Agriculture, Forestry, and Waste Management Technical Work Group

Summary List of Draft Priorities for Analysis

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/t$CO_2e$)	Level of Support
		2015	2025	Total 2008 2020			
AFW-1	Agricultural Crop Management						TBD
AFW-2	Land Use Management Approaches for Protection and Enrichment of Soil Carbon						TBD
AFW-3	In-State Liquid Biofuels Production						TBD
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production						TBD
AFW-5	Forestry Management Programs to Enhance GHG Benefits						TBD
AFW-6	Forest Protection – Reduced Clearing and Conversion to Nonforest Cover	5.4	5.7	59.4	TBD	TBD	TBD
AFW-7	Integrated Waste Management						TBD
AFW-8	End of Use Waste Management Practices						TBD
	Sector Total After Adjusting for Overlaps						
	Reductions From Recent Actions (table to be added below)						
	Sector Total Plus Recent Actions						

Draft Policy Option

AFW-1 Agricultural Crop Management

Policy Description

This option addresses both agricultural soil carbon management as well as nutrient management to achieve greenhouse gas (GHG) benefits. For soil carbon management, conservation-oriented management of agricultural lands, cropping systems, crop management, and agricultural practices can regulate the net flux of carbon dioxide (CO_2) from soil. Each farm operation and each field management unit has unique traits that allow management practices to influence nutrient, water and carbon cycling and sequestration. Defining GHG outcomes based upon management indices will allow farmers to incorporate management practices within their specific operational needs to meet desired GHG goals. Providing cropping and management flexibility within each field or tract management unit allows both production goals and [carbon] resource management goals to be transparent and readily-valued.

The efficient use of agricultural fertilizer, both commercial and animal-based, can be improved through certain management practices and systems. An example is over application of nitrogen that can result in nitrogen not being fully metabolized by plants. This is important because free nitrogen can leach into groundwater and/or be emitted to the atmosphere as nitrous oxide (N_2O). Better nutrient utilization can lead to lower nitrous oxide emissions from run-off. An example is tile drainage systems that use the latest technology and design models to reduce nitrates leaching into surface water and groundwater.

Policy Design

Goals: *Soil Carbon Management:* No-till, strip till, other conservation farming practices, or other cropping management practices that achieve similar soil carbon benefits will account for 33% of all annual crop production in Minnesota.

Nutrient Management: Increase fertilizer application efficiency (measured by crop output per lb of nitrogen applied) by 50% by 2025.

Timing: *Soil Carbon Management:* By 2015, no-till, strip till or other conservation farming practices that reduce GHG emissions and increase soil carbon sequestration will account for 15% of all annual crop production in Minnesota or manage cropping systems to achieve similar outcomes. By 2025, the full goal will be achieved.

Nutrient Management: By 2015, increase fertilizer application efficiency by 25% and achieve the full goal by 2025.

Parties Involved: SWCD, NRCS, MDA, U of MN, FSA, and Agriculture Organizations

Other: Research and incentives will be needed to help farmers convert current farming practices over to no-till, strip till or other conservation farming practices. These practices will

reduce GHG emissions and increase soil carbon sequestration. Research will be used to develop methods to efficiently and effectively determine outcomes.
Research and incentives will be needed to speed adoption of GPS based technologies and to develop outcome-based and performance-based methods. Research will be needed to determine the best management practices of animal and commercial based fertilizer. Encouraging incorporation of livestock manure to reduce GHG emissions and possible run-off issues is an example of best management practices for livestock produces.

More information about MDA's BMPs can be found at: http://www.mda.state.mn.us/chemicals/fertilizers/nitroch4.htm.

Implementation Mechanisms

- Encourage farmers to adopt voluntary best management practices (BMPs) as prescribed by the Minnesota Department of Agriculture.
- Develop GHG outcome-based indices to identify the greatest sequestration capacity by individual management field or tract.
- Fund research and development of farming practices and cropping systems that increase carbon input (e.g., reversion to native vegetation, setting agricultural land aside as grassland, improved crop rotations, yield enhancement measures, organic amendments, cover crops, improved irrigation practice) or decrease carbon output (e.g., proper tillage methods) while maintaining crop yield so that GHG emissions are reduced.
- Evaluate and implement economical agricultural practices that maintain a primary income source from crop production or that might become a primary income source from land set-asides.
- Evaluate and implement economical mechanisms that might affect crop choice (support payments, crop insurance, disaster relief) and farmland preservation (conservation easement, use value taxation, agricultural zoning) as incentives to increase carbon stock of agricultural soil.
- Document environmental co-benefits of carbon sequestration practices such as soil fertility, soil buffering capacity, pesticide immobilization, reduced energy for field operation, enhanced water infiltration, prevention of wind and water erosion, and improved fertilizer management.
-

TWG comments: Flexible outcome-based measures will give farmers the ability to use various management methods and practices.
Recommend a strong research and development component.
Suggestion from TWG: Management outcomes could be used with indices rather than practice-based approaches (i.e. energy consumption indices and nutrient indices related to carbon).

Related Policies/Programs in Place

Blue Earth River Basin Initiative ran a project called the Third Crop Initiative. This initiative aims to replace annual crops with perennial crops.

Types(s) of GHG Reductions

- N_2O: reductions occur when nitrogen run-off and leaching are reduced, which 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 Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 ($MMtCO_2e$): TBD, TBD**
- **Net Cost per $MtCO_2e$: TBD**
- **Data Sources:**

1.1 Reference Abstract: Tristram O. West and Gregg Marland, *Net carbon flux from agriculture: Carbon emissions, carbon sequestration, crop yield, and land-use change,* Biogeochemistry, Volume 63, Number 1, April, 2003.

1.2 Reference: Draft Document; The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle, Synthesis and Assessment Product 2.2, Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Edited by the Scientific Coordination Team: Anthony W. King (Lead), Lisa Dilling (Co-Lead), Gregory P. Zimmerman (Project Coordinator), David M. Fairman, Richard A. Houghton, Gregg H. Marland, Adam Z. Rose, and Thomas J. Wilbanks, March 2007

1.3 1.3 Minnesota Draft Inventory and Forecast. Appendix F. Agriculture, Minnesota Pollution Control Agency and Center for Climate Strategies, July 2007.

1.4 Quantification of the no-till portion of this option is based upon XXXXX ha of agricultural land in Minnesota. This land is comprised of dryland and irrigated land. Using standard unit conversions, the soil carbon accumulation rate of 1.37 MtCO2/ha-year was calculated from the midpoint of the range provided by Naderman et al. The estimated cost savings ($14.33/ha) related to the adoption of no-till farming was derived from an article by Tim McAlvay of Texas A&M. The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre[1]. From the Minnesota Inventory & Forecast, the fossil diesel GHG emission factor is XXX MtCO2e/1,000 gallons.

Farm Land Use	2002 acres
Harvested Cropland	19,398,309
Cropland Pasture Grazing	728,593
Other Cropland	2,602,256
Woodland	1,975,495

[1] Reduction associated with conservation tillage compared to conventional tillage, at http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html, accessed August 2006.

Pasture Rangeland	1,187,082
Total Acres	25,891,735

1.5 The historical quantity of fertilizer used is consistent with the Agriculture module of the Minnesota Draft Inventory & Forecast. This forecast also provides the resulting N2O emissions and carbon equivalent emissions. Data regarding the cost savings associated with an increase in the efficiency of fertilizer use is taken from an average of the cost of common fertilizers in the spring of 2004.

- **Quantification Methods:**

Soil Carbon Management (No-till Cultivation)

The total farmland in Minnesota in 2002 was 27.51 million acres. Cropland accounted for the majority (82.6%) of farmland at 22.73 million acres[2].

Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation are shown in Table X-1. The mid-point of the estimated range for carbon sequestration– 2.47 Metric tons carbon per hectare (MtC/ha)–in agricultural soils was used to estimate the total amount of carbon to be sequestered. Based on the Naderman et al. study[3], it was further assumed that this additional carbon would be sequestered in the soil over a period of 10 years (after 10 years, no further carbon is stored). The resulting annual carbon accumulation rate was converted into its CO_2 equivalent yielding X $MtCO_2$/ha-year.

To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in the policy program each year. After 10 years, the crop acres that entered the program were assumed to not store additional carbon. Results are shown in X.

Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate provided above. Results are shown in Table X along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

Table X-1. GHG benefits for no-till cultivation

Year	Percent of total cropland in program	Acres in Program	Acres Still Accumulating Carbon	$MMtCO_2e$ Sequestered	Diesel Saved (1,000 gal)	$MMtCO_2e$ From Diesel Avoided	Total $MMtCO_2e$ Saved
2008							
2009							
2010							

[2] U.S. Department of Agriculture, *Minnesota Fact Sheet* (http://www.ers.usda.gov/StateFacts/MN.HTM). Accessed on 10-26-2007.

[3] G. Naderman, B.G. Brock, G.B. Reddy, and C.W. Raczkowski, "Long Term No-Tillage: Effects on Soil Carbon and Soil Density Within the Prime Crop Root Zone," Project Report, January 2006.

Year	Percent of total cropland in program	Acres in Program	Acres Still Accumulating Carbon	$MMtCO_2e$ Sequestered	Diesel Saved (1,000 gal)	$MMtCO_2e$ From Diesel Avoided	Total $MMtCO_2e$ Saved
2011							
2012							
2013							
2014							
2015	15%						
2016							
2017							
2018							
2019							
2020							
2021							
2022							
2023							
2024							
2025	33%						

Costs savings were estimated by multiplying the estimated savings per acre cited above ($14.33) by the number of acres in the program each year. This savings estimate takes into account budget changes for the cost of fuel, labor, chemicals, and equipment. Two studies that cited the need to provide a financial incentive to generate more widespread adoption of no-till cultivation—despite the expected cost savings of the practice—were consulted. The midpoint ($7.9/ha) of the incentive needed for wheat ($4/acre)[4] and corn ($2.4/acre)[5] was multiplied by the total quantity of land entering the cultivation program each year. The resulting cost-effectiveness of no-till cultivation is a cost savings of X/$MtCO_2e$. The result is a net cost savings for the no-till cultivation program with a net present value of $X million.

Costs for adoption of conservation tillage/no-till practices are estimated to be $0 based on averaging costs from two studies. The first study from North Carolina State University on applying these practices to cotton growing in NC resulted in a range of cost savings from about $3 to $14 per acre per year.[6] CCS used the low end of the range as a conservative estimate of cost

[4] S. Brooks and R.N. Elliot. "Agricultural Energy Efficiency Infrastructure: Leveraging the 2002 Farm Bill and Steps for the Future. *American Council for an Energy Efficient Economy*. Report No. IE072. July 2007.

[5] L. Kurkavola, C. Kling, and J. Zhao. "Green Subsidies in Agriculture: Estimating the Adoption Costs of Conservation Tillage from Observed Behavior." *Center for Agricultural and Rural Development; Iowa State University*. Working Paper 01-WP 286. April 2003

[6] $3–$14/acre savings dependent on comparison of no-till to either strip till or conventional tillage. From "Economic Comparison of Three Cotton Tillage Systems in Three NC Regions," S. Walton and G. Bullen, NCSU, at www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt , accessed February 2007.

savings. The second study from Iowa found that subsidy of $3 would be required to get non-adopters to switch to no-till.[7]

Nutrient Management

In 2005 emissions associated with fertilizer leaching and runoff were estimated at 2.02 MMT CO2e (DRAFT Minnesota Greenhouse Gas Inventory and Reference Case Projections 1990-2020[8]).

Historical fertilizer use and crop output for Minnesota were obtained from the USDA[9]. This provided a basis for calculating fertilizer efficiency as measured by crop output per lb of fertilizer applied. The projected business-as-usual (BAU) fertilizer efficiency is determined by extrapolating the trend in historical fertilizer use from USDA data source with Excel's projection tool. The application of this tool results in a projected moderate annual growth in fertilizer use in Minnesota. The target efficiency improvements laid out in this policy are applied to the BAU fertilizer use projection to determine how much fertilizer use will be avoided for the years 2007–2020.

Historical fertilizer application rates (i.e. lbN/Acre) were obtained through the USDA/ERS data website (http://www.ers.usda.gov/Data/FertilizerUse/). Using the the USDA/ERS historical data the average fertilizer use was calculated as indicated below.

Table: Historical Average Nitrogen Use (lb/Acre)

	1964-1969	1970-1979	1980-1989	1990-1999	2000-2006
Corn	63	97	111	111	121
Soybeans	9	18	18	21	19
Wheat	23	54	73	88	90
All crop average	32	56	67	73	77

The nitrous oxide emission factor for fertilizer use is calculated by multiplying the carbon dioxide equivalent emissions in the Minnesota Draft I&F by the Equivalence Factors: IPCC Second Assessment Report. Then, the CO_2e emission factors for the years 1990–2002 are averaged to provide an estimated emission factor (X $MMtCO_2e/kg$ N) that is used to calculate the avoided GHG emissions from the proposed increase in fertilizer efficiency. The results of the calculations detailed in the preceding discussion are displayed in Table X-2. Note that this approach does not capture the avoided life cycle GHG reductions that would occur through fertilizer efficiency programs (emissions associated with the production, transport, and energy consumption during application).

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[7] "Costs and Environmental Effects from Conservation Tillage Adoption in Iowa," Lyubov Kurkalova, Catherine Kling, and Jinhua Zhao.

[8] Center for Climate Strategies. *DRAFT Minnesota Greenhouse Gas Inventory and Reference Case Projections 1990-2020* , July 2007

[9] http://www.ers.usda.gov/Data/FertilizerUse/

Table X-2. Fertilizer reduction targets and avoided emissions

Year	Total BAU Fertilizer Use (kg N)	Policy Target: Efficiency improvements	Target Fertilizer Reduction (kg N)	Avoided GHG Emissions (MMtCO_2e)
2007				
2008				
2009				
2010				
2011				
2012				
2013				
2014				
2015		25%		
2016				
2017				
2018				
2019				
2020				
2021				
2022				
2023				
2024				
2025		50%		

The cost savings associated with using less fertilizer is calculated by multiplying the total fertilizer reduction in each year by the average cost of fertilizer in the spring of 2004.[10] The non-discounted cost savings from 2007 to 2025 of this option is $X million.

The program costs of nutrient management were estimated as the sum of fertilizer savings (negative cost); costs for soil testing; costs for staff, overhead, and travel; and guidance document preparation costs. Soil testing would be required for each crop field once every 4 years. The total number of harvested hectares were divided by the assumed average field size of X acres (X ha) and divided by 4. The cost for each soil test was estimated to be $10, for a total cost of Xx10/year for soil testing. Costs for 2 full-time equivalents (FTEs) of additional staff, overhead, travel, lab, and associated costs was estimated at $250,000/year, and preparation of guidance documents was assumed to be $75,000 in the first year.[11]

The net cost of programs to increase fertilizer efficiency has a net present value of cost savings at –$X million over the course of the policy period.

[10] 2004 Fertilizer Use and Cost. Accessed on, from www.ers.usda.gov/Data/FertilizerUse/Tables/Fert%20Use%20Table%207.xls.

[11] Brian Hurd, NMSU Agricultural Economics, personal communication with H. Lindquist, CCS, June 2006.

The total net cost of AFW-1 is a cost/savings of X/MtCO_2$e with a net present value of $X million. Table X-3 provides a summary of the data used to calculate the program costs and cost-effectiveness.

Table X-3. Fertilizer efficiency program costs and cost-effectiveness

Year	Total Cost Savings ($MM)	Total Avoided GHG Emissions (MMtCO_2e)	Cost of Programs ($MM)	Discounted/ Levelized Cost ($MM)	Discounted/Levelized Cost-Effectiveness ($Mt)
2008					
2009					
2010					
2011					
2012					
2013					
2014					
2015					
2016					
2017					
2018					
2019					
2020					
	Totals				

- **Key Assumptions:**

  Assumed carbon sequestration potential is representative across all of the crop systems to which the policy is applied; a 10-year period for accumulating the soil carbon; no additional significant accumulation of soil carbon after 10 years; any potential increase in N_2O emissions is not large enough to significantly effect the estimated CO_2 benefits; cost savings is a representative average of savings to be achieved across all crop systems.

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

TWG Suggestion: IPCC prioritizes N_2O management as high, with important water quality benefits.

Feasibility Issues

1.1 If changes in management result in decreased crop yields, the net carbon flux can be greater under the new system, assuming that crop demand remains the same and additional lands are brought into production. Conversely, if increasing crop yields lead to land abandonment, the overall carbon savings from changes in management will be greater than when soil carbon sequestration alone is considered.

1.2 Options to increase carbon can be implemented in the short-term, but the amount of carbon sequestered typically is low initially then rising for a number of years before tapering off again as the total potential is achieved. There is also a significant risk that the carbon sequestered may be released again by natural phenomena or human activities.

Practices for conserving carbon affect emissions of other greenhouse gases. Of particular importance is the interaction of carbon sequestration with N2O emission because N2O is such a potent greenhouse gas. In some environs, carbon-sequestration practices, such as reduced tillage, can stimulate N2O emissions thereby offsetting part of the benefit. Elsewhere, carbon-conserving practices may suppress N2O emissions, amplifying the net benefit. Similarly, carbon-sequestration practices might affect emissions of CH4 if the practice, such as increased use of forages in rotations, leads to higher livestock numbers. Policies designed to suppress emission of one greenhouse gas need to also consider complex interactions to ensure that net emissions of total greenhouse gases are reduced.

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-2 Land Use Management Approaches for Protection and Enrichment of Soil Carbon

Policy Description

Convert marginal or sensitive agricultural land with an immediate history of use for annual crop production to permanent cover such as grassland/rangeland, orchard, or forest on land that was formerly forested, where the soil carbon and/or carbon in biomass is substantially higher under the new land use. Includes opportunities to keep CRP, CREP and RIM lands in well-managed, continual cover, while also providing opportunities for working lands to increase carbon sequestration through biomass production that can provide feedstocks for in-state bioenergy production.

Incentives need to be created to convert annual row crop acres to perennial crops that prevent these acres from either returning to conventionally-tilled production or to suburban/urban development. Incentives also need to be created for promoting carbon sequestration goals on public lands and lands enrolled in existing conservation programs. Finally, research should be conducted and programs adopted to identify and eliminate threats to the vast carbon pools currently stored in lands that hold high levels of soil organic carbon, such as peatlands and wetlands.

Finally, research and increased management of the vast carbon pools stored in wetlands and peatlands is critical. A high percentage of all carbon stored in Minnesota is in wetlands and peatlands. Efforts are needed to protect these carbon reservoirs from the impacts of warmer and drier conditions and increased fire risk. Efforts should include identification of wetlands and peatlands at risk of re-emitting sequestered carbon dioxide and methane. Additional study is needed to understand greenhouse gas dynamics in the full range of wetland types in Minnesota and to apply this understanding to the state's wetlands conservation policies.

Policy Design

Goals: *Natural Coverage Protection*- Protect 10% by 2015 and 30% by 2025 of lands in natural cover and/or existing conservation programs that would have been converted to intensive agricultural production or urban/suburban development.

Perennial Production on Working Lands- By 2025, expand the Reinvest in Minnesota – Clean Energy (RIM-CE) program land to 200,000 acres.

Protection of Peatlands & Wetlands- Protect or restore northern peatlands and other wetlands to prevent releases of greenhouse gases and fire. The TWG is not comfortable presenting numeric goals at this time. Please see alternative goals under "Protection of Peatlands & Wetlands" below.

Timing:

- *Natural Coverage Protection* - Protect 10% by 2015 and 30% by 2025 of lands in natural cover and/or existing conservation programs that would have been converted to intensive agricultural production by 2015. Achieve the full goal by 2025. The goal could be met in whole or in part by: increasing the amount of privately held high carbon value lands in land protection programs by 10% by 2015, and by 25% by 2025; and making carbon sequestration an additional management priority for 25% of publicly held and managed lands in Minnesota by 2025.

  Perennial Production on Working Lands- By 2015, 20,000 acres of land should be established and/or producing low-carbon perennial energy crops in Minnesota. Achieve the full goal by 2025.

  Protection of Peatlands & Wetlands- By 2015, identify peatlands at risk of releasing greenhouse gases because of lowered water tables, fire potential, or industrial uses (horticulture, sod-farming, or mining). By 2015, initiate research program on fire potential and management in peatlands. By 2015, develop carbon management standards for wetlands and peatlands. By 2025, raise water table elevations as high as practicable on degraded peatlands and/or plant with appropriate forest species.

Parties Involved: Board of Soil and Water Resources, Department of Natural Resources, University researchers, Rural Advantage, AURI, Minnesota Waterfowl Association, Delta Waterfowl, Ducks Unlimited, Izaak Walton League of America, Institute for Agriculture and Trade Policy, Land Stewardship Project, Minnesota Project, Farmers Union..

Other: ***Agricultural Land Protection:*** This policy would create a program to provide additional tax incentives for landowners donating development rights as part of an easement transaction for the carbon storage value of their land. These programs need to be assessed for their carbon sequestration benefit. Management strategies need to assure that the original goals and public values (water quality, soil conservation, and wildlife habitat) are not diminished as carbon sequestration goals are met.

This option can assist with the promotion of the goals of AFW-3 and AFW-4, by providing some incidental biomass for bioenergy and biofuel production, but these lands should not be viewed as primary biomass sources. Federal and state managed and contracted lands (including federal wildlife refuges, DNR wildlife management areas, state forest lands, national and state park areas, BLM lands, national forests and grasslands, and CRP, CREP and RIM acres) are managed for a variety of purposes and under many state and federal laws, and in many instances these purposes could include carbon sequestration. Most public lands, and all CRP, CREP, and RIM lands, are managed at least in part to preserve the public's interest in their non-commodity values, mainly water quality improvement, soil conservation, and wildlife habitat.

At present, the carbon storage value of lands protected is an uncompensated additional benefit that comes with the open space and wildlife habitat protection values of protecting lands.

Moreover, there are clear examples of public lands being managed in ways that are counterproductive or simply squander natural carbon sequestration and detention potentials of the land. Additional incentives that monetize stored carbon and changes in carbon storage on the land, over and above existing compensation for retiring development and production rights, would increase acreage of high carbon value lands that are managed for carbon sequestration, and compensate landowners for the additional societal benefit of avoided carbon emissions.

Perennial Production on Working Lands: While protection of existing perennial production on conservation and public lands is necessary, the vast majority of agricultural land is currently used intensively to produce annual crops that have minimal ability to sequester carbon over the long term. Programs to encourage production of perennial crops on acres currently in agricultural production must be funded and expanded quickly.

The RIM-CE program should be fully funded in 2008. This program is a working lands program for bioenergy production that was established in the 2007 Minnesota legislative session. It provides long-terms easements and training to farmers who want to begin growing next generation energy crops, such as diverse native prairie or monocultures of native species such as switchgrass, for sale to facilities needing the crops for heat, power and transportation fuel production. Tiered payments are made based on increased levels of public benefits, specifically carbon sequestration in the deep root systems of diverse native perennial grassland plantings, improvements to water quality, and improved wildlife habitat. After a short lead time for establishment of the crops, we will begin reaping the benefits as each acre sequesters carbon below ground while producing harvestable biomass fuels above ground. This will jumpstart the production of energy crops in the state, providing some of the feedstocks to meet the goals outlined in AFW-3 and AFW-4.

Protection of Peatlands & Wetlands: Wetlands have among the highest potential carbon sequestration capacities for any type of land use in Minnesota. Peatlands are likely Minnesota's largest single carbon sink containing 37% of all carbon stored in the state compared to 3% stored in the state's forests. Protecting these enormous carbon reservoirs from the impacts of warmer and drier conditions and increased fire risk is critical. Early attention should be given to identifying degraded peatlands at risk of re-emitting sequestered carbon dioxide and methane. Additional study is needed to understand greenhouse gas dynamics in the full range of wetland types in Minnesota and management options to reduce the risk of catastrophic releases of stored greenhouse gases from these systems.

Policies need to be designed that assure protection of peatland and wetlands from drainage and other carbon-releasing land uses. Additional research must be done to evaluate their contribution to carbon sequestration and long-term storage. In particular, policies should:

1. Identify areas where significant peatland carbon stocks are in danger of being oxidized by drainage infrastructure. Evaluate and conduct hydrologic or vegetation management, including afforestation with appropriate forest species.
2. Evaluate GHG impacts of horticulture, sod farming, and energy production on peatlands and develop standards to protect carbon stocks.
3. Protect carbon stocks in freshwater mineral wetlands. Support development of scientific understanding and management options for GHGs associated with mineral wetlands.

4. Initiate serious research program of the fire potential and management in peatlands.

Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

Related Policies/Programs in Place

Minnesota has invested significantly in preservation and restoration of significant conservation lands -including forests, prairies, and wetlands. The Minnesota DNR owns and manages over 1.1 million acres of public conservation lands in addition to the state forestland. In addition, the State of Minnesota holds long term conservation easements on nearly 200,000 acres of privately owned lands. Restoration and management strategies for these lands focus on restoring diverse native plant communities, which are shown to be very productive in the sequestration of carbon.

In 1991, Minnesota established one of the most sweeping wetlands protection laws in the country: the Wetland Conservation act. With a goal of no-net-loss of wetlands, the Wetland Conservation Act requires anyone proposing to drain, fill, or excavate a wetland first try to avoid disturbing the wetland; second, to try to minimize any impact on the wetland; and, finally, to replace any lost wetland acres, functions, and values.

Types(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).

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 (MMtCO_2e): TBD, TBD**
- **Net Cost per MtCO_2e: TBD**
- **Data Sources:**

Natural Resources Conservation Service data on CRP acres expiring during the policy period, NRI data on agricultural/range/forest land lost to urban development, data on above and below ground soil carbon levels from XXX, US Forest Service (USFS), and the scientific literature, costs for conservation easements on ag/range/forest land in Minnesota.

- **Quantification Methods:**

Natural Coverage Protection

Need to determine the amount of lands in natural cover and/or existing conservation programs that which is potentially available for conversion. CCS used the baseline conversion estimates of X acres/year. These conversion estimates are multiplied by the targets (10% by 2015 and 30% by 2025) to yield the averted conversion in the target years. Conservation programs are assumed to increase at a linear pace to reach the targets. The carbon value of grasslands that is lost due to conversion is X MMtC/1,000 acres. The cost of easements for both forests and grasslands is assumed to be $X/acre.

Table X. Benefits and costs for Agricultural Land conversion

Year	Agricultural land Converted (Acres)	$MMtCO_2e$ Saved	Costs	Discounted Costs	Levelized Cost-effectiveness
2007					
2008					
2009					
2010					
2011					
2012					
2013					
2014					
2015					
2016					
2017					
2018					
2019					
2020					
Totals					

Conservation of Agricultural Lands

Preventing agricultural lands being converted to suburban/urban developments.

The annual rate of agricultural land in Minnesota converted to developed uses is XXX acres per year based on data from the National Resources Inventory. The typical level of soil carbon in agricultural soils in Minnesota was estimated by averaging soil carbon data for entisol and inceptisol type cultivated soils to depths of 30 cm,[12] resulting in a value of XX 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 XXXX.

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.

[12] 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

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 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 X provides a summary of the estimates for each year.

Table X. Land protection schedule and associated benefits

Year	% of Conversion Reduced	Ag Acres Protected	$MMtCO_2e$ Saved
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Costs

To estimate program costs in each year, CCS used multiplied the estimated agricultural acres protected from development by the conservation cost ($X/acre) minus the assumed contribution from funding mechanisms (e.g. NRCS) ($X/acre). The resulting cost-effectiveness is $X/$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 above-ground carbon stocks; 75% loss of soil carbon on 50% of developed land; 50% cost share available city/local governments, or other sources. No appreciable carbon sequestration occurs post-development.

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-3 In-State Liquid Biofuels Production

Policy Description

Promote sustainable in-state production and consumption of transportation biofuels from agriculture and/or agroforestry feedstocks to displace the use of gasoline and diesel. Decrease the use of fossil fuel in the production of these biofuels, which will improve the GHG profile of in-state liquid biofuels production and consumption. Sustainability standards also need to be developed for low-carbon biofuels, so that producers are rewarded accordingly.

Promote the in-state development of feedstocks, such as cellulosic material and perennials that are able to be utilized. Realize that conversion technologies, such as thermo-chemical Fischer Tropsch processes and enzymatic conversion, are developing fast in this sector, so facilitate their development but not be prescriptive.

Promote multiple biofuel (ethanol, biodiesel, biobutanol) production systems that improve the embedded energy content, life cycle, and carbon profile of biofuels. Focus on plant material feedstocks that favor energy production and are carbon neutral or negative and have multiple other positive environmental benefits, such as maintaining carbon sequestration potential and soil productivity, and decreasing water and fossil fuel inputs in their production.

It is understood that promoting biofuel production must be coupled with strong policies to reduce overall transportation fuel consumption if true gains in reducing greenhouse gases is to be achieved. Upon successful implementation of this policy, MN consumption of biofuels produced in-state will produce better GHG benefits than these same fuels obtained from a national market due to lower embedded CO2 (due to out of state fuels produced using feedstocks/production methods with lower GHG benefits; and transportation of biodiesel, ethanol, other fuels, or their feedstocks from distant sources).

<u>Note:</u> *This option is linked with TLU Option 3 on Biofuels and the ES Option 2 on a Low Carbon Fuels Standard. This option seeks to achieve incremental GHG benefits beyond the TLU option by promoting in-state production of biofuels using feedstocks with greater GHG benefits than the likely business as usual national production methods..*

Policy Design

Goal: *Lower the carbon content of ethanol produced from existing plants:* By 2015, 80% of the thermal heat used in ethanol facilities will be produced from biomass or other renewable energy; by 2017, 80% the electrical power consumed by ethanol facilities will produced from biomass or other renewable energy. The goal of this policy design is to decrease the use of fossil fuel in the existing production of Minnesota biofuels by using low-GHG life-cycle biomass for the heat and power inputs into biofuel production facilities. A technology that could achieve this goal is biomass gasification, which is currently available.

Gasoline displacement goals: By 2025, achieve in-state production volume equivalent to offsetting gasoline consumption in the state by 50% of the gasoline consumed in the state (ie replace gasoline with biofuels using GHG superior feedstocks and conversion processes).*

Fossil diesel displacement goals: Increase in-state biodiesel production to offset 10% of fossil diesel consumption by 2025 (i.e. the fossil diesel consumed in the state will by replaced by biodiesel produced using feedstocks and conversion processes that are superior to today's conventional sources).

Timing:
Lower the carbon content of ethanol produced from existing plants: See above.

Gasoline displacement goals: Incremental increases, up to achieving the full goal by 2025.

Fossil diesel displacement goals: Incremental increases, up to achieving the full goal by 2025.

Parties Involved: Ethanol facilities, Department of Commerce, Department of Agriculture, Next Generation Energy Board, sustainable agriculture groups, conservation and renewable energy nonprofits, those currently developing standards (i.e. Forest Resource Council, Board of Water and Soil Resources), engineering firms, forest products industry, agriculture production groups.

Other: Current State policy for fossil diesel displacement is 2% biodiesel blend. For gasoline displacement, current policy is 20% ethanol displacement by 2013; with a carve-out goal for 5% derived from cellulosic material. Current petroleum displacement goal is 20% of the liquid fuel sold in the State will come from renewable sources by the year 2015 and 25% by 2025. This new policy would need to be coupled with strong reductions in fossil gasoline/diesel consumption demand out to 2025 and high biofuels content (i.e. E85) vehicle/infrastructure.

Money related to capital conversion for certain near-term technologies, such as gasifiers, may need to be allotted. A certification process to acknowledge that Minnesota-produced biofuels have lower carbon footprints (i.e. for future Minnesota, California and potentially national LCFS markets) is needed. Incentives for planting crops that have a low carbon profile that can be used as boiler fuel should be enacted (i.e. RIM-CE program).

Note the linkage to the TLU option for establishing a low carbon fuel standard (LCFS) that will stimulate the biofuels production envisioned by this option, as well as innovation and investment in biofuel production technologies. Promote efficiency and low carbon feedstocks/fuel inputs in biofuels production facilities, and increase demand for biofuels blending in transportation fuel production processes. Within AFW or TLU, policies should address labeling and certification to verify low and zero-carbon biofuel players should be implemented, which will allow for a sound low-carbon fuels market to be developed locally and nationally. Any Minnesota based fuel standard/certification process should be able to easily integrate into the emerging California, federal (EPA) and European LCFS as well as any tax or cap regimes established for Minnesota and the Upper Midwest.

Note the linkage to AFW-2 on funding the Reinvest in Minnesota – Clean Energy (RIM-CE) program (200,000 acres growing low-carbon energy crops by 2025). This program is a working lands program for bioenergy production that was established in the 2007 legislature. It provides long-term easements and training to farmers who want to begin growing next generation energy crops such as switchgrass and other diverse prairie grasses for sale to facilities needing the crops for heat and power (gasifiers). Tiered payments are made based on increased levels of public benefits such as carbon storage in the roots, improvements to water quality/use and wildlife habitat. We need to begin getting these energy crops in the ground and farmers trained on how to grow them, especially since there is a lead time for establishment of the crops. Getting started on that now will set the stage for utilizing the energy crops for biofuels in the coming years as well as link to goals outlined in AFW-1 and AFW-2.

Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

TWG Suggestion: *A low-carbon index or biofuels production should be incorporated, along with feedstock sustainability standards.* By 2015, a life-cycle certification/labeling process for low-carbon fuels should be implemented (either through MN-specific or adoption of regional/national standards) that credits biofuels for varying reductions in their carbon intensity, ranging from 25-100%.

Related Policies/Programs in Place

Ethanol: Minnesota established an ethanol production incentive to provide payment to producers to help develop a new market for Minnesota's agricultural products. On the market side, Minnesota requires that all gasoline sold in the state be blended with a 20% ethanol mix by 2013. Of this, there is a state goal that a quarter of the RFS will come from cellulosic derived biofuel by 2015, or when 60,000,000 gallons comes online, whichever is first. In addition, Minnesota began efforts in 1997 to develop a network of fueling stations for flex fuel vehicles that could run on an 85% ethanol blend.

Biodiesel: According the U.S. Department of Energy, biodiesel has the most favorable energy balance of any currently commercially viable transportation fuel. For every unit of energy needed to produce a gallon of biodiesel, 3.2 units of energy are gained. As of September 29, 2005, Minnesota requires nearly all diesel fuel sold in the state to contain at least a 2 percent biodiesel blend.

Petroleum Replacement Goal: There exists a state goal that 20% of the liquid fuel sold in the state will come from renewable sources by the year 2015, and 25% will by 2025. There are many grants available for bioenergy facilities, through the Department of Commerce and the Department of Agriculture.

RIM-Clean Energy – a reinvest in Minnesota program within the Board of Soil and Water Resources. RIM –CE is a working lands program that allows for growing and harvesting of bioenergy crops with added payments for increased conservation, water quality benefits. The program still needs funds for granting easements for bioenergy crops.

Types(s) of GHG Reductions

- **CO_2:** Lifecycle emissions are reduced to the extent that biofuels are produced with lower embedded fossil-based carbon than conventional (fossil) fuel. Feedstocks used for producing bioruels can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon).

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 (MMtCO_2e): TBD, TBD**
- **Net Cost per MtCO_2e: TBD**
- **Data Sources: [**TBD by CCS on TWG approval]
- **Quantification Methods:**

GHG reductions from lowering the carbon content of ethanol produced from existing plants
80% of energy (both thermal and electricity) consumed by ethanol facilities should come from biomass or other renewable sources. 80% thermal by 2015 and 80% of electricity by 2017.

The energy intensity of existing ethanol production was calculated plants using information from GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model developed at Argonne National Laboratory. The energy required to produce one gallon of ethanol is estimated to be X Btu. It was assumed that coal accounted for the majority of non-electrical energy for ethanol production while electricity was sourced from the grid. The emissions intensity of an ethanol facility using conventional sources for heat and electricity was calculated to be X Btu/gallon (based on coal emission intensity coefficients for heat and regional electricity emissions intensity coefficients for electricity). The emissions intensity of an ethanol facility using renewable sources for heat was calculated to be X Btu/gallon. Using the BAU projected ethanol production from the MN inventory and forecast, the GHG benefit was estimated to be X MtCO2e in 2015.
The emissions intensity of an ethanol facility using renewable heat and renewable electricity was calculated to be X Btu/gallon. Using the same process outlined above the GHG benefit of using renewable heat and renewable electricity was estimated to be X MtCO2e in 2017.

Note that this policy may overlap with AFW-3.

Cost of lowering the carbon content of ethanol produced from existing plants
The cost of this policy was estimated by multiplying the average additional cost of renewable energy compared to conventional coal using the costs in The DOE publication Electricity Market Module[13]. While the cost of renewable energy supply technologies are expected to decline at a faster rate than the

[13] Report #:DOE/EIA-0554(2007) Release date: April 2007

cost of conventional fossil fuel technologies, it was considered to be beyond the scope of this option to consider possible technological improvement rates and a standard improvement rate of X% was assumed.

GHG reductions through gasoline and fossil diesel displacement with superior feedstocks and processes.

By 2025, replace 50% of the gasoline consumed and 10% of the fossil diesel consumed in the state with biofuels using GHG superior feedstocks and conversion processes.

A 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[14]). 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. Lifecycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al to be 41%.

For this option, the additional incremental benefit of in-state production is derived from the lower embedded GHG content of biodiesel feedstocks (vegetable 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 with rail transport shipments to central Minnesota estimated at about X 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 X $MtCO_2$/MMgal oil was calculated.

When combined with the other feedstocks needed to produce biodiesel (e.g., either methanol or ethanol),[17] 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.

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 $MtCO_2$e/MMgal from the Hill et al study).

The benefits of the biodiesel component will likely be considered by TLU/ES low carbon fuel option and is based on displacement with soybean-based biodiesel. Additional benefits occur through the development 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), animal fats, 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

[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.

[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.

[17] While the analysis here focuses on the primary feedstock for biodiesel, vegetable oil, the policy should also promote the production and use of alcohol feedstocks produced from renewable resources (e.g., starch or cellulosic ethanol, renewable methane to methanol).

for canola would be 7,261 x 48/127 or 2,744 $MtCO_2e$/MMgal. So the additional benefit of canola over soy is 7,261 - 2,744 = 4,517 $MtCO_2e$/MMgal.

For animal fats and algal oils, CCS assumes that these have negligible embedded energy. So the incremental benefit over soy equals the lifecycle fossil diesel emission factor (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 2025, Table X-4 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 new production data summarized below excludes BAU production, which is estimated to be X MMgal/yr in 2015 and X MMgal/yr in 2025[18]

BAU production is further assumed to be soybean-based with little incremental benefit above the option developed by the TLU TWG.

Table X-4.

Year	Oil Feedstock	Fraction of New Production	MMgal/yr Needed*
2015	Soy		
2015	Canola		
2015	Animal		
2015	Algal		
		2015 Total	
2025	Soy		
2025	Canola		
2025	Animal		
2025	Algal		
		2025 Total	

* Excludes BAU production estimated to be X MMgal/yr in 2015 and X MMgal/yr in 2020.

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 and the Life cycle emission benefits estimated above.

Cost of gasoline and fossil diesel displacement with superior feedstocks and processes

[18] See http://www.eere.energy.gov/states/state_specific_information.cfm/state=MN,.

Costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[19] 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.[20] 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.

- **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 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 – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

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[19] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html;.

[20] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-4 Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production

Policy Description

Dedicate a sustainable quantity of biomass from agricultural lands, land restoration activity, agricultural industry residues, wood industry process residues, those normally unused forestry residues, and agro forestry resources for efficient conversion to energy and economical production of heat, steam, or electricity. This biomass should be used in an environmentally-acceptable manner considering proper facility siting and feedstock use (e.g., proximity of users to biomass, impact on water supply and quality, control of air emissions, solid waste management, cropping management, nutrient management, soil and non-soil carbon management, and impact on biodiversity and wildlife habitat). The objective is to create concurrent reduction of carbon dioxide due to displacement of fossil fuel considering life cycle GHG emissions associated with viable collection, hauling, energy conversion, and energy distribution systems.

The potential feedstocks associated with this policy are summarized as follows. An estimate of Minnesota biomass resource available for electricity, steam, or heat production is:

Expanded biomass resources can be developed from agricultural industry process residues and agro forestry products as new industrial facilities are built and through conversion of existing facilities. Analyses project that there is theoretically enough residual biomass and energy crops in Minnesota that, if collected and fed to the most efficient conversion technologies available, could produce up to 99% of the total electricity currently used in Minnesota. Actual results are highly dependent on economically attractive methods for collection of materials, hauling, energy conversion and energy distribution systems, as well as sustainable harvest methods. Current research and increasing numbers of demonstration projects occurring nationally are available to determine which system components are most functional and cost effective for given locations.

The policy will address the following needs:

- Provide resources to advance the rate of development of domestic biomass yield through research and development without compromising soil carbon stability and long-term viability of the production area, and to develop standards and methods to measure ecological sustainability and economical aspects of yield and harvest methods.
- Advance energy collection and conversion technologies for a range of applications from farm-scale point of use to larger industrial size units designed for specific use. Collection and conversion processes should be designed to maximize overall GHG reductions through life cycle analysis.

Provide market incentives to develop a Minnesota biomass to energy conversion equipment industry and to enhance market infusion of biomass conversion products.

Policy Design

Goals:

Energy Crop Production

By 2015 have 50,000 acres of land producing high MMBTU and ecologically sustainable energy crops near energy facilities. By 2025 have 1,000,000 acres.

Biomass Utilization:

Increase the usage of plant residue material for renewable energy (heat, steam or electricity) generation to 40% of available biomass by 2015 and 100% 2025.

Timing:. See above.

Parties Involved: Review and analysis of power sector industry restructuring issues must consult with affected and interested parties, including representatives of: area land planners, rural and other energy consumers (commercial, industrial, small); investor-owned, cooperative, and municipal utilities; local units of government; Minnesota Pollution Control agency and local environmental agencies; renewable energy developers and providers; natural gas distribution utilities; community action agencies; and the public utilities commission; Agro-industries with waste products, Forest-product industries with waste products, conservation groups, Forest Resource Council, Board of Water and Soil Resources, Department of Natural Resources, Department of Agriculture.

- **Other:**

Implementation Mechanisms

TBD TWG Suggestion: Focus on high potential, low cost actions that do not adversely effect existing agriculture and forestry practices.

By 2015, establish criteria/standards for sustainable harvest and utilization of agricultural and forest residues. Build on FSC guidelines and other FRC, RIM-CE, Department of Ag guidelines for residue removal to ensure soil health and soil carbon storage.

Strong efficiency incentives will need to be put in place on both the heat and/or electricity side in order to reduce the land use pressures for the biomass development in meeting the % energy goals.

Need to get energy crops in the ground so the feedstock is available. Pilot projects maybe needed in the near term so research and economics can be assessed for intention of broader scale commercialization in the long term (i.e. via RIM-CE)

Dollars for sustainability standards development may need to be allotted. This would be to complete the research gaps identified by the Forest Resource Council on their woody biomass residue harvest guidelines, and establishment of ag sector energy crops (i.e. via BWSR programs)

MMBTU energy incentives for biomass conversion facilities may need to be established. This incentive may be needed for facilities to install biomass feedstock acceptance (conveyers, etc) on their facilities, storage needs. An MMBTU incentive is preferable as it focuses on incentivizing input of high MMBTU feedstocks and efficient conversion of the biomass into energy (for a high MMBTU output). This would be technology neutral (i.e. could be used for gasifiers, or whatever technology is developed in this rapidly changing market). It is performance based.

Need some type of template contract for between facilities and farmers/intermediary/coop – in order to minimize risk for both parties (i.e. what if farmer can't meet long-term contractual need?).

Related Policies/Programs in Place

The Renewable Electricity Standard became Minnesota law in February of 2007. It requires that 30% of the electricity sold by Xcel Energy to Minnesota consumers be renewable by 2020 and, for all other utilities that 25% be renewable by 2025. Under the new RES and efficiency legislation passed, Minnesota will likely add between 5,000 to 6,000 MW of new renewable electricity to its system.

Biomass Mandate – Xcel Energy has a mandate to purchase 110 MW of biomass electricity. Currently that mandate has been filled with the St. Paul District Energy facility, the FibroMinn turkey litter project, and the Virginia/Hibbing biomass project. There is not expected to be space available within this mandate for further projects.

RIM-Clean Energy – a reinvest in Minnesota program within the Board of Soil and Water Resources. RIM –CE is a working lands program that allows for growing and harvesting of bioenergy crops with added payments for increased conservation, water quality benefits. The program still needs funds for granting easements for bioenergy crops.

There are currently multiple grants opportunities for biomass facility feasibility and project development. This includes granting authority from the Department of Commerce, the Renewable Development Fund, and the Department of Agriculture (via the NextGen Energy Board).

There are multiple existing and planned bioenergy heat and power projects in Minesota. Some of them include:

- A gasification plant that is planned for the University of Minnesota at Morris will use crop waste (corn stover) to produce heat, electricity, syngas and/or hydrogen. The University of Minnesota Duluth's Coleraine Lab has obtained a grant to develop a gasification project that will convert wood waste to hydrogen. (8)
- The Center for BioRefining at the University of Minnesota has developed a biomass/hydrolysis process that converts waste biomass, such as corn stover, into bio-oil which can be used to make polymers for products and hydrogen-rich gas. (8)
- St. Paul District Energy – provides over 80% of power for downtown from woody biomass. Also, MN Power in Duluth has a large biomass to energy plant.
- Numerous other projects for reference such as: Koda Energy, CMEC, CVEC, municipal energy projects.

For Certification, The Laurentian Energy Authority (Virginia/Hibbing) Biomass Energy Project has provided $150,000 to the Minnesota Forest Resources Council (MFRC) to establish guidelines for sustainable removal of woody biomass from forests for energy, and to the MN DNR to develop similar guidelines for brushlands and open lands. The MFRC has identified existing research gap and may need increased allotment of funds to further refine the standards being developed.

Types(s) of GHG Reductions

CO_2, N_2O, CH_4: Displaces emissions from fossil fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 ($MMtCO_2e$): TBD, TBD**
- **Net Cost per $MtCO_2e$: TBD**
- **Data Sources:**

1. "Identifying Effective Biomass Strategies: Quantifying Minnesota's Resources and Evaluating Future Opportunities," Center for Energy and Environment, 2007. Funded by Xcel Energy's Renewable Development Fund. Layering maps for project siting, the report and project feasibility spreadsheet are available: http://www.mncee.org/public_policy/renewable_energy/biomass/index.php
2. Plant Power: Biomass-to-Energy for Minnesota Communities, Shalini Gupta, 2004, prepared for Fresh Energy (Minnesotans for an Energy-Efficient Economy at the time) and the Department of Commerce.
3. Biomass Mandate: An assessment, David Morris 2005, Institute for Local Self-Reliance.
4. *Processing Cost Analysis For Biomass Feedstocks*, Phillip C. Badger, General Bioenergy, Inc., Florence, Alabama, Date Published: October 2002, Prepared for U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Biomass Program, Budget Activity Number EB 24 04 00 0, Prepared by OAK RIDGE NATIONAL LABORATORY, Oak Ridge, Tennessee 37831, managed by UT-BATTELLE, LLC for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-00OR22725, ORNL/TM-2002/199
5. *A Geographic Perspective On The Current Biomass Resource Availability In The United States*, A. Milbrandt, Technical Report NREL/TP-560-39181, December 2005, Prepared under Task No. HY55.2200.
6. *Biomass As Feedstock For A Bioenergy And Bioproducts Industry: The Technical Feasibility Of A Billion-Ton Annual Supply*; Robert D. Perlack, Lynn L. Wright, Anthony F. Turhollow, Robin L. Graham. Environmental Sciences Division, Oak Ridge National Laboratory; Bryce J. Stokes, Forest Service, U.S. Department of Agriculture; Donald C. Erbach, Agricultural Research Service, U.S. Department of Agriculture; A Joint Study Sponsored by U.S. Department of Energy, U.S. Department of Agriculture; Prepared by: Oak Ridge National Laboratory; Managed by: UT-Battelle, LLC for the U.S. Department of Energy under contract DE-AC05-00OR22725, DOE/GO-102005-2135, ORNL/TM-2005/66
7. ORNL 1999 database: http://bioenergy.ornl.gov/resourcedata/
8. NREL GIS database, updated with new sources of data: mill residue data are from the 2002 Timber Products Output Database by the USDA Forest Service; agricultural residue data are from the National Agricultural Statistics Service at USDA (http://www.nass.usda.gov:81/ipedb/)
9. ILSR 1997 database:
10. http://www.carbohydrateeconomy.org/library/admin/uploadedfiles/Survey_of_Minnesotas_Agricultural_Residues_and.html

11. *Minnesota Biomass-Hydrogen And Electricity Generation Potential*, A study by the National Renewable Energy Laboratory Golden, Colorado, Provided with financial assistance from the U.S. Department of Energy for The Minnesota Department of Commerce and The Minnesota Office of Environmental Assistance, February 2005
12. A Report To The Minnesota Legislature, Minnesota Department Of Commerce, State Energy Office, January, 2006
13. Center for Energy & Environment Report, 2007, on Biopower (theoretical, technical, economically available biomass for power production).
14. http://bioenergy.ornl.gov
15. http://www.eere.energy.gov/biomass/biomass_feedstocks.html

- **Quantification Methods:**

Biomass Utilization GHG Benefits

For the GHG benefit, there is a need to determine amount of biomass available, the amount currently utilized and the amount likely to be utilized by recent actions including the Renewable Portfolio Standards.

This policy calls for 40% of available biomass by 2015 and 100% by 2025 to be used to offset fossil fuel combustion in the ES or RCI sectors. The benefit of the utilization of this additional biomass assumes that the biomass is used to offset coal consumption (different benefits would occur if other carbon fuels like natural gas or oil were offset).

Table: Projected biomass energy use associated with gross electricity generation (billion btu) - with the RPS

Fuel type	2005	2010	2015	2020	2025
MN utilities/NUGs	325	325	19,698	29,832	45,467
MN CHP facilities	10,250	10,949	11,114	11,325	11,537
Total	10,575	33,237	33,237	33,237	18,931

Biomass Utilization Costs

The cost analysis for this option is based on the difference in costs between a supply of woody biomass fuel and the assumed fossil fuel that it is replacing (for the purposes of this analysis, natural gas). The cost of natural gas is assumed to be $X/MMBtu, which is a nominal cost across residential/commercial/industrial users based on data. The cost of supplying biomass is $X/ton. This value compares to an estimate of $140/ton associated with an 80-mile radius between supply and use and a cost of $108/ton for a 25-mile radius in a recent study on western biomass supply and use.[21]

The cost estimates do not include capital costs for new equipment purchases or retrofits. It is assumed that changes in equipment use occur after the useful life of existing fossil fuel-fired equipment. The up-front cost of a biomass combustion system can be greater than a traditional system; however the fuel is far less expensive, such that, over time, fuel savings can more than offset upfront costs. Net cost savings are more likely in certain circumstances, in particular: 1) when the price of fossil fuel equipment options are relatively expensive and 2) in larger, heat-using facilities whose unit savings on heating fuel costs result in a better payback on the up-front investment.

Energy Crop Production

It is assumed that the energy crops production is additional to the goals set by the biomass energy. It is assumed that the average energy content of the energy crop is X btu/acre per year. This results in the following energy potential:

Year	Acres of Additional Energy Crop	Energy Per Acre	Total Energy Provided million Btu	GHG Benefits (MtCO2-e)
2008	6,250			
2009	12,500			
2010	18,750			
2011	25,000			
2012	31,250			
2013	37,500			
2014	43,750			
2015	**50,000**			
2016	55000			
2017	60000			
2018	65000			
2019	70000			
2020	75000			
2021	80000			
2022	85000			
2023	90000			
2024	95000			
2025	100,000			

- **Key Assumptions:**

[21] Based on 80-mile radius, dry ton basis. From McNeil Technologies Report: *Western Regional Biomass Energy Program*, FINAL REPORT, Evaluating Biomass Utilization Options for Colorado: Summit and Eagle Counties, 2003.

The benefit of the utilization of this additional biomass assumes that the biomass is used to offset coal consumption (different benefits would occur if other carbon fuels like natural gas or oil were offset). The emission factor developed for MN biomass delivery does not include emissions for equipment used for on-site collection/processing of biomass due to a lack of information (the high end of the range of transport radius, 50-miles, was selected to compensate for this lack of data); All biomass is utilized by the RCI or ES options.

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

Expanded biomass resources can be developed from agricultural industry process residuals and agro forestry products as new industrial facilities are built and through conversion of existing facilities. Analyses project that there is theoretically enough residual biomass and energy crops in Minnesota that, if collected and fed to the most efficient conversion technologies available, could produce a percentage of the energy currently used in Minnesota. Actual results are highly dependent on economically attractive methods for collection of materials, hauling, energy conversion and energy distribution systems, as well as sustainable ecological harvest methods. Current research and increasing numbers of demonstration projects occurring nationally are available to determine which system components are most functional and cost effective for given locations.

1. Any action to expand use of biomass for energy conversion must consider ecological sustainability and standards for harvesting. In addition, actions must consider land use limitations and resource needs for relatively scaled heat/power facilities.
2. Feedstock has certain inherent physical and chemical characteristics. The fuel preparation steps must change the characteristics inherent in the feedstock into the characteristics needed for the conversion device, thus the feedstock requirements for the conversion device must be known. (1)
3. Various wood sources can have different physical and chemical characteristics, which can greatly influence its conversion to energy. Feeding of these materials with differing characteristics as slugs into the conversion device can cause rapid changes in operating conditions, and make control difficult. Even wood sources differing only in moisture content can cause significant variations in operating conditions and cause control problems. (1)
4. Environmental factors associated with processing wood include noise, solid waste disposal, air emissions, water pollution, and facility aesthetics. (1)
5. The ability to cost-effectively collect, store, and transport biomass feedstock presents many challenges. A biobased industry will require a safe and sustainable supply system. Research and Development in this area is designed to overcome the engineering systems barriers of

collection, delivery, and storage of agricultural residues. (US Department of Energy, Energy Efficiency and Renewable Energy)

6. Among the plant growth factors that pose barriers to yield increase, soil moisture is the most limiting factor. Thus, continued selection for stress tolerance, including tolerance to moisture deficits, will be critically important to achieving a crop's potential yield. (3)
7. Additional analyses would be required to discern the potential impact that larger-scale forest residue and crop residue collection and production of perennial crops could have on traditional markets for agricultural and forest products

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-5 Forestry Management Programs to Enhance GHG Benefits

Policy Description

Forests – public, private, urban, managed, and wild - provide many GHG benefits. The following actions are recommended: 1) Protect and enhance the carbon stored in tree biomass by maintaining and improving the health, longevity, and number of trees in urban and residential areas. Emissions reductions from reduced heating and cooling as a result of planting shade trees are a significant co-benefit; 2) Promote forest cover and associated carbon stocks by establishing forests on former forestland. Additional benefits include public recreation, water quality, wildlife habitat and enhanced biodiversity. Implement practices such as soil preparation, erosion control, and stand stocking to ensure conditions that support forest growth; 3) Encourage activities that promote forest productivity and increase carbon dioxide sequestration in forest biomass and soils, and in harvested wood products. Practices may include: adjusting rotation ages to increase carbon sequestration; increased stocking of poorly stocked lands; thinning and density management; increasing the acreage of short rotation woody crops (for fiber and energy) on agricultural lands previously converted from forest cover; fire management and risk reduction, and management of detrimental insects and disease; and 4) Reduce the severity of wildfires to reduce GHG emissions by lowering the forest carbon lost during fire and by maintaining carbon sequestration potential. Similarly, reducing damage from insects, disease, and invasive plants reduces GHG emissions by maintaining the carbon sequestration potential of healthy forests.

Policy Design

Goals:

Reforestation: Increase permanent forestland in the state by 1 million acres by planting trees on converted forestland.

Urban Forestry: Increase the canopy cover of urban forest in Minnesota communities by 25%.

Wildfire Fuel Reduction: Conduct fuel reduction on all forest areas requiring these treatments. Direct the biomass to most beneficial use. Primary benefits are displacement of fossil fuel and reduced combustion of live forest stands.

Forest Health and Carbon Sequestration: Develop scientific information for incorporating carbon sequestration into forest management plans. Evaluate impacts of increased forest harvest on greenhouse gas emissions and sequestration. Increase proportion of harvested wood going into durable wood products. Establish a monitoring program to document long-term impacts of climate change on Minnesota forests. **This is a non-quantified goal.**

Increase Stocking of Under-stocked Lands: Identify under-stocked forestlands administered by the state and counties in Minnesota and optimally stock identified lands where appropriate.

Timing:

Forest Restoration: Identify lands appropriate for re-establishing forest by 2008. Restore/establish 250,000 acres by 2015. Achieve full goal by 2025.

Urban Forestry: Increase the canopy cover of urban forest in Minnesota communities by 25% by 2025.

Wildfire Reduction: Identify and prioritize areas where wildfire fuel reduction, would substantially reduce the risk of stand-replacing fires. Conduct fuel reduction on 50% of identified areas by 2015 and 100% by 2025. Direct biomass to most beneficial uses, including biomass fuel production where appropriate.

Forest Health and Carbon Sequestration: Examine the carbon sequestration effects of shifting to desired future forest conditions using carbon friendly management methods. *Develop scientific information on forest management options and harvest methods to increase the amount of carbon sequestered in forests.* Incorporate this information into forest management plans for all publicly administered forests by 2015. Identify and increase incentives for durable wood product industry by 2010. Establish monitoring program to document long-term impacts of climate change to Minnesota forests by 2010.

Increase Stocking of Under-stocked Lands: Identify under-stocked stands on state and county lands by 2010. Where appropriate, optimally stock 25% of identified stands by 2015 and all such stands by 2025.

- **Parties Involved:** TBD.
- **Other:** TBD.

Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

TWG Note: Many funding sources can help implement these multi-faceted options.

Develop scientific foundation of carbon sequestration practices in Minnesota forests, including stocking, rotations (lengthened and shortened rotation), harvest methods, and tree species. Evaluate CO_2 impacts of fire management and fire-fighting activities. Evaluate the impacts of increasing annual timber harvest on greenhouse gases and production of wood fiber products and other forest values. Analyze GHG impacts of different end uses of MN timber harvest (e.g., engineered products, pulp and paper, energy, solid wood products).

Evaluate and provide incentives, such as tax benefits or government purchasing programs, to support investments into wood products that store carbon for long periods of times.

Increase the number of communities implementing inventory-based forest management plans from 50 to 150 by 2025.

Related Policies/Programs in Place

The Board of Soil and Water Resources (BSWR) has been directed by the 2007 MN legislature to administer $500k in grants to conduct site level ecological research and assessments, a clean energy program, and technical teams for native seed harvesting and working lands initiatives.

State has spent many millions of dollars since 1990 on a nationally recognized program called Minnesota ReLeaf, a cost-share program designed to plant trees in urban and rural areas to sequester carbon, promote energy conservation, and provide an array of other co-benefits. The MN DNR Division of Forestry may have cost per ton figures available.

Types(s) of GHG Reductions

CO_2: Promotion of forestry management programs serves to increase the sequestration of carbon in forested lands, as well as preventing carbon currently stored in Minnesota's forests from being released.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 (MMtCO_2e): TBD, TBD**
- **Net Cost per MtCO_2e: TBD**
- **Data Sources: [**TBD by CCS on TWG approval]
- **Quantification Methods:**

Suggested quantification approach divides option into three or four discrete components:

(1) Reforestation goal – Note if the land had not been in a forest condition prior to development this might more accurately be called "afforestation." If "reforestation" is meant then this option might be logically quantified under (4), restocking understocked land. (What is meant by "planting trees on converted forestland" under "options"?)

(2) Urban forestry

(3) Wildfire reduction (has there been previous work on this in MN?)

(4) Increase stocking of understocked land owned by state and county (harvest, then replant?) Is there an existing estimate of the extent of understocked land in these ownerships?

- **Key Assumptions: [**TBD, as needed on TWG approval]

Key Uncertainties

TBD – [as needed and approved by the TWGs]

TWG Note: Tree mortality has doubled since 1977, from 123 to 250 million cubic feet. Mortality rate could continue to increase, increasing susceptibility to wildfires and large releases of CO_2

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

TWG Suggestion: Management for carbon sequestration will also benefit production of high quality wood products for the construction industry keeping the carbon out of the cycle for a greatly increased time period.

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-6 Forest Protection – Reduced Clearing and Conversion to Nonforest Cover

Policy Description

In the mid- to late 1800s, forests covered 31 million acres in Minnesota. Over the subsequent 100+ years, l5 million acres of this forestland was converted to other uses, mainly to farmland but also to developed areas. Between 1990 and 2003, Minnesota forestland acreage was reduced by nearly one-half million acres, from 16.7 million acres to 16.2 million acres (Appendix H: Forestry, p. H3, Table H1, USFS Carbon Pool Data for Minnesota). Because forestland captures and stores carbon dioxide in trees, soil and other forest biomass at a much higher rate than developed areas and other areas without forest cover, priority should be placed on reducing conversion of forested lands to land uses with lower carbon sequestration potential.

Policy Design

- **Goals:** Achieve "no net loss" or an increase in forest carbon stocks through local land use planning, conservation easements, technical and financial assistance to family forest landowners, education, revised tax policy, and other appropriate mechanisms.
- **Timing:** Stabilize current statewide forest cover acres and achieve no net loss in carbon stocks by 2015. Decrease conversion of forestland to non-forest uses/cover. Increase carbon stocks by 2025 through reforestation and fully-stocking forestlands (see AFW-5).
- **Parties Involved:** TBD
- **Other:**

Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

Related Policies/Programs in Place

Some counties have comprehensive land use plans in place that encourage retention of forestland (e.g., Aitkin County), but many counties either do not have such plans or their plans do not address forestland retention. The same statement applies to municipalities. It is unlikely that any of these plans encourage no net loss of carbon stocks.

The Minnesota Forest Legacy Partnership is a group of public and private business and non-profit interests engaged in promoting large-scale forest conservation easements in northern and central Minnesota. A 51,000+ acre forest easement in Koochiching and Itasca County was recently completed, and two additional easements comprising a total of 76,000 acres have been proposed in Koochiching County (located on the Ontario border in north central MN). The funding for purchasing the 51,000 easement was obtained from private foundation, other private, and state sources, and funding for the additional easements is being sought from these plus federal sources. Additional forestland easements from 1,600 to over 5,000 acres have recently been completed in Itasca, Crow Wing, and Lake counties, in part with federal Forest Legacy funds. Smaller forestland easements have been completed in other counties (e.g., Rice County).

Although a number of federal and state technical and financial assistance and educational programs for family forestland owners have been in place for many years, these programs are not specifically directed at forestland or carbon stock retention. Federal funding for these programs has declined in recent years, and is highly likely to decline further in coming years.

The Sustainable Forest Incentive Act provides for reduced property taxes for private landowners who make a long-term commitment to sustainable management of their forestland. Neither this program nor other forestland tax policy, however, is specifically designed to retain forestland or carbon stocks.

The Minnesota Forest Resources Council has funded research by the University of Minnesota on rates of parcelization and subsequent development of forestland in Itasca County. Funds are being sought from private and public sources to extend this research across northern Minnesota, to evaluate current use and potential applicability in Minnesota of the policy tools listed above plus other tools (e.g., land exchange, fee title ownership, regulatory programs), and to make recommendations to the legislature.

Types(s) of GHG Reductions

CO_2: Avoided emissions from forest clearing and maintenance of annual carbon sequestration from forest growth.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 ($MMtCO_2e$):** 5.4, 5.7
- **Net Cost per $MtCO_2e$: TBD**
- **Data Sources:** US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy 1605(b) Voluntary GHG Reporting Program); Strong, Terry F. 1997. Harvesting intensity influences the carbon distribution in a northern hardwood ecosystem. North Central Research Station Research Paper NC-329; Austin, Kemen. 2007. The intersection of land use history and exurban development: Implications for carbon storage in the northeast. Bachelor's thesis, Brown University. Data provided by the USFS for the MN Forestry Inventory and Forecast.
- **Quantification Methods:**

Carbon savings from this option were estimated from two sources: (1) the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., "avoided emissions"); and (2) the amount of annual carbon sequestration potential that is maintained by protecting the forest area.

(1) Avoided Emissions

Carbon savings from avoided emissions were calculated using statewide average estimates of total standing forest carbon stocks in MN, provided by the USFS as part of the Forest Inventory and Forecast for MN (Appendix H).

Loss of forests to development results in a large one-time surge of carbon emissions. In this case, it was assumed that 53% of the vegetation carbon stocks (Strong 1997) and 35% of the soil carbon stocks (Austin 2007) would be lost in the event of forest conversion to developed uses, with no appreciable carbon sequestration in soils or biomass following development. Using the statewide average C densities from the MN FIA results, roughly 92.5 tons C are avoided for every hectare of forest preserved in MN (37.5 tons C avoided per acre preserved).

Between 1989 and 2003, roughly 14,952 hectares of forest were lost in MN annually (FIA statistics). To reach the no net forest loss target by 2015, this option therefore assumes that 14,952 hectares must be preserved each year beginning in 2015. The number of hectares targeted for policy implementation between 2008 and 2015 was calculated by dividing 14,952 by eight and implementing the option gradually and linearly over the eight years between 2008 and 2015.

Each year, the number of hectares estimated to remain in forest as a result of the program was converted to units of million metric tons CO2 equivalent (MMTCO2e) to estimate avoided emissions. Table 1 shows the annual and total hectares targeted by the program and associated avoided emissions that would be generated between 2008 and 2020.

Table 1. Hectares protected from conversion and associated avoided emissions.

	Hectares protected from development	Avoided emissions from development (t C/ yr)
2008	2,990	276,648
2009	5,980	553,295
2010	8,970	829,943
2011	11,960	1,106,591
2012	14,950	1,383,238
2013	14,950	1,383,238
2014	14,950	1,383,238
2015	14,950	1,383,238
2016	14,950	1,383,238
2017	14,950	1,383,238
2018	14,950	1,383,238
2019	14,950	1,383,238
2020	14,950	1,383,238
cumulative totals	164,450	15,215,621

(2) Annual Sequestration Potential in Protected Forests

The calculations in this section of the analysis used default carbon sequestration values for Aspen-Birch and Spruce-Fir forest types in the Northern Lake States (USFS GTR-343, Tables A7 and A11). Average annual carbon sequestration for these forest types was calculated over 125 years by subtracting non-soil carbon stocks in 125-yr old stands from non-soil carbon stocks in new stands and dividing by 125 (Table 2). Soil carbon density was assumed constant and is not included in the calculation.

Table 2. Forest Carbon Sequestration Rates

	MtC/ha (0 yr)	MtC/ha (125 yr)	MtC/ha/yr (average)
Aspen-Birch	25.6	143.0	0.9
Spruce-Fir	51.9	174.9	1.0

Since 41% of MN forests statewide are Aspen-Birch and 27% are Spruce-Fir (FIA statewide data, Appendix H), this option assumes that forests saved from development are roughly proportional to existing forests. Protected forests were assumed to be 66% Aspen-Birch and 38% Spruce-Fir.

The results for annual sequestration potential under policy implementation are given in Table 3. Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration potential includes benefits from acres preserved cumulatively under the program.

Table 3. Annual and cumulative C sequestration in forests protected from conversion between 2008 and 2020.

	Hectares protected from development		Cumulative C sequestration (t C/ yr) for land protected in all years
	this year	in prior years	
2008	2990	0	2971.4
2009	5980	2990	8914.3
2010	8970	8970	17828.6
2011	11960	17940	29714.4
2012	14950	29900	44571.6
2013	14950	44850	59428.8
2014	14950	59800	74286.0
2015	14950	74750	89143.1
2016	14950	89700	104000.3
2017	14950	104650	118857.5
2018	14950	119600	133714.7
2019	14950	134550	148571.9
2020	14950	149500	163429.1
cumulative totals		164450	995431.8

(3) Overall GHG benefit of avoided land conversion

The cumulative GHG benefit of avoided forest land conversion (including avoided emissions from reduced conversion as well as annual sequestration in protected forest) was calculated in units of MMTCO2e (Table 4). Figure 1 shows the relative impact of avoided emissions and sequestration in protected acreage.

Table 4. Combined GHG impact of avoided forest land conversion under policy implementation.

	t C/ yr	MMTCO2e/yr
2008	279619.1	1.0
2009	562209.6	2.1
2010	847771.6	3.1
2011	1136305.0	4.2
2012	1427809.9	5.2
2013	1442667.0	5.3
2014	1457524.2	5.3
2015	1472381.4	5.4
2016	1487238.6	5.5
2017	1502095.8	5.5
2018	1516953.0	5.6
2019	1531810.2	5.6
2020	1546667.4	5.7
Cumulative total		59.4

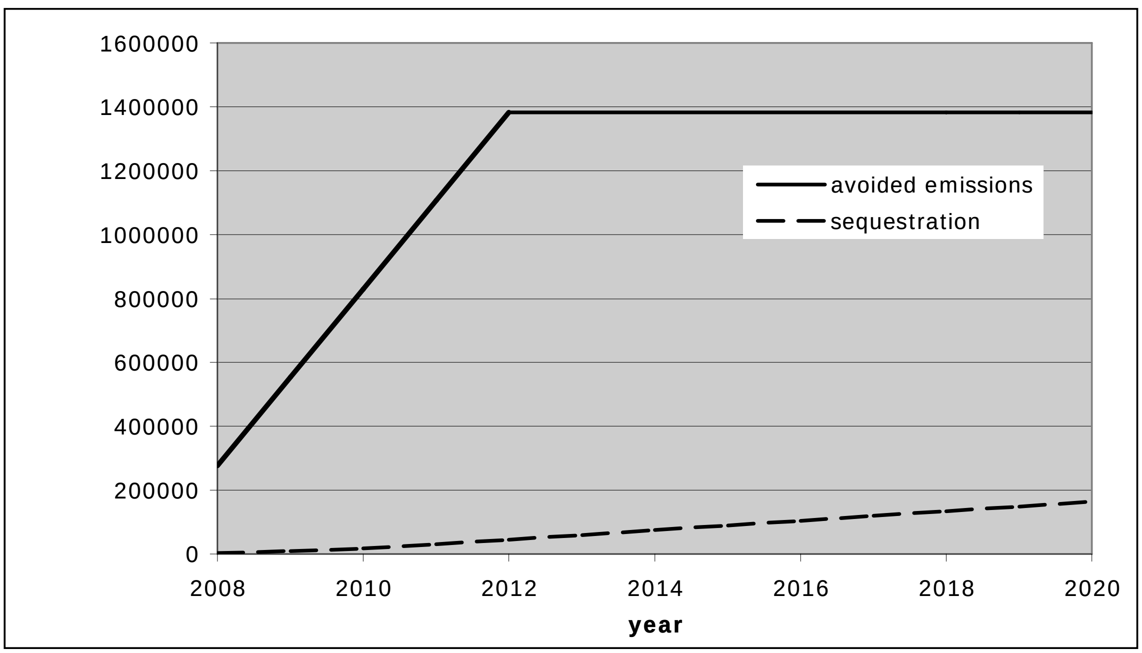

Figure 1. Relative impact of avoided emissions from protecting forest and annual sequestration on protected acreage for AFW-6.

Economic Analysis

Need data from TWG on implementation mechanisms: easements, acquisition? $$ Costs of each?

- **Key Assumptions: [**TBD, as needed on TWG approval]

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-7 Integrated Waste Management

Policy Description

Integrated waste management promotes the reduction of the sheer volume of waste produced as well as a reduction in consumption through incentives, awareness and increased efficiency. Three major areas of focus in Minnesota are source reduction, organic waste management and advanced recycling. Source reduction and recycling provide GHG benefits not only from avoided landfill emissions, but also product lifecycle emission reductions (associated with the manufacture and transport of new packaging/products). Redirecting organic wastes (such as food, yard, and paper) from landfills into composting programs or energy recovery is very effective at reducing methane emissions, since the organic fraction of the waste stream is responsible for methane generation.

Policy Design

Goals:

- *Source Reduction Goal: Achieve a 3% per capita decrease in waste generation by 2025.*
- *Recycling and Composting:* Minnesota will achieve a combined recycling and composting (diversion) rate of 75% by the year 2025.

Timing:

- *Source Reduction: Achieve a 0% per capita increase by 2020 and a reduction of waste generation per capita of 3% by 2025.*
- *Recycling and Composting:* Recycling rate of 50% by 2011 and 60% by 2025. Composting rate of 10% by 2012 and 15% by 2020 (for a total diversion rate of 75% by 2025).
- **Parties Involved:** Food Residuals Diversion Team (currently staffed from MN Office of Environmental Assistance); MPCA; others,
- **Other:** Current per capita increase in waste generation is 1.9%/yr. In 2005, the state of Minnesota had a recycling rate of 41%, a composting rate of 5% (although mostly yard waste, 0.02% was source separated compostables which represented a doubling from the prior year) and an estimated source reduction rate of 3% (citation – 2005 SCORE report?).

Implementation Mechanisms

TBD –

Source Reduction: Reduce the volume of wastes from residential, commercial, and government sectors through programs that reduce overall disposal. Reduction of waste generation at the source – of production (including packaging) and of consumption – reduces both landfill and waste to energy (WTE) combustion emissions as well as upstream production emissions. To achieve the source reduction goals of this policy, MN should:

1. Identify consumer products and packaging that are neither recyclable nor compostable;
2. Voluntary initiatives, including increasing consumer education about waste and working with manufacturers and retailers to change packaging type and reduce overall packaging would be developed, prioritized and targeted at products and packaging based on the quantities in the waste stream and the energy intensiveness of their production and the emissions resulting from their ultimate disposal. Depending on the success of these initiatives, other options could include product stewardship and regulations to reduce use of non recyclable and non-compostable materials;
3. .

Organic Waste Recovery: Reduce methane emissions associated with landfilling by reducing the biodegradable fraction of waste emplaced and also remove the wet and dense fraction that reduces the BTU potential of the combustible components of the waste stream (for use in waste to energy or WTE applications, see AFW-8). To achieve the organic waste recovery goals of this policy, MN should:

1. Increase recycling of organic wastes (lawn & garden, food waste, wood, paper, etc.) through the use of various methods including food to people (food recovery) and food to animals;
2. Expansion of composting programs;
3. Digestion?.

Recycling: Increase reuse and recycling in order to limit greenhouse gas emissions associated with landfill methane generation, waste combustion, waste-to-energy combustion processes, and the extraction of raw materials and energy consumption during the manufacturing process. To achieve the recycling goals of this policy, MN should:

1. Expand existing re-use and recycling programs;
2. Create new recycling programs;
3. Provide incentives for the reuse/recycling of construction materials;
4. Develop markets for recycled materials;
5. Increase average participation/recovery rates for all existing recycling programs.
6.

Related Policies/Programs in Place

Recycle More Minnesota Campaign: The Minnesota Pollution Control Agency (MPCA) is undertaking a campaign to "reinvigorate recycling". The state has one of the nation's highest recycling rates, but the MPCA intends to increase that rate. This effort is an important means to attaining the Agency's strategic goal to achieve a statewide 43 percent recycling rate by January 1, 2007 and a 50 percent recycling rate by January 1, 2011. Of garbage sent to the landfill, 75 percent is recyclable. . In fact, the PCA is aware of over 500,000 tons of material (paper, plastic, metals, and glass) from residential waste that could be recycled. That material is worth over $82 million. Even a slight increase in the rate has a significant impact on reducing greenhouse gas emissions. http://www.pca.state.mn.us/publications/reports/lrw-sw-1sy06.pdf.

MN State Resource Recovery Program. The State Resource Recovery Program is intended to promote waste reduction and recycling in Minnesota government. It has targeted programs to reduce office paper waste, reduce the costs and materials associated with publication design and printing; promote reuse of materials and commodities; and recycle paper, cans, glass and plastic. Currently there is a recycling challenge involving state buildings. http://www.rro.state.mn.us/.

Increase Organics Recovery: MPCA promotes increased composting of yard waste and other source separated organics. By applying it to soils, compost sequesters carbon by utilizing the short term carbon cycle. In 2005, about 19,000 tons of compost was created and used as soil amendment. That is only capturing about 1% of the organic materials in the solid waste stream. A more aggressive effort could capture 5% to 10% of the organics in the solid waste stream. The agency is also promoting the collection of restaurant and grocery store waste to be used as food for hogs and other recovery options. This does not include any industrial waste such as vegetable processing wastes, bio-solids, manure composting or digestion. There is a large potential here that is as yet untapped. MPCA is working to increase the amount of organic material recovered. http://www.reduce.org/compost/index.html.

MPCA Waste-to-Energy Program: waste to energy produces clean, reliable, renewable power, and is a vital part of the energy infrastructure in those Minnesota communities where such facilities are located. Currently, nine waste-to-energy facilities in Minnesota process 3,800 tons of MSW per day for industrial heat and electrical generation. The total energy reclaimed since 1982, when these facilities first began to come on-line, is the equivalent of 12 million tons of coal. Currently, these facilities produce approximately 100,000 megawatts of electrical energy, or enough energy to power 110,000 homes. The MPCA has a strategic objective to increase the state's waste-to-energy capacity by 60% by 2011. In 2005, Minnesota waste-to-energy reduced carbon dioxide and methane gases by an amount equivalent to taking 90,000 cars off the road. http://www.pca.state.mn.us/publications/reports/lrw-sw-1sy06.pdf.

Types(s) of GHG Reductions

- **CO_2:** Upstream Energy Use Reductions – The energy and GHG intensity of manufacturing a product/packaging is generally less using recycled feedstocks than from using virgin feedstocks. Source reduction also reduces upstream energy use, since fewer products/packaging are needed.
- **CH_4:** Diverting biodegradable wastes from landfills will result in a decrease in methane gas releases from landfills.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 ($MMtCO_2e$): TBD, TBD**
- **Net Cost per $MtCO_2e$: TBD**
- **Data Sources:** Data on current waste generation and recycling rates taken from the 2005 SCORE Programs report.[22] As stated in the goals section above, in 2005, the state of Minnesota had a recycling rate of 41%, a composting rate of 5% (although mostly yard waste, 0.02% was source separated compostables which represented a doubling from the

[22] *Report on 2005 SCORE Programs, A summary of waste management in Minnesota,* MPCA, 2006.

prior year) and an estimated source reduction rate of 3%.GHG emission reductions modeled using EPA's Waste Reduction Model (WARM).[23]

- **Quantification Methods:** Table 7-1 provides the latest MN municipal solid waste (MSW) generation data from the 2005 SCORE report.

Table 7-1. Current MN MSW Generation

	1991	1998	1999	2000	2001	2002	2003	2004	2005	Changes 2004-05
Greater Minnesota	1.54	2.07	2.14	2.21	2.32	2.37	2.41	2.53	2.56	1.3%
Metropolitan Area	2.37	3.22	3.30	3.42	3.42	3.49	3.51	3.45	3.52	2.1%
Minnesota	3.90	5.29	5.44	5.63	5.74	5.86	5.92	5.98	6.09	1.8%

Projections for waste management in MN were developed based on the 41% current level of recycling and information provided in the 2005 SCORE report. The business-as-usual (BAU) waste management projection for MN is provided in Table 7-2.

Table 7-2. BAU Waste Management Projection for MN

Item	Tons				
	2005	2010	2015	2020	2025
MSW Generation (1.9%/yr growth 1998-2005)	6,090,000	6,690,957	7,351,215	8,076,627	8,873,623
MSW Generation per capita (tons/person)	1.17	1.28	1.40	1.53	1.67
MSW Recycled (41%)	2,496,900	2,743,292	3,013,998	3,311,417	3,638,185
MSW Disposed in landfills	2,252,874	2,475,186	2,719,435	2,987,787	3,282,619
Waste to Energy (35% of waste not recycled)	1,243,213	1,365,892	1,500,677	1,648,763	1,811,461
On-site Disposal (2%)	71,862	78,953	86,744	95,304	104,709
MSW & Source-Separated Compost (0.7%)	25,152	27,634	30,361	33,356	36,648

[23] Version 7, August 2005. From http://www.epa.gov/climatechange//wycd/waste/calculators/Warm_home.html. EPA created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions from several different waste management practices. WARM is available both as a Web-based calculator and as a Microsoft Excel spreadsheet. WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon equivalent (MtCe), metric tons of carbon dioxide equivalent ($MtCO_2e$), and energy units (million BTU) across a wide range of material types commonly found in municipal solid waste. For explanation of methodology, see the EPA report: *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* (EPA530-R-02-006), at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

Table 7-3. Waste Management Projection for MN Including Policy Goals

Item	Tons				
	2005	2010	2015	2020	2025
MSW Generation (based on Source Reduction Goals)	6,090,000	6,690,957	7,351,215	8,076,627	8,636,993
MSW Generation per capita (tons/person)	1.17	1.28	1.40	1.50	1.46
MSW Source Reduced	-	-	-	-	236,630
Incremental MSW Recycled (2011- 50% rate; 2025- 60% rate)	-	164,598	331,540	463,598	691,255
MSW Disposed in landfills (after incremental recycling & composting)	2,252,874	2,171,480	2,078,946	2,081,980	1,848,225
Waste to Energy (35% of waste not recycled)	1,243,213	1,308,941	1,385,964	1,488,358	1,490,413
On-site Disposal (2%)	71,862	75,661	80,114	86,032	86,151
MSW & Source-Separated Compost (2012 - 10%; 2020 - 15%)	25,152	226,984	460,653	645,242	646,133

To estimate the GHG reductions associated with the changes in MSW management between Tables 7-2 and 7-3, two different WARM runs were conducted to represent BAU and Policy Scenario waste management in 2015 and 2020. WARM provided estimates of GHG reductions due to changes in landfilling practices (including subsequent landfill methane emissions), source reduction, and increased recycling. For source reduction and recycling, WARM estimates lifecycle GHG reductions associated with lower energy use from fewer products/packaging being manufactured and fewer raw (virgin) materials being used.

Costs

Source Reduction. The net cost for source reduction is the cost associated with implementing the associated programs minus the landfill tipping fees. Program implementation costs include education and program staffing. Costs estimated for implementing source reduction via "Pay as You Throw" (PAYT) programs was estimated at $2.00/household) during the analysis of a similar option in Colorado.[24] Landfill tipping fees are currently $15/ton and are expected to double by 2020.

Recycling. The cost of increasing recycling rates in MN is calculated by taking the difference of the sum of the capital cost and collection cost and the cost saved through avoided landfill tipping fees. The capital costs are determined on a per-household basis, with the figure of $129 per household derived from input given to a similar state climate change planning process in Vermont.[25] The annual cost of collection per household is assumed to be

[24] Personal communication from E. Lombardi, Eco-Cycle, to B. Strode, CCS, September 5, 2007.

[25] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, April 26, 2007.

$60 per year ($5 per month per household).[26] The landfill tipping fee is currently $15 per ton, expected to double by 2020.[27]

Composting. Information on the capital and operating costs of composting facilities was received from Cassella Waste Management during the analysis of a similar option in Vermont.[28] These data are summarized in Table 7-4 below.

Table 7-4. Cost Information for Composting Facilities

Annual Volume (tons)	Capital Cost (2007$,000)	Operating Cost ($/ton)
<1,500	75	25
1,500-10,000	200	50
10,000-30,000	2,000	40
30,000-60,000+	8,000	30

CCS assumed that the composting facilities to be built within the policy period would tend to be from the largest category (achieving the most efficient operating costs) shown in Table 7-4. The composting volumes in 2015 and 2025 shown in Table 7-3 suggest the need for about 10 large composting operations by 2015 and another 4 large operations by 2025. To annualize the capital costs for these facilities, CCS assumed a 15-year operating life and a 5% interest rate.

Table 7-5 below provides a summary of the annualized costs for each of the policy elements, as well as a total policy cost. The GHG reductions in each year are also included along with the overall cost effectiveness for the policy.

Table 7-5. Summary of Policy Costs

To be added.

- **Key Assumptions:** For the MSW management input data to WARM, the key assumption is that none of the goals would be achieved via existing programs in place. To the extent that those programs will achieve or partially achieve the goals of this policy, the GHG reductions estimated with WARM will be lower.

Key Uncertainties

TBD – [as needed and approved by the TWGs]

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[26] Personal communication from E. Lombardi, Eco-Cycle, to B. Strode, CCS, September 5, 2007.

[27] *Ibid.*

[28] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007.

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]

Draft Policy Option

AFW-8 End of Use Waste Management Practices

Policy Description

Promote activities that reduce greenhouse gas production during end-of-life disposal activities. Encourage and promote the use of energy recovery technologies for waste materials for which more desirable front–end waste management alternatives are not available or feasible. These projects will help reduce greenhouse gas emissions from waste management while producing cleaner energy. These technologies make a two-fold contribution to climate protection: the discharge of methane and other greenhouse gases into the atmosphere is reduced, and the burning of fossil fuels is replaced with recovered energy. For example, the energy created by bioreactor landfills (methane) can be used to make electric power, space heat, or liquefied natural gas.

Policy Design

- **Goals:** *Landfilled waste:* For all waste entering landfills in 2020, 90% of the methane generated over the lifespan of the facility will be captured.

  Organics recovery and waste-to-energy: by 2015, achieve a 35% reduction in the landfilling of organic waste through organics recovery (see AFW-7) or waste-to-energy.

  Waste to energy facilities: by 2020, all waste entering waste to energy facilities will be pre-processed to remove recoverable materials and enhance energy recovery.

- Timing: By 2015, identify which of the available end-of-use practices are best applied to the: 1) most energy intensive materials to produce, 2) the largest GHG emitting materials, and 3) by type, the materials that are found in the greatest quantity in the end-of-use waste stream.

- **Parties Involved:** TBD.

- **Other:** After implementing the upper hierarchy Front-End Waste Management goals (Reduce, Reuse, Recycling, Composting in AFW-7), the best End-of-Use practices should be employed to minimize the release of GHG emissions. The Minnesota Pollution Control Agency shall conduct ongoing evaluation of the success of front end abatement activities and the environmental viability and greenhouse gas reduction feasibility of different waste management technologies to refine and update information on best practices.

Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

Related Policies/Programs in Place

Currently, nine waste-to-energy facilities in Minnesota process 3,800 tons of MSW per day for industrial heat and electrical generation. The total energy reclaimed since 1982, when these facilities first began to come on-line, is the equivalent of 12 million tons of coal. Currently, these facilities produce approximately 100,000 megawatts of electrical energy, or enough energy to power 110,000 homes. The MPCA has a strategic objective to increase the state's waste-to energy capacity by 60% by 2011. In 2005, Minnesota waste-to-energy reduced carbon dioxide and methane gases by an amount equivalent to taking 90,000 cars off the road.

There are twenty-one open mixed municipal landfills in Minnesota. The majority of these facilities are owned and operated by county governments. Two of these facilities (Waste Management's Elk River Facility, and BFI's Pine Bend Facility) currently generate electricity derived from the collection and combustion of the methane gas generated as a result of waste decomposition. Methane is a potent greenhouse gas. A third facility, Three Rivers Landfill in Kanabec County, will be capturing methane for the production of energy in the near future. Lyon County is currently assessing the potential of a landfill gas-to-energy project at their county owned facility. The MPCA has been proactive with landfill owners and operators in promoting and encouraging the capture and utilization of this valuable resource.

Types(s) of GHG Reductions

- **CH_4:** Reductions in landfill methane via composting or digestion of organics instead of landfilling. Landfill methane reductions via collection and control (via flaring, or preferentially via energy utilization).
- **CO_2:** Reduction of fossil fuels and associated GHGs through the generation of electricity from landfill methane.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG reduction potential in 2015, 2025 ($MMtCO_2e$): TBD, TBD**
- **Net Cost per $MtCO_2e$: TBD**
- **Data Sources:** This analysis builds on the analysis conducted for AFW-7. Therefore, the same data sources are applicable to this option.
- **Quantification Methods:** *GHG Reductions.*

  Organics recovery & waste to energy. From the AFW-7 analysis, CCS will develop estimates of the organic fraction of waste still being landfilled following the implementation of the source reduction/recycling. This amount of organic waste will be multiplied by 35% to determine the amount of organic waste targeted under this policy. The amount of organic waste being utilized under the AFW-7 composting element will be subtracted from this amount to estimate the amount of organic waste remaining for energy recovery.

  For the remaining organic waste, CCS will derive an estimate of the dry tons available, associated heat content, potential electricity generation, and the GHGs offset from the electricity produced. *CCS requests input from the TWG on typical moisture content of organic waste, heat content, and heat rates for MN WTE plants.*

Costs. Based on the mass of waste available, we'll need to determine if additional WTE plants are needed. If additional plants are needed, we'll need some estimates on capital and operating costs.

Methane recovery from landfilled waste. For the waste still entering landfills in 2020 and beyond, CCS will enter these amounts into EPA's Landfill Gas Emissions Model (LandGEM) to determine the amount of methane to be generated in subsequent years. Per the policy design, 90% of the methane is to be captured (CCS also assumes that it will be utilized for energy recovery). The GHGs reductions associated with this capture and use will be compared to a baseline of methane capture and use from the GHG inventory & forecast. The benefit of the policy will be the incremental GHGs reduced per the 90% capture/control requirement as compared to the baseline.

Costs. CCS requests feedback on the following assumptions: most of the waste entering MN landfills by 2020 will be directed to larger modern landfill sites that have collection and control systems in place (due to federal NSPS/EG requirements). To achieve compliance with the policy goals, waste would need to be directed to these modern sites. Most industry contacts feel that their modern landfills already do capture 90% or more of the methane generated. Hence, incremental capital costs do not seem to apply to this policy element.

Since it was not included in the policy design, CCS requests input from the TWG on whether to include the incremental costs of methane utilization versus flaring (which could be considered o.k. with the current text).

Waste to energy facilities. *CCS requests information from the TWG on information regarding the costs and benefits of this policy element. e.g. previous assessments at MN WTE facilities.*

- **Key Assumptions: [**TBD, as needed on TWG approval]

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

Pending – [until MCCAG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MCCAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MCCAG]