. These federal incentives have not been factored into the cost estimates for this option.

The costs for this option were estimated using the $0.23/gal incentive multiplied by the production needed in each year. By 2015, it is assumed that these incentives will no longer be needed as cellulosic ethanol technologies become fully commercialized.

- **Key Assumptions:** Life-cycle GHG emission factors utilized/derived for this analysis are representative for each feedstock and for fossil diesel. Production incentives offered by this option are sufficient to drive production of GHG-superior feedstocks (e.g., superior to soybeans) and to increase the level of research and development needed for non-crop based feedstocks (e.g., algal biodiesel, Fischer-Tropsch biodiesel).

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[73] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[74] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

Starch-based ethanol production using renewable fuels achieves equivalent GHG life cycle benefits as cellulosic ethanol; cellulosic production or starch-based production with renewable fuels can achieve the production levels in the near term (2014 production of 310 MMgal/years) required by this policy option; Federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate. The level of incentives for ethanol and biodiesel are assumed to be adequate to foster the production of feedstocks for each biofuel (no accounting was made for the differences in production costs for each feedstock – e.g., canola versus soy).

## Key Uncertainties

It is unclear whether the levels of feedstock production described in this option would create significant disruption to Vermont's current agricultural systems that supply food and livestock feed. This is an area which will require sufficient planning and monitoring by the State. The TWG structured the goals mindful of these issues, such that the production goals in the last half of the policy period are driven by feedstocks from emerging technologies like cellulosic ethanol and algal biodiesel.

## Additional Benefits and Costs

Additional jobs will be created in-state to serve biofuels industry. Farmers will have additional options for high value crops. Increase in conventional air pollution if light duty diesel vehicles begin to displace light duty gasoline vehicles.

## Feasibility Issues

Vermont uses approximately 234,000,000 gallons of distillates (heating oil and on and off-road diesel) and 328,000,000 gallons of gasoline per year.[75]

Biocardel Vermont, Inc., located in Swanton is due to begin production of biodiesel from soy oil in early 2007 with 4 mgy (million gallon per year) capacity and increase to 8 mgy by 2010. One commercial biodiesel producer is in operation in Winooski, with an annual capacity of just 50,000 gallons. Several other small producers may be approaching commercial status for an additional 150,000 gallons of capacity in 2007–2008.

- Eighteen Vermont farms are currently showing interest in growing oilseed crops for biofuel (soy, sunflower, canola) and a few have begun producing biodiesel. The Vermont Biofuels Association (VBA), UVM Extension, UVM Ctr for Sustainable Agriculture and Vermont Sustainable Jobs Fund (VSJF) are collaborating on several integrated research and demonstration projects with several of these farms to assess the feasibility of increased oilseed production to meet both farm livestock feed and fuel (biodiesel) need. Vermont's farms use a total of 6.4 mgy of petrodiesel and heating oil distillates and the VBA estimates that by 2015 over half of Vermont's farm distillate use plus an additional 6 mgy will be produced in state, on 100,000 acres (or 17% of cropland[76]).

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[75] Source: U.S. Dept of Energy, Energy Information Administration. Report: Adjusted Sales of Distillate Fuel by End Use/Vermont. http://tonto.eia.doe.gov/dnav/pet/pet_cons_821dsta_dcu_SVT_a.htm

[76] Source: U.S. Dept of Agriculture, 2002 Census of Agriculture – Vermont. Table 9. http://www.nass.usda.gov/census/census02/volume1/vt/index1.htm

- With seed funding from the Vermont Agency of Agriculture, a Montpelier company is working with the VBA and Gund Institute (UVM) researchers to optimize the production of algae in *photobioreactors* to be located on dairy farms. Using a patented, but as yet untested technology, the systems are two to three years from being commercially viable. It is estimated that over 100 Vermont dairies would provide a suitable location for the commercial units. Once established a single *photobioreactor* may be capable of producing above 500,000 gallons per year of high quality biodiesel feedstock (oil) as well as cellulosic feedstock as a 'by-product'.

Numerous government studies confirm microalgae organisms' ability to sequester abundant amounts of $CO_2$ through photosynthesis and other biological processes.[77] This potential should also be examined and evaluated as a component of the Governor's Commission on Climate Change.

There is currently no commercial production of ethanol from cellulosic feedstock in the United States. However, recent announcements by New England based cellulosic biomass-to-ethanol company Mascoma Corp. (a national leader in this technology), point to a 15,000 sq. ft. test facility planned for the Rochester, NY area. The facility, to be constructed over the next 12 to 15 months, is expected to operate using a number of agricultural and/or forest products as biomass, including paper sludge, wood chips, switch grass and corn stover. At the New York demonstration facility the company and its strategic partners "will demonstrate the commercial scale production of ethanol from biomass," according to a statement issued by the company president in December 2006.

Vermont has an opportunity to position itself as a creator of sustainably produced biofuels by focusing on cellulosic ethanol and biodiesel derived from stringent agricultural and forestry practices. VSJF, the VBA, the Vermont Alternative Energy Corporation (VAEC), and other organizations have already completed preliminary research on the potential of cellulosic ethanol in Vermont. However, biofuels research and development is still at an early stage in Vermont. Tapping the capacity of these and other organizations, including Vermont's educational institutions and the cellulosic ethanol expertise at Dartmouth College should help to accelerate the development of the cellulosic ethanol sector.

Which cellulosic feedstocks grow best in Vermont? VAEC's cellulosic ethanol feasibility study concludes that wood, lumber, forest residue, and grass straw would make up the most likely ethanol feedstocks in Vermont. VAEC believes that10 million gallons of cellulosic ethanol can be produced, with about 60,000 acres of land devoted to hay. This is equal to 17% of the land currently devoted to forage in Vermont (and 4.8% of all agricultural land in Vermont). According to the Vermont Division of Forestry, there are over 140 million tons of wood in Vermont's forests. The McNeil Generating Station in Burlington uses 180,000 tons of wood per year (less than 1% of the total). Statistics for 2003 show that less than 1% (1,096,382 tons) of Vermont's total amount of wood was harvested.

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[77] Source: U.S. Dept of Energy, National Renewable Energy Laboratory. Report June 2001, Kiran L. Kadam; Microalgae Production From Power Plant Flue Gas: Environmental Implications On A Life Cycle Basis. Contract DE-AC36-99-GO10337

## Status of Group Approval

Complete.

## Level of Group Support

Unanimous.

## Barriers to Consensus

Not applicable.

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# Appendix I
# Cross-Cutting Issues
# Policy Recommendations

## Summary List of Policy Options

| | Policy Option | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2020 | Total 2008–2020 | | | |
| CC-1 | GHG Inventories and Forecasts | Not quantified | | | | | Unanimous Consent |
| CC-2 | State GHG Reporting | Not quantified | | | | | Unanimous Consent |
| CC-3 | State GHG Registry | Not quantified | | | | | Unanimous Consent |
| CC-4 | State Climate Public Education and Engagement | Not quantified | | | | | Unanimous Consent |
| CC-5 | Adaptation | Not quantified | | | | | Unanimous Consent |
| CC-6 | Options for State GHG Goals or Targets | Not quantified | | | | | Pending |
| CC-7 | The State's Own GHG Emissions | Not quantified | | | | | Pending |
| | **Sector Total After Adjusting for Overlaps** | | | | | | |
| | **Reductions From Recent Policy Actions** | | | | | | |
| | **Sector Total Plus Recent Policy Actions** | | | | | | |

GHG = greenhouse gas.

# CC-1. GHG Inventories and Forecasts

## Policy Description

Greenhouse gas (GHG) emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks (both anthropogenic and natural), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. The initial use for inventories and forecasts will be to inform state leaders and the public on statewide trends, opportunities for mitigating emissions or enhancing sinks, and verifying GHG reductions associated with implementation of Vermont's Climate Action Plan. However, it is expected that other uses of the data will be identified as the program evolves. The responsibility for preparing GHG inventories and sinks should reside with the Department of Environmental Conservation (DEC), which has the expertise needed to systematically compile information on GHG sources and sinks using established methods and data sources. Other state agencies as well as private facilities (sources) will need to provide data to DEC on a periodic basis. This function should be integrated with the existing DEC emissions inventory program as seamlessly as possible. The GHG inventory and forecast will be an ongoing effort that will improve over time based on improvements to the accuracy and completeness of GHG emissions data.

## Policy Design

The Cross-Cutting (CC) Issues Technical Work Group (TWG) recommends that Vermont institute a formal GHG inventory and forecast function within the DEC, to be assisted by other state agencies as needed. Additional information regarding key program characteristics can be found in the *GHG Inventories and Forecasts Design Options Matrix* (posted on the Plenary Group Web site at: www.vtclimatechange.us/plnarygroup.cfm )

**Goals:**

- Develop a periodic, consistent, and complete inventory of emission sources and sinks and an accompanying forecast of future GHG emissions in at least 5- and 10-year increments, out to and including 2030 (and eventually beyond). The GHG forecast should reflect projected growth as well as the implementation of scheduled policy options, and should, through differences year-to-year, provide a basis for documenting and illuminating trends in state GHG emissions.
- Inventory all natural and man-made emissions generated within the boundaries of the state (i.e., a production-based inventory approach) as well as emissions associated with energy imported and consumed in the state (i.e., a consumption-based inventory approach).

**Timing:** This function should be implemented as soon as allowed by current funding and should be enhanced over time.

**Parties Involved:** All GHG emission sources and sinks (both anthropogenic and natural) should be included in the inventory and forecast. Therefore, the owners, facility operators, and land managers of these sources as well as relevant state agencies and inventory and registry experts are potential parties involved.

### Implementation Mechanisms

None cited.

### Related Policies/Programs in Place

Vermont DEC periodically develops GHG inventories in keeping with the Vermont Climate Neutral Working Group and the state's commitments under the New England Governors/Eastern Canadian Premiers Climate Change Action Plan.

### Type(s) of GHG Reductions

Establishing a GHG inventory and forecasting function within the state government will assist in the tracking, management, and ultimately reduction of GHG emissions; it will not reduce GHG emissions itself per se. Public disclosure of emissions may encourage reductions by sources.

### Estimated GHG Savings and Costs per $MtCO_2e$

This option could be considered an administrative and enabling function of the Climate Action Plan (including enabling any future cap- and-trade options) and will incur overhead costs but not directly reduce emissions per se except where these data motivate reductions for public relations by individual companies or sources.

**Data Sources:** Many.

**Quantification Methods:** Several will be designed to follow standard, comparative, and accepted approaches that allow eventual exchange/sale of emission credits.

**Key Assumptions:** Not quantified.

### Key Uncertainties

Adequacy of ongoing funding for a statewide GHG inventory and forecasting function.

### Additional Benefits and Costs

None cited.

### Feasibility Issues

None cited.

### Status of Group Approval

Approved.

### Level of Group Support

Unanimous consent

## Barriers to Consensus

None.

## CC-2. State GHG Reporting

### Policy Description

GHG reporting is the measurement and reporting of GHG emissions by sources to a state entity in order to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities. Reporting can help sources reduce their risks associated with possible future GHG reduction requirements by helping them move "up the learning curve" concerning their GHG emissions, Tracking and reporting GHG emissions will also help in the preparation of periodic state GHG inventories. GHG reporting is a precursor for sources to participate in GHG reduction programs, gain opportunities for recognition, participate in a GHG emission reduction registry, and secure "baseline protection." Further, collaboration with other states in the development of a GHG reporting program could enable Vermont to influence the development of GHG reporting practices throughout the region and nation and build consistency and reciprocity with other state or regional GHG reporting programs.

### Policy Design

The CC TWG recommends that Vermont institute a GHG emissions reporting program. Additional information regarding key program characteristics can be found in the *GHG Reporting Design Options Matrix*.

- Subject to consistently rigorous quantification, GHG reporting should not be constrained to particular sectors, sources, or approaches, in order to encourage GHG mitigation activities from all quarters.
- GHG reporting should be phased in by sectors as standardized quantification protocols, base data, and tools become available, and as responsible parties become clear. All entities (including the state, municipalities, and other jurisdictions) should be allowed to report GHG emissions associated with their own activities and any programs they may implement to reduce GHG emissions.
- Reporting should be applicable to all sources (e.g., combustion, processes, and vehicles) but common sense should apply regarding de minimis emissions.
- The goal should be reporting of GHG emissions on an organization-wide basis within Vermont, but with greatest possible detail by facility in order to facilitate baseline protection.
- Reporting should occur annually on a calendar-year basis for all six traditional GHGs and, to the extent possible, for black carbon.
- Reporting of direct emissions[1] should be required, reporting of emissions associated with purchased power and heat[2] should be phased in, and voluntary reporting of other indirect emissions[3] should be allowed.

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[1] Defined as "Scope 1" emissions in the *GHG Protocol*.

[2] Defined as "Scope 2" emissions in the *GHG Protocol*.

[3] Defined as "Scope 3" emissions in the *GHG Protocol*.

- Every effort should be made to maximize consistency with federal, regional, and other states' GHG reporting programs.
- GHG emissions reports should be verified through self-certification and Vermont DEC spot-checks; to qualify for future registry purposes, reports should undergo third-party verification.
- Reporting of emissions from GHG reduction projects should qualify for reporting, when they are identified as such and adhere to equally rigorous quantification standards.
- The reporting program should provide for appropriate public transparency of reported emissions.

**Goals:** Implementation of a Vermont GHG Reporting Program as early as possible.

**Timing:** As soon as possible, preferably by 2008.

**Parties Involved:** Universal.

## Implementation Mechanisms

Reporting protocols, opportunities and, in the case of mandatory reporting, underlying regulatory requirements.

## Related Policies/Programs in Place

Many sources in Vermont report criteria pollutant emissions in order to comply with various federal and state regulatory programs. Most electric generating units are also required to report $CO_2$ emissions to the Energy Information Administration (EIA). Some sources may report GHG emissions on a voluntary basis to federal, state, or privately run programs. Otherwise, there is no broad, statewide GHG reporting program in Vermont.

## Type(s) of GHG Reductions

GHG reporting is an enabling policy to encourage management, and ultimately reduction, of GHG emissions. It does not reduce GHG emissions itself per se.

## Estimated GHG Savings and Costs per $MtCO_2e$

The reporting of GHGs under this policy option would help position Vermont entities for participation in an emissions trading program if one develops in the future, leading to cost savings. Although establishment of a credible reporting program is essential for participating in a trading program, these elements themselves do not reduce GHG emissions.

## Key Uncertainties

Uncertainties exist with respect to quantification of some GHG emissions from some sources, but standard quantification protocols are rapidly being developed and accepted widely. There remain significant uncertainties with respect to how various state, regional, or federal GHG reporting programs may develop.

## Additional Benefits and Costs

Not applicable.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## CC-3. State GHG Registry

### Policy Description

A GHG registry enables uniform measurement and recording of GHG emissions reductions in a central repository. Typically, a registry also includes transaction ledger capability in order to support tracking, management, and ownership of emission reductions. Registries can help encourage sources to undertake GHG reduction efforts, enable recognition for such actions, provide baseline protection, and support the crediting of early GHG mitigation actions. A registry can also provide a mechanism for regional, multistate, and cross-border cooperation. Subject to appropriately rigorous quantification standards, participation in a GHG registry should be open to all sectors, sources, or approaches in order to encourage GHG mitigation activities of all types from all quarters. In particular, a GHG registry should be able to incorporate activities associated with all of the options that the Governors' Commission on Climate Change–Plenary Group (GCCC-PG) recommends, whether reflective of reductions in emissions of GHGs or increases in biological or geological sequestration of carbon.

### Policy Design

The CC TWG recommends that Vermont actively engage with other states in developing a regional or national GHG registry that will comprehensively meet the state's needs. If developing regional or national multistate registries do not initially include all of the state's preferred criteria, Vermont should still join, participate to the greatest extent possible, and work to develop whatever additional registry capacity is necessary to meet the remaining needs of Vermont sources (e.g., registration of carbon sequestered due to reforestation). Together, these approaches should cover all policy options that the GCCC-PG recommends, provide adequate quality verification, and allow project-level reporting. Costs should be borne primarily by participants. Recommendations for key registry design characteristics build off the State GHG Reporting Policy Option (CC-2). Key elements important to Vermont include the characteristics below. Additional information regarding important program characteristics is included in the *GHG Registry Design Options Matrix*.

- Geographic applicability at least at the statewide level and as broadly (i.e., regionally or nationally) as possible.
- Inclusion of as broad an array of sectors, sources, facilities, and approaches as possible.
- Allowing sources to start as far back chronologically as good data exist, as affirmed by third-party verification, and allowing registration of project-based reductions or "offsets" that are equally rigorously quantified.
- Incorporating adequate safeguards to ensure that reductions are not double-counted by multiple registry participants and providing appropriate transparency.
- Striving for maximum consistency with other state, regional, and/or national efforts; allowing for the greatest flexibility as GHG mitigation approaches evolve; and, providing guidance to assist participants.

- Allowing the state and its political subdivisions to be valid participants for registering reductions associated with their programs, direct activities, or efforts, including the registration of emission reductions associated with the stationary and mobile sources they own, lease, or operate. Similarly, the state and its political subdivisions should be allowed to participate in emission trading if and when such a program is developed and authorized. Revenues associated with the sale of any emission reduction credits generated by the state or its political subdivisions could be used to support the GHG emission inventory, forecasting, reporting, and registry functions within state government.

**Goals:** Participation in a regional or national multistate registry as described above.

**Timing:** As soon as possible after a GHG reporting program is operating.

**Parties Involved:** Coverage should include all entities that can verify ownership of GHG emission reductions.

## Implementation Mechanisms

Implementation of this program should probably be led by Vermont DEC. Costs should be shared by participants benefiting from the registry.

## Related Policies/Programs in Place

Vermont is participating in regional and national multistate efforts to develop a GHG registry.

## Type(s) of GHG Reductions

A GHG registry is an enabling function for recording GHG reductions; it does not generate emission reductions in and of itself.

## Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

## Key Uncertainties

There remain significant uncertainties with respect to how various state, regional, and/or federal GHG registry programs may develop. Involvement in early registry implementation—as issues are deliberated among states—will advantage Vermont in their ultimate outcome.

## Additional Benefits and Costs

None cited.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## CC-4. State Climate Public Education and Engagement

### Policy Description

Public education and engagement proposed by the GCCC-PG will be the foundation for long-term success of all the mitigation actions advanced in the State of Vermont. It is vital to foster a broad awareness of climate change problems and effects (including co-benefits, such as clean air and public health) and to encourage action among the State's citizens.

Public education, marketing, and engagement efforts should integrate with and build upon existing efforts involving climate change and related issues in the state. In the past 10 years, many diverse, forward-looking groups have advanced activities and initiatives in Vermont led by professionals and citizens who are aware that climate change is a critical problem. Statewide coordination and resources, including an interactive Web site, are needed to support, expand, and institutionalize these broad educational activities that are already underway in support of GHG emissions reductions.

In all these activities, every effort should be made to engage the public through transferable marketing-oriented frameworks that can provide measurable year-to-year results.

### Policy Design

The CC TWG recommends the four policies below to develop and implement a unified, proactive approach to public education and engagement to build capacities for behavior change in the diverse audiences in the state, including municipalities and community-based organizations; nongovernmental organizations; general public, younger generations; and the commercial, industrial, and economic sectors.

1. Develop and maintain a strong Web-based presence to provide critical support to the many broad educational activities already underway. A State-level interactive Web site could 1) improve community leader, policy maker, and community-based organizational access to useful resources and services; 2) provide tools and resources that support a growing network of groups and project activities; 3) advance a statewide marketing brand to encourage behavior change and advancement of shared goals; and 4) coordinate statewide activities on climate change and all related energy activities.

   This interactive Web site could host the following:

   - A calendar of community-level events and educational programs open to the public and specific sectors.
   - An educational climate change library with links.
   - A catalog of documents relevant to Vermont's plans and legislation for discussion.
   - Several managed forums for discussion: one for input to Vermont's plans and legislation and a second for the general exchange of ideas, technical solutions, success stories, and needs in Vermont.

- An interactive directory of energy and climate change groups/entities to communicate contemporary planning and project activities at the municipal and regional levels.
- Emissions calculator tools (e.g., 10% Challenge at www.10percentchallenge.org) for individual households and businesses to estimate their emissions.
- A listing of rebates and tax credits related to energy efficiency improvements.
- A marketing and promotional kit for use by interested entities and community-based groups to help raise public awareness and motivate behavior change and educational outreach activities.
- Recognition program including awards for GHG emissions reductions.

2. Establish a state funding mechanism to help subsidize coordinated education, engagement, marketing, and technical assistance programs including, but not limited to the following:
   - Vermont Energy Education Program—currently funded in part by the Department of Public Service, which provides in-depth, science-based, in-school programs on energy efficiency and climate change at all levels (www.veep.org).
   - 10% Challenge—a voluntary civic outreach program to encourage households, businesses, and institutions to reduce GHG emissions by at least 10% (www.10percentchallenge.org).
   - Vermont Energy and Climate Action Network—encourages and supports energy committee project efforts in every community.
   - Vermont High Performance Schools Initiative—(www.vthps.org).
   - Vermont Land Use Education & Training Collaborative—(www.vpic.info).
3. Identify and establish climate change "best practices" for public and private use in all sectors of the economy, with particular emphasis on integrating best practices into public school design, construction, and operations to help educate students, staff, and parents about sustainable building environments.[4]
4. Encourage, foster, and promote the research and academic excellence necessary to advance statewide solutions to climate change. Suggested examples include 1) developing university "Centers of Excellence" to advance technical solutions to climate problems, and 2) encouraging faculty, staff, and student energy teams and student-led projects and initiatives as modeled by the Vermont Campus Energy Group (www.vceg.net).

**Goal:** Build an informed and involved public to help reverse the growth in GHG emissions via a coordinated collaborative of education and outreach partners. Specific objectives include

- Raising awareness among policy makers, regulators, staff, and community leaders to encourage everyone to implement climate actions in their personal and professional lives.

[4] Refer to the 2006 Legislative School Constructions Standards Committee and the Vermont High Performance Schools Initiative endorsement of the Northeast High Performance Schools Protocol (as amended) to establish and advance performance-based design and construction standards in Vermont schools.

- To develop the education, engagement, and marketing frameworks, infrastructure, and tools to encourage action, leadership, role models, and shared success stories.
- To support local public education and engagement efforts to advance sustainable community-based projects.
- To integrate climate change into educational curricula, post-secondary degree programs, and professional licensing programs.

**Timing:** Public education and outreach efforts should commence now.

**Parties Involved:** In collaboration with the Vermont Agency for Natural Resources (ANR), a State Climate Change Advisory Group that includes business, government, nongovernmental organizations and citizen advocacy representatives should be formed to help guide a coordinated effort moving forward.

## Implementation Mechanisms

Implementation mechanisms for this policy include the early establishment of an Advisory Group to be responsible for guidance and oversight of the public education and engagement programs on climate change. Creating this advisory group would leverage the brain trust within the state on climate change and ensure credibility of information as well as participation. It would also serve to leverage available resources to implement engagement programs to work collectively towards reduction goals.

Members of this independent advisory group should have broad representation and include stakeholders from but not limited to business, including industry and trade groups; government, including local, regional and state agencies; and nonprofit organizations, including citizen advocacy groups on health, the environment, land use, and transportation.

The group, with the suggested title “State Climate Change Advisory Group,” will

- Develop priorities and a social marketing plan to encourage behavior change to meet reduction goals.
- Provide guidance and oversight to state officials and legislators to help inform, plan, and implement a Web-based framework to facilitate communications.
- Research and synthesize the other suggested statewide policies to ensure that a unified and multilayered marketing brand is coordinated, implemented, and maintained.
- Define and carry out social marketing strategies with broad ethical goals to ensure the content of the education and engagement programs provides impartial technical information as well as achievable mitigating measures to reach targeted reduction goals.

A Public Education and Engagement Framework should be based on an ethical model of social marketing to develop a consistent brand identity framed with market data to adapt messaging to different user groups within Vermont. Once created, this would establish a recognizable identity around climate change and connect individuals to the broader goals of the state’s reduction strategies.

A benchmarking system is necessary to measure and track barriers and opportunities for behavior change. This can be done through surveys that measure successes of GHG reduction strategies in the public sector.

A consistent messaging strategy will be critical to the public's ability to make lifestyle changes that reduce emissions. For example, transportation is the biggest barrier to the state's reduction goals and affects all Vermont citizens across many levels and sectors including the agriculture sector of the economy.

Public education, marketing, and engagement program development recommended under this policy option must be directly connected to and support greenhouse gas reduction goals established in other policy areas recommended by the TWGs, including all of the Transportation and Land Use policy options; Energy Supply and Demand policy options ESD-8, ESD-9, and ESD-10; and Agriculture, Forestry and Waste Management policy options AFW-1, AFW-4, AFW-8, AFW-9, and AFW-10.

## Related Policies/Programs in Place

Within Vermont numerous related programs are underway:

- Vermont Energy Education Program (www.veep.org)
- Vermont Campus Energy Group (www.vceg.net)
- Vermont Energy and Climate Action Network (see http://www.vnrc.org/article/view/9452/1/625)
- 10% Challenge (www.10percentchallenge.org)
- Vermont High Performance Schools Initiative (www.vthps.org)
- Association of Vermont Recyclers (www.vtrecyclers.org)
- Climate Action toolkit (http://www.cleanair-coolplanet.org/for_communities/toolkit_home.php
- Vermont Green Building Network (www.vgbn.org)
- Vermont Earth Institute (www.vtearthinstitute.org)
- Vermont Energy Investment corporation and Efficiency Vermont (www.veic.org) and (www.efficiencyvermont.org)
- Vermont Interfaith Power & Light (www.vtipl.org)

## Type(s) of GHG Reductions

Not applicable.

## Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

## Key Uncertainties

None cited.

## Additional Benefits and Costs

None cited.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## CC-5. Adaptation

### Policy Description

Because of the existing buildup of GHGs in the atmosphere that has already occurred, Vermont will experience effects of climate change for years to come, even if immediate action is taken to reduce its future GHG emissions. Some climate impacts could substantially affect Vermont's economy and quality of life. Thus, it is essential that the state develop a plan to manage the projected impacts of global warming while broader mitigation efforts to lower atmospheric concentrations worldwide are being developed and implemented.

### Policy Design

The CC TWG recommends that while taking action to reduce GHG emissions in Vermont, the state should develop, adopt, and implement a state Climate Change Adaptation Plan that includes identification of a) potential short-term, mid-term, and long-term impacts of climate change scenarios likely to affect the state, and b) implementation mechanisms for addressing these impacts. The state should create a Commission on Adaptation to Climate Change to develop a state Climate Change Adaptation Plan within one year of establishment of the Commission. The Commission should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified in the plan. The Commission should also enlist the expertise of all appropriate state and local agencies, organizations, and institutions in developing and implementing measures for mitigating these impacts. The state should provide funding to support development and ongoing revision to the state Climate Change Adaptation Plan, including funds to support the cost-benefit analysis needed to guide and inform the development and implementation of the Plan and to cover expenses incurred by the Commission and Commission members.

The Plan should be reviewed and updated on a periodic basis (every 5–10 years) to expand or refine the Plan as necessary, to improve implementation of the Plan, and to incorporate new information as it becomes available.

The state Climate Change Adaptation Plan should include at least the following key elements:

- Comprehensive identification of potential short-term, mid-term, and long-term impacts associated with climate change in Vermont.
- Recommended steps to minimize risk to humans, natural and economic systems, water resources, temperature-sensitive populations and systems, energy systems, transportation systems, communications systems, vital infrastructure and public facilities, and natural lands (such as wetlands, forests, and farmland), and all other identified and affected sectors or areas of concern throughout the state.
- Coordination of response efforts through the appropriate state, local, and federal agencies, organizations, or other entities or initiatives.

- Characterization of the potential risks and costs of inaction; characterization of the potential costs, benefits, and co-benefits associated with specific policy and program actions; and establishment of time- and program-based goals.
- Use of cost-benefit analysis to guide and inform the development and implementation of the state Climate Change Adaptation Plan. The analysis should include an examination of the benefits and costs of adaptation measures or responses relative to a status quo or no-action approach and the resources needed to implement adaptation measures in the plan. The results of the cost-benefit analysis should also be used to set priorities for addressing short-term, mid-term, and long-term impacts of climate change on citizens, ecosystems, and the economy of Vermont.
- Creation of a scientific strategy, engaging the environmentally aware public, educational institutions, and state agencies for the monitoring of climate and ecological trajectories in Vermont to inform updates to the Adaptation Plan.
- Adaptation measures that also mitigate GHG emissions should be given priority in the state Climate Change Adaptation Plan.

**Goals:** Create a state-sanctioned Commission on Adaptation to Climate Change to develop a comprehensive state Climate Change Adaptation Plan that identifies opportunities to address adaptation issues and risks and recommends tangible, implementable measures to mitigate these issues and risks to Vermont citizens. Conduct cost-benefit analyses comparing the potential costs of a status quo approach as opposed to implementing the recommendations proposed in the Climate Change Adaptation Plan. Prioritize recommendations in the adaptation plan, based on the certainty and severity of adverse impacts to citizens, ecosystems, and local economies. Development of the plan should a) involve all affected agencies and entities at all levels of government; b) engage all affected sectors and interests; and c) provide for periodic review and update concerning adaptation risks, responses, and opportunities in the state.

**Timing:** The Commission should be established as soon as possible. The development of a state Climate Change Adaptation Plan should be completed within one year of establishing the Commission. Benefit-cost analyses noted above should be conducted as a component of the plan. Parallel public education and outreach efforts regarding adaptation should commence immediately. “Low-hanging fruit” opportunities should be addressed as rapidly as feasible (even before the Commission is established, if possible), and proactive adaptation initiatives should commence within the next 2–3 years.

**Parties Involved:** The Commission on Adaptation to Climate Change should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified and to ensure the successful development and implementation of the plan.

## Implementation Mechanisms

- State Climate Change Adaptation Strategy. Subgroups should be formed under the Commission on Adaptation to Climate Change to address specific issues and sectors, such as societal infrastructure, agricultural and forest resources, and recreational and ecological sectors.

- Public education and engagement. The involvement of the public, citizens groups, schools, and colleges in the monitoring of climate and ecological trajectories in Vermont is needed to inform and update the State Adaptation Plan.
- Development of policy recommendations as necessary.
- Establishment of financial structures and creation of markets that are likely to thrive under anticipated climate impacts.

## Related Policies/Programs in Place

State and local emergency management response plans are in place that address short-term responses to natural disasters (e.g., violent storms). To the extent possible, measures recommended in the Climate Change Adaptation Plan should assist with and complement these existing state and local efforts. The Vermont Institute of Natural Science (www.vinsweb.org) engages the public in the active monitoring of the environment, particularly with regard to birds and butterflies.

## Type(s) of GHG Reductions

Not applicable.

## Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

## Key Uncertainties

Some impacts of climate change, such as species migration and precipitation impacts are certain, but their specific timing and magnitude remains unclear. Other impacts are less certain and may have significant variability.

## Additional Benefits and Costs

- Innovative early adaptation responses to climate change impacts can be designed to
  - Help prevent and/or reduce costs associated with future catastrophic events and long-term climate change impacts,
  - Direct future public and private investment more effectively, and
  - Ensure preparedness to help avoid extensive cost implications to state, county, city and federal agencies.
- Early preparedness can raise public awareness and encourage further GHG mitigation efforts, which can drive economic opportunities for alternative fuels, agriculture, forestry, and advanced technologies.

## Feasibility Issues

None cited.

## Status of Group Approval

Approved.

## Level of Group Support

Unanimous consent.

## Barriers to Consensus

None.

## CC-6. Options for State GHG Goals or Targets

### Policy Description

The GHG reduction goals established by Executive Order # 07-05 and the Vermont Legislature were to reduce GHG emissions from Vermont with this timetable: 25% below 1990 levels by 2012, 50% below 1990 levels by 2028, and 75% below 1990 levels by 2050. The policy options being considered by the GCCC-PG principally address the 2012 short-term goal and the 2028 medium-term goal because of the difficulty of quantifying policy options as far out as 2050.

Based on quantification of the policy options being considered by the PG, the short-term goal, a 25% reduction by 2012, appears to no longer be attainable on a statewide basis because of the short time frame between now and 2012.[5] Although it may no longer be feasible to achieve a statewide 25% reduction by 2012, the policy options considered by the PG appear to be able to achieve the 50% reduction goal by 2028. The Policy Options detailed by the four TWGs (Agriculture, Forestry, and Waste Management, AFW; Energy Supply and Demand, ESD; Transportation and Land Use, TLU; and Cross-Cutting Issues, CC) include policies that would reduce GHG emissions at low net cost, with substantial net savings in many cases because of the high cost of fossil fuels. Implementation would bring significant economic benefits to the Vermont economy, by reducing fuel costs through efficiency measures, by reducing the export of capital from the state, and by stimulating the Vermont economy through the creation of jobs in energy efficiency and renewable energy development.

### Policy Design

The PG recommends that Vermont comport with the Governor’s and Legislature’s 2012 and 2028 goals for all practical purposes by constraining cumulative GHG emissions to the area under the curve represented by these goals. This can be accomplished through reductions greater than the specified 2028 targets to compensate for any shortfall in 2012. Because the atmospheric lifetime of GHGs is long (decades to centuries), the cumulative burden of GHG emissions determines the degree of climate impact during this century, so this approach makes sense. Additionally, the PG recommends no further delays in implementing GHG emissions reductions in order to avoid the need for steeper reductions in the future.

Vermont has historically been a leader in reducing GHG and other pollutants nationwide. Vermont’s per capita GHG emissions currently stand at nearly half the national average and are on track to drop further as the Regional Greenhouse Gas Initiative (RGGI), the Clean Car program, and other initiatives take effect. To help maintain this achievement and make similar progress in the future, the PG recommends that a senior advisory body (e.g., the State Climate Change Advisory Group suggested in policy option CC-4) be formed to help guide and coordinate implementation strategies for GHG reduction policies, including regulatory and non-regulatory initiatives.

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[5] State government, through its Climate Neutral Working Group, is implementing a plan for achieving the 2012 goal. State government, however, represents only a few percent of Vermont’s total emissions.

A summary of the current major sources of GHG emissions in Vermont and the significant options for emission reductions policy options considered by the PG—as assessed by the CC TWG in considering this policy option—is attached as a separate annex to this Appendix.

**Goals:** As noted above.

**Timing:** As soon as possible.

**Parties Involved:** State government, municipalities, citizens' groups, nongovernmental organizations (NGOs), and the commercial, industrial, and economic sectors.

## Implementation Mechanisms

The policy option descriptions from the individual TWGs suggest specific implementation mechanisms.

Many are regulatory, requiring executive action or further legislation. However, the very scale associated with comprehensively addressing climate change suggests that there are essential nonregulatory aspects to implementation as well, such as education and engagement of the general public, municipalities, and the commercial, industrial, economic, and educational sectors in the state at many levels (as discussed further in CC-4).

In all sectors, improvements in energy efficiency directly reduce fuel costs, giving rapid payback on investment to the user. However, funding the up-front costs of efficiency measures is likely to require a diverse range of innovative funding mechanisms and incentives to ensure sufficiently rapid penetration of the market to achieve the 2028 goals of a 50% reduction in GHG emissions from the state.

## Related Policies/Programs in Place

GHG emission reduction goals have been established by Governor Douglas and the Vermont General Assembly.

## Type(s) of GHG Reductions

All.

## Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

## Key Uncertainties

None cited.

## Additional Benefits and Costs

None cited.

## Feasibility Issues

None cited.

## Status of Group Approval

Pending.

## Level of Group Support

To be determined.

## Barriers to Consensus

To be determined.

# CC-7. The State's Own GHG Emissions

## Policy Description

State government is responsible for providing a multitude of services for the public that are delivered through very diverse operations and result in wide-ranging GHG emission activities. State government can take the lead in demonstrating that reductions in GHG emissions can be achieved through analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and services provided. The state also encourages and/or creates incentives for reductions by others in a variety of ways.

The support of broad-ranging goals for GHG reductions for state government through the Climate Neutral Working Group (CNWG) will be helpful for setting an example and building expectations, with actual reductions realized at the agency level. Disaggregating the State's own GHG emissions to the agency level and showing the result in the biennial report from the CNWG on GHG reduction progress is an effective way to measure and manage the State's emissions. A multiagency group oversees the ongoing climate efforts of state agencies, providing direction, guidance, resources, shared approaches, and recognition to agencies and employees working to reduce the State's GHG emissions.

## Policy Design

The State has established GHG reduction targets for its own GHG emissions. The State's GHG reduction goals are disaggregated to individual State agencies based on each agency's contribution to the initial GHG emissions inventory of the State's emissions. Executive Order #14-03 establishes a baseline against which agency emission reduction activities will be measured and summarized in the biennial reports.

**Goals:** Reduce GHG emissions from Vermont state operations from a 1990 baseline by 25% by 2012, 50% by 2028 and, if practical using reasonable efforts, 75% by 2050.

**Timing:** Future annual reports should show further progress toward the State's emission reduction goals in reducing agency GHG reductions.

**Parties Involved:** Coverage should include all operations of all state agencies via the members of the Climate Neutral Working Group.

## Implementation Mechanisms

- Implementation may be possible or at least assisted by current, parallel efforts to implement the 2005 Vermont Energy Plan.
- The State should lead by example by adopting best practices across the board to serve as a model for other emitters.
- The State should frame—and target—the emission reductions called for as continuous annual improvement efforts (e.g., reducing emissions ~3% per year over the long term).

- State procurement processes should contribute substantially in assisting agency emission reduction efforts.
- Education, outreach, and marketing efforts should apply to and engage the State as well as nongovernmental sources. High performing agencies should receive public recognition as well. Ways to promote greater interaction and cross-pollination within and among state agencies should be developed.
- Agency progress in meeting the State's reduction targets should be one of the yardsticks by which agency performance is measured.

## Related Policies/Programs in Place

- State of Vermont CNWG.
- The Vermont State Agency Energy Plan (see: http://www.bgs.state.vt.us/pdf/VTStateEnergyPlan.pdf)
- Act 250 requirements (e.g., Criteria 9F). Legislature asked the Natural Resources Board to ensure that GHG issues are considered.

## Type(s) of GHG Reductions

Not applicable.

## Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

## Key Uncertainties

Future growth rate in emissions, particularly after 2020, as well as the timing and scope of implementation of the GCCC-PG recommendations for specific policy options.

## Additional Benefits and Costs

None cited.

## Feasibility Issues

None cited.

## Status of Group Approval

Pending.

## Level of Group Support

To be determined.

## Barriers to Consensus

To be determined.