Vermont Governor's Commission on Climate Change

www.vtclimatechange.us

Agriculture, Forestry, and Waste Management Technical Work Group

Summary List of Policy Options

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2028 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2012	2028	Total 2007-2028			
	AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT						
AFW-1	Programs to Support Local Farming/Buy Local						TBD
AFW-2	Agricultural Soil Carbon Management Programs						TBD
AFW-3	Manure Management Methods to Achieve GHG Benefits						TBD
AFW-4	Protect Open Space/Agricultural land						TBD
AFW-5	Forestry Programs to Enhance GHG Benefits						TBD
AFW-6	Increased Forest Biomass Energy Use						TBD
AFW-7	Forest Protection – Reduced Clearing and Conversion to Non-Forest Cover						TBD
AFW-8	Expanded Use of Durable Wood Products (especially from VT sources)						TBD
AFW-9	Advanced/Expanded Recycling and Composting	0.16	0.88			3	TBD
AFW-10	Programs to Reduce Waste Generation						TBD

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2028 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2012	2028	Total 2007-2028			
AFW -11	**Waste Water Treatment – Energy Efficiency Improvements**						TBD
AFW -12	**In-State Liquid Biofuels Production – Ethanol Production** **In-State Liquid Biofuels Production – Biodiesel Production**	0.03 0.004	0.42 0.24	3.7 2.2	5.0 40	1 18	TBD
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS						
	REDUCTIONS FROM RECENT ACTIONS (table to be added below)						
	SECTOR TOTAL PLUS RECENT ACTIONS						

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.

Food products consumed in the U.S. 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**. *Achieve the 30% goal by 2028.*

Parties Involved: Center for Sustainable Agriculture at UVM, Agency of Agriculture, 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 in accordance with sustainable agricultural practices 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 continued research and data collection to establish a baseline on local farm sales for farmers markets and farm stands.

Related Policies/Programs in Place

Vermont Sustainable Agriculture Council (www.uvm.edu/sustainableagriculture);

VSJF, VFN, NOFA-VT, Intervale, CSA, UVM, Shelburne Farms, North Country Framers, RAFFL, Vital Communities—Sustainable Ag Network (SAN);

UVM efforts to define local products and work with Sadexo 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).

Types(s) of GHG Reductions

To be determined. (TBD)

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–2. Agricultural Soil Carbon 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 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 Agricultural Agencies, Vermont non-profit farming organizations, Agricultural Coops, eco-agriculture consulting companies, Vermont farmers, USDA, NRCS, Vermont natural resource agencies, environmental organizations, University of Vermont and other Vermont Colleges.
- **Other:** Nutrient Management Plans would cover a wide variety of practices that will increase soil carbon levels and reduce nitrogen run-off. 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 re-introduction.

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 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.
- 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.

Related Policies/Programs in Place

- USDA's Natural Resource Conservation Service (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
- University of Vermont Extension Program

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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.

Timing: Increase the anaerobic digestion from five (5) percent (in operation and under construction) to 15 percent of the dairy cattle manure in Vermont over the next five years (2012). By 2028, digest 50 percent of the dairy cattle manure in Vermont; Increase the percent 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.
- 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

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per MtCO_2e

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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: Pending.

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) Fully 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 (Current Use). To expand landowner incentives for enrollment in UVA, allow properties to be enrolled for farm and forest management, carbon sequestration and the protection of open space.

(3) Strengthen regional and local land use planning to better protect the viability of farm and forestland from conversion and development.

(4) 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.

(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.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per MtCO$_2$e

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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 being done 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. Increasing production of high quality, high density wood with subsequent use of these products in durable wood products (building materials, furniture, etc.) is important for ensuring net carbon benefits associated with forest management. Use of biomass waste from forestry programs for energy purposes is covered under AFW-6.

Policy Option Design

Goals: Increase production (i.e., forest carbon sequestration and harvest volume of high quality, high density wood) of Vermont's forests by 40%

Timing: Increase production by 20% by 2028 and 40% by 2048.

Parties Involved: Pending.

Other: Increases in production can increase carbon sequestration within Vermont's forest ecosystems as a result of improved forest health and enhanced forest growth. In addition, carbon sequestration can increase in durable wood products harvested from the forests—the increased harvest volume is intended to provide more high quality wood (high density, large diameter wood) for the wood products industry. The impacts of increased production on harvested wood products, in terms of GHG benefits and cost/cost savings, will be covered in AFW-8.

Implementation Mechanisms

VT Current Use Program (to be elaborated)

Develop markets for durable wood products made form high-quality wood (e.g., Wood Products Development Program) (to be elaborated)

New state forest management program (to be elaborated)

Voluntary programs (to be elaborated)

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

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.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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.[1]

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: Pending.

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.

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

[1] 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).

should be shifted over to use for energy production. Currently 12-15% of harvested biomass is going to paper production.

- Productivity increases in AFW-5 may also increase feedstock supply
- Other implementation mechanisms might address the retention and use of wood pallets in Vermont.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

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.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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: Pending.

Other: Chittenden County alone experienced a 4.4% loss in forestland over the past 15 years. NRI data show a statewide 0.13%/yr annual rate of forest loss from 1982-1997 for VT. Landsat (satellite imagery) data show a statewide 0.52%/yr annual rate of forest loss from 1992-2002 (J. Jenkins and E. Elizabeth, UVM).

Implementation Mechanisms

- Increased enrollment in the Use Value Appraisal Program (see Related Policies/Programs in Place).
- Incentives to reduce landowners dividing forests into small parcels.
- Incentives to maintain forest cover in developed uses.
- Encourage forest stewardship and best practices.

Related Policies/Programs in Place

- Housing and Conservation Board
- Use Value Appraisal Program
- Forest Legacy Program, Land Trust activity
- Regional Planning Commissions
- Growth Centers Legislation
- Act 200, Act 250
- Forest Stewardship Program
- Urban & Community Forestry Program

- Agency of Natural Resources
- Wood Utilization programs
- Biomass Energy Resource Center.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per MtCO$_2$e

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AFW–8. Expanded Use of Durable Wood Products (Especially from VT Sources)

Policy Option Description

This option covers programs designed to increase the use of durable wood products in VT with an emphasis on wood products produced in VT. 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, GHG emissions can be reduced.

Policy Option Design

Goals: 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*. In addition, increase the supply of locally produced durable wood products as a result of increasing forest productivity under AFW 5.

Timing: *By 2012, increase wood products use by 2%; achieve 10% increase by 2028.*

Parties Involved: Pending.

Other: Not applicable.

Implementation Mechanisms

Leveraging/expanding the Cornerstone Project and Vermont Sustainable Job Funds (see Related Policies/Programs in Place).

Related Policies/Programs in Place

The Cornerstone Project and Sustainable Jobs Fund: increase the use and production of wood products (e.g., furniture).

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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). Reducing the quantify 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%).[2]
- **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, to encourage all Vermont residents and businesses to divert recyclable materials from the waste stream (VT's diversion rate is essentially unchanged in the last several years (2002: 30%, 2003: 31%, 2004: 29%, 2005: 30%[3]) This

---

[2] Vermont, Agency of Natural Resources, 2005 Solid Waste Generation Report, Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm.

[3] Vermont, Agency of Natural Resources, 2005 Solid Waste Generation Report, Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm.

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 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.[4]
- 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).[5]

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

Types(s) of GHG Reductions

Net reduction in CO_2 and methane emissions.

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: 0.16, 0.88

Cost Effectiveness: $3

- **Data Sources:** Municipal solid waste (MSW) diversion data for 2005 was obtained from the VT Agency of Natural Resources (ANR).[6] These data are shown below:

[4] U.S. EPA “Waste Wise” retrieved from www.epa.gov/epaoswer/non-hw/reduce/wstewise/pubs/overview.pdf.

[5] Vermont, Agency of Natural Resources, 2005 Solid Waste Generation Report, Summary, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm.

[6] 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.

MATERIAL	SOURCE OF MATERIAL: 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)	TOTAL
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.[7] The wastes in the table above were aggregated into the applicable WARM material categories: mixed paper waste (fibers in the table above), mixed metals (scrap metals in the table above), and mixed recyclables (containers and miscellaneous in the table above). 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 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%/yr population growth as used in the GHG inventory and forecast. The table below shows the resulting waste recycling amounts and rates in each year.

Table 1. Waste Diversion Rates

	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

[7] The WARM model and associated documentation can be downloaded from: www.yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html.

For the incremental tons recycled, WARM provided the following results:

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).[8] Since, landfill gas generated at operating landfills in VT 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):

Baseline CH_4 = (32,726 ton organics) x (0.21) x (0.50) x (0.907 Mt/ton) x (16/12) x 21 x (1-0.75) x (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 1 above, the benefit of organic material recycling in 2012 is 5,528 $MtCO_2e$ and 30,417 $MtCO_2e$ in 2028.

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.[9] 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[10] (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: 1,220 $MtCO_2e$ and 6,713 $MtCO_2e$, respectively. Hence, the net GHG benefits for the incremental organics composting are:

---

[8] 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.

[9] 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.

[10] 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).

Estimate	2012 $MtCO_2e$	2028 $MtCO_2e$
Landfill methane avoided	5,528	30,417
Composting methane	99	540
Composting nitrous oxide	1,220	6,713
Net GHG Benefit	**4,209**	**23,164**

Therefore, the overall emission reductions for the policy option are 160,102 MtCO2e in 2012 and 880,902 $MtCO_2e$ 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.[11] 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 cost for all households is $5.4 million.

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 VT range from $75 to $90 per ton. 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/yr. Using the mid-point of the range in tipping fees, the avoided landfill cost is $3.1 million/yr. The net cost for the non-organics recycling is $2.4 million/yr. Using the GHG reduction estimates derived above, the cost effectiveness in 2028 is $2.4 million/880,902 Mt = $2.72/$MtCO_2e$.

Organics Composting

To be added.

- **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.

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

Post consumer organic waste diversion.

[11] 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.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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.[12]

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.

---

[12] Vermont, Agency Natural Resources, 2005 Solid Waste Generation Report, Table 2, retrieved from www.anr.state.vt.us/dec/wastediv/solid/DandD.htm.

- Encourage manufacturers to provide end-of-life management solutions that reduce the environmental impact of waste
- 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

Types(s) of GHG Reductions

Net reduction of CO_2 emissions.

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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

Policy Option Description

Energy efficiency programs at water and wastewater treatment plants 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.[13]

Goals of the assessment are to:

1. 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.
2. Assess the potential for energy savings for the sector.
3. 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;

[13] 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

Net reduction in CO_2 emissions.

Types(s) of GHG Reductions

TBD

Estimated GHG Savings and Costs per $MtCO_2e$

TBD

- **Data Sources:** TBD
- **Quantification Methods:** TBD
- **Key Assumptions:** TBD

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

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 lifecycle 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, VT 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 CO2 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 the table below.

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 above.

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 VT).
- Active solicitation of new producers.
- Expanded consumer education to drive demand.
- Expanded producer education to develop skilled workforce.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

CO_2: Lifecycle 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),[14] biodiesel from soybeans contains 93% more useable energy than its petroleum equivalent and reduces lifecycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the lifecycle 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.

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_2e of ethanol compared to importation from the current U.S. primary ethanol producing regions. Current research indicates

[14] Hill et al, 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," Proceedings of the National Academy of Sciences, volume 103, pp. 11206-11210, July 25, 2006.

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 $MtCO_2e$

- **GHG reduction potential in 2012, 2028 ($MMtCO_2e$):** Biodiesel: 0.004, 0.24; Ethanol: 0, 0.4
- **Net Cost per $MtCO_2e$:** Biodiesel: $18; Ethanol: $1
- **Data Sources:**

  The CO_2e emission factor for fossil diesel used in the inventory and forecast is 10.04 Mt/1,000 gallons. The lifecycle 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 lifecycle GHG benefits for biodiesel production and use was used to estimate the CO_2e 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 VT). Lifecycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al to be 41%. 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.[15] Rail fuel consumption is about 400 ton-miles/gallon.[16] 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.

[15] U.S. National Atlas, at http://nationalatlas.gov/natlas/Natlasstart.asp.
[16] U.S. National Atlas, at http://nationalatlas.gov/articles/transportation/a_freightrr.html.

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 lifecycle 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 lifecycle 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 lifecycle 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, the table below 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/yr.

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	

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.

Biodiesel Costs

Costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[17] 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.[18] This program offers production incentives of $0.30/gallon to producers up to 15 million gallons of production/yr. 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/yr. 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. Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Lab study.[19] 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_2e/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_2e by offsetting gasoline consumption). This value was used along with the lifecycle emission factor for gasoline[20] and the production in each year to estimate GHG reductions.

Ethanol Costs

[17] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.
[18] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.
[19] 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.
[20] 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.

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).[21] 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.[22] 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 VT. 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).

  Starch-based ethanol production using renewable fuels achieves equivalent GHG lifecycle 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/yr) required by this policy option; Federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate.

Key Uncertainties

TBD

Additional Benefits and Costs

TBD

Feasibility Issues

---

[21] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.
[22] 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.

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[23].

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 VT 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[24]).
- 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 VT 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.[25] 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

---

[23] Source: U.S. Dept of Energy, Energy Information Administration. Report: Adjusted Sales of Distillate Fuel by End Use/Vermont. URL: http://tonto.eia.doe.gov/dnav/pet/pet_cons_821dsta_dcu_SVT_a.htm.

[24] Source: U.S. Dept of Agriculture, 2002 Census of Agriculture – Vermont. Table 9. URL: http://www.nass.usda.gov/census/census02/volume1/vt/index1.htm.

[25] 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

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 percent of the land currently devoted to forage in Vermont (and 4.8 percent 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 one percent of the total). Statistics for 2003 show that less than one percent (1,096,382 tons) of Vermont's total amount of wood was harvested.

- With a yield of 66 gallons of ethanol per bone dry ton of forest residues, 151,515 tons of residue (less than one percent of the total amount of wood in Vermont's forests) would be required to produce 10 million gallons of cellulosic ethanol.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD