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## Catalog of State-Level GHG Reduction Policy Options Agriculture, Forestry, and Waste Management

Prepared by The Center for Climate Strategies (CCS) for the Montana Climate Change Advisory Committee (CCAC) and its Scientific Advisory Panel (SAP) and Technical Work Groups (TWGs) based on actions undertaken or considered by all US states.

### Key to Future Rankings of Options in the Table that Follows:

Potential Emission Reductions <u>1/</u>	Potential Cost or Cost Savings <u>1/ 2/</u>
<b>High (H):</b> At least 1 Million Metric Tons (MMT) carbon dioxide equivalent (CO <sub>2</sub> e) per year by 2020 (~1% of current MT emissions)	<b>High (H):</b> \$50 per Metric Ton CO <sub>2</sub> e (MTCO <sub>2</sub> e) or above
<b>Medium (M):</b> From 0.1 to 1 MMT CO <sub>2</sub> e per year by 2020	<b>Medium (M):</b> \$5-50/MTCO <sub>2</sub> e
<b>Low (L):</b> Less than 0.1 MMT CO <sub>2</sub> e per year by 2020, or 1 MMT CO <sub>2</sub> e by 2050	<b>Low (L):</b> Less than \$5/MTCO <sub>2</sub> e
<b>Uncertain (U):</b> Not able to estimate at this time	<b>Uncertain (U):</b> Not able to estimate at this time
<p><small>1/ Several measures may overlap in terms of emissions reductions and/or cost impacts. Estimates assume measures would be implemented independently from other measures.</small></p> <p><small>2/ Costs are denoted by a positive number. Cost savings (i.e., “negative costs”) are denoted by a negative number.</small></p>	

### Definition of “Priorities for Analysis”:

- **High:** High priority options will be analyzed first.
- **Medium:** Medium priority options will be analyzed next, time and resources permitting.
- **Low:** Low priority options will be analyzed last, time and resources permitting.

Notation of Options: Options will be marked with an asterisk (\*) at a later date to indicate options that are at least partially “base case” policies, i.e., that have been considered or undertaken at some level in Montana.

**Potential State Actions - Agriculture, Forestry, & Waste Management (AFW)**

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
<b>AFW-1</b>	<b>AGRICULTURE – PRODUCTION OF FUELS AND ELECTRICITY</b>					
1.1	Manure Digesters/Other Waste Energy Utilization		low	Neg to Low	<ul style="list-style-type: none"> <li>Linked with Option AFW2.2 below</li> </ul>	<ul style="list-style-type: none"> <li>Low potential for reductions in MT due to low level of confined animal feeding operation activity</li> <li>Recent proposed projects to incorporate this option with ethanol production (e.g. beef feedlots) in other states.</li> <li>Includes manure combustion for energy recovery</li> </ul>
1.2	Biodiesel Production (incentives for feedstocks and production plants)		Medium	?	<ul style="list-style-type: none"> <li>Production from both virgin and waste vegetable oils</li> </ul>	<ul style="list-style-type: none"> <li>Costs are dependent upon the design of incentives program</li> <li>Could be limited to small on farm operations</li> </ul>
1.3	Biomass Feedstocks for Electricity or Steam/Heat Production		Medium	Neg to Low	<ul style="list-style-type: none"> <li>Need to identify viable feedstocks and volumes [e.g. crop residue (wheat straw, corn stover) or energy crops (switchgrass)]</li> </ul>	<ul style="list-style-type: none"> <li>Linkage to Energy Supply TWG to determine availability of biomass plants or co-firing opportunities</li> <li>Linkage to RCI TWG for offsets of fossil based steam or space heat</li> </ul>

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1.4	Ethanol Production		Medium	?	<ul style="list-style-type: none"> <li>Starch- (e.g. corn-) and cellulosic production processes</li> <li>Costs dependent on structure of incentives program</li> </ul>	<ul style="list-style-type: none"> <li>Starch-based ethanol has small GHG benefits, while cellulosic ethanol has much higher benefits due to the energy required for ethanol production</li> <li>Additional benefits can be achieved through capture of CO<sub>2</sub> during fermentation</li> </ul>
<b>AFW-2</b>	<b>AGRICULTURE – FERTILIZER AND MANURE MANAGEMENT</b>					
2.1	Nutrient Management (improve efficiency of fertilizer use)		Low to Medium	Low	<ul style="list-style-type: none"> <li>Significant opportunities beyond current practice?</li> </ul>	
2.2	Manure Management (improve application methods)		Low	?	<ul style="list-style-type: none"> <li>Linked with Option AFW1.1 above and 2.1, 2.3 below.</li> <li>Co-benefits include reduction of ammonia and VOC emissions.</li> </ul>	<ul style="list-style-type: none"> <li>Application improvement includes incorporation into soil, instead of surface spray/spreading.</li> <li>Low reduction potential due to low estimated emissions from manure application.</li> </ul>
2.3	Manure Composting		Low	Low to Med	<ul style="list-style-type: none"> <li>Potentially most feasible in the beef cattle sector.</li> </ul>	<ul style="list-style-type: none"> <li>Potential for reduction in CH<sub>4</sub> emissions.</li> <li>Current science on levels of CH<sub>4</sub> reduction uncertain; potential for increase in N<sub>2</sub>O.</li> </ul>
2.4	Change Feedstocks (optimize nitrogen for N <sub>2</sub> O reduction and enteric CH <sub>4</sub> reduction)		Low	High	<ul style="list-style-type: none"> <li>Co-benefits include reduction in ammonia emissions.</li> </ul>	<ul style="list-style-type: none"> <li>Option includes supplements to reduce CH<sub>4</sub> from enteric fermentation, as well as nitrogen efficiency to reduce downstream N<sub>2</sub>O.</li> </ul>

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2.5	Reduce Non-Farm (Residential and Commercial) Fertilizer Use		Low	?	<ul style="list-style-type: none"> <li>Emissions from non-farm application are not currently in the inventory; unclear what the costs would be.</li> </ul>	<ul style="list-style-type: none"> <li>Additional research needed on the levels of N20 emissions from lawns, golf courses, etc.</li> </ul>
<b>AFW-3</b>	<b>AGRICULTURE – SOIL CARBON MANAGEMENT</b>					
3.1	Conservation Tillage/No-Till (carbon sequestration and reduced energy use)		Med to High	Low	<ul style="list-style-type: none"> <li>Significant opportunities beyond current practice?</li> </ul>	<ul style="list-style-type: none"> <li>Need estimates on current practices/potential for increased acreage.</li> </ul>
3.2	Reduce Summer Fallow (increase soil C content, reduce N <sub>2</sub> O emissions)		Medium	Low	<ul style="list-style-type: none"> <li>Significant opportunities beyond current practice?</li> </ul>	<ul style="list-style-type: none"> <li>Need estimates of fallow summer acreage</li> </ul>
3.3	Increase Winter Cover Crops (increase soil C and/or N content)		Low	Low	<ul style="list-style-type: none"> <li>Significant opportunities beyond current practice?</li> </ul>	<ul style="list-style-type: none"> <li>Need estimates of winter acreage available for cover crops</li> </ul>
3.4	Improve Water and Nutrient Use (to minimize soil C loss)		Low	Low	<ul style="list-style-type: none"> <li>Significant opportunities beyond current practice?</li> </ul>	
3.5	Rotational Grazing/Improve Grazing Crops and/or Management		Low	Low	<ul style="list-style-type: none"> <li>Is impaired rangeland an issue in MT?</li> </ul>	
3.6	Incentives for Maintenance of Conservation Reserve Program (CRP) Acreage		Medium to High	?	<ul style="list-style-type: none"> <li>Option protects carbon on existing CRP acres that are projected to enter back into active production</li> </ul>	<ul style="list-style-type: none"> <li>Costs are dependent on the design of the incentives program</li> <li>Note tax implications locally</li> </ul>
3.7	Incentives for Establishing Windbreaks		Medium	?	<ul style="list-style-type: none"> <li>Size of the benefit dependent on the amount of windbreak acreage</li> </ul>	<ul style="list-style-type: none"> <li>Benefits are achieved via higher above and below ground carbon stocks</li> </ul>

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3.8	Promote Weed Management Programs		?	?	<ul style="list-style-type: none"> <li>Difference in carbon density between knapweed and grassland</li> </ul>	<ul style="list-style-type: none"> <li>Benefits are potentially achieved through lower fuel consumption, and lower chemical inputs. According to Joel Brown, NRCS, these programs not likely to achieve significant carbon benefits due to differences in above and below ground carbon between weedy cover and native cover.</li> </ul>
<b>AFW-4 AGRICULTURE – LAND USE CHANGE</b>						
4.1	Convert Land to Grassland or Forest or Woody Shrubs		Medium	Med to High	<ul style="list-style-type: none"> <li>Reductions dependent on available acreage and end use</li> </ul>	<ul style="list-style-type: none"> <li>Need estimates of marginal agricultural land with the potential for conversion.</li> <li>Policies should favor native species</li> </ul>
4.2	Preserve Open Space/Agricultural Land		High	Med to High	<ul style="list-style-type: none"> <li>Reductions occur both from higher retention of carbon in soil and lower transportation activity</li> </ul>	
4.3	Promote “No Net Loss” of Agricultural Land		High	Med to High	<ul style="list-style-type: none"> <li>Reductions occur both from higher retention of carbon in soil and lower transportation activity</li> </ul>	
4.4	Promote Restoration of Wetlands		?	?	<ul style="list-style-type: none"> <li>Benefits are dependent on both changes in above- and below-ground carbon stocks and potential changes in GHG emissions (e.g., CH4)</li> </ul>	<ul style="list-style-type: none"> <li>Could also consider protection of existing uncultivated organic soils.</li> </ul>
<b>AFW-5 AGRICULTURE – FARMING PRACTICES</b>						

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5.1	Convert Diesel Farm Equipment to LNG/CNG, Hybrid Technology, or Biodiesel		Low	Medium to High	<ul style="list-style-type: none"> <li>LNG/CNG engines or engine conversions reduce BC emissions</li> <li>Availability of diesel hybrid equipment for farm applications?</li> </ul>	•
5.2	Organic Farming		Low to Medium	Low	<ul style="list-style-type: none"> <li>Reductions occur via lower intensity agricultural practices (nutrient/pesticide application, reduced tillage)</li> </ul>	•
5.3	Programs to Support Local Farming/Buy Local		Medium	?	<ul style="list-style-type: none"> <li>Reductions occur through lower transport related emissions.</li> </ul>	•
5.4	Policies to Promote Non-Irrigated Cropland		?	?	<ul style="list-style-type: none"> <li>Reductions occur through lower water use and associated pumping</li> </ul>	<ul style="list-style-type: none"> <li>What changes in cultivation practices occur as a result of change over to non-irrigated cropland?</li> </ul>
<b>AFW-6</b>	<b>FORESTRY – BIOMASS PROTECTION AND MANAGEMENT</b>					
6.1	Forest Protection – Reduced Clearing and Conversion to Nonforest Cover		Low	Low to Med	<ul style="list-style-type: none"> <li>Depends on business as usual rates of land clearing and viable alternatives</li> </ul>	•
6.2	Increase Maintenance of Urban and Residential Trees		Low	Low to High	<ul style="list-style-type: none"> <li>Lowers energy use and has other benefits</li> </ul>	<ul style="list-style-type: none"> <li>Includes planting of new trees</li> </ul>
6.3	Afforestation and/or Restoration of Nonforested Lands		Low to High	Low	<ul style="list-style-type: none"> <li>depends on available acreage and risk</li> </ul>	•

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6.4	Reforestation/Restoration of Managed Stands		Low to High	Low	<ul style="list-style-type: none"> <li>depends on available acreage and risk</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
6.5	Improved Management of Existing Stands		Low to High	Low to High	<ul style="list-style-type: none"> <li>Benefits depend on available acreage</li> <li>Age extension of managed stands involves significant tradeoffs with carbon savings from harvested wood products, as well as ecological risk</li> <li>Thinning and density management can have cost and technology barriers to market use of harvested biomass may be high; supply potential is high</li> <li>Fertilization and waste recycling (e.g. mill waste) is site and situation specific</li> <li>For program elements that generate biomass-implementation and market barriers may be significant, potential is high if biomass is directed to constructive reuse</li> </ul>	<p>The policy could include a number of program elements, such as:</p> <ul style="list-style-type: none"> <li>Increased Stocking of Poorly Stocked Lands</li> <li>Age Extension of Managed Stands</li> <li>Thinning and Density Management of Managed Stands</li> <li>Fertilization and Waste Recycling</li> <li>Expanded Use of Genetically Preferred Species</li> <li>Modified Biomass Removal Practices (reduced decay and opportunities for energy use)</li> </ul>
6.6	Forest Health Programs: <ul style="list-style-type: none"> <li>Ecosystem Health Risk Reduction Programs</li> </ul>		Low to High	Low to Med	<ul style="list-style-type: none"> <li>benefits depend on available acreage</li> <li>other forest values</li> </ul>	<ul style="list-style-type: none"> <li>Programs may employ any number of the management practices covered by option</li> </ul>

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	(pest/disease, invasive species) <ul style="list-style-type: none"> <li>• Drought Management Programs (tree selection, placement, protection)</li> <li>• Flood and Riparian Management Programs (tree selection, placement, protection)</li> <li>• Watershed Management Programs (stand retention, enhancement and management)</li> <li>• Habitat Management Programs (stand retention, enhancement and management)</li> <li>• Fire Management and Risk Reduction Programs</li> </ul>				need to be considered (e.g. wildlife habitat)	6.5 to meet program objectives. <ul style="list-style-type: none"> <li>• May be opportunities to use biofuels for equipment.</li> </ul>
6.7	Expand Short Rotation Woody Crops (for fiber and energy)		Low to Medium	Low to High	<ul style="list-style-type: none"> <li>• depends on available acreage and market demand</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>
6.8	Promote Use of Fuel-Efficient Equipment or Alternative Fuels		Low to Medium	Low to Medium	<ul style="list-style-type: none"> <li>• Level of benefit dependent on program design (level of penetration)</li> </ul>	<ul style="list-style-type: none"> <li>• Alternative fuels include biodiesel</li> </ul>
<b>AFW-7</b>	<b>FORESTRY - WOOD PRODUCTS AND WASTE</b>					
7.1	Improved Mill Waste Recovery and Use		Low	Low to High	<ul style="list-style-type: none"> <li>• technology and market dependent</li> </ul>	<ul style="list-style-type: none"> <li>• Opportunities beyond current practice?</li> </ul>

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7.2	Improved Logging Residue Recovery		High	Low to High	• technology and market dependent	•
7.3	Expanded Use of Wood Products for Building Materials		Med to High	Low to High	• technology and market dependent • includes small diameter trees	• Supplant use of non-wood products (e.g. steel, cement) with wood products, where possible. • Could include expanded use of small diameter wood for products
7.4	Expanded Use of State and Locally-Grown Wood Products		Low to High	Low to High	• technology and market dependent	• Reduces transportation-related emissions and embedded energy.
7.5	Residential Slash/Open Burning Alternatives		Low to Med	Low to Med	• Benefit and cost effectiveness dependent on whether beneficial reuse is possible (e.g. as energy source)	•
<b>AFW-8</b>	<b>FORESTRY – ENERGY PRODUCTION</b>					
8.1	Expanded Use of Forest Biomass Feedstocks for Electricity (fuel switching)		High	Low	• technology and market dependent	•
8.2	Expanded Use of Forest Biomass Feedstocks for Residential, Commercial/Institutional, or Industrial Heating		High	Low	•	•
8.3	Improved Efficiency of Wood Burning Stoves and Direct Heat		Low to Medium	Med to High	•	• Option refers to change-outs in equipment

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8.4	Improved Energy Capture from Wood Waste Combustion		Low to High	?	<ul style="list-style-type: none"> <li>technology and market dependent</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
8.5	Improved Commercialization of Biomass Gasification and Combined Cycle		Low to High	Med to High	<ul style="list-style-type: none"> <li>requires improved technology and market incentives</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
8.6	Biofuels Production from Forest Residue				<ul style="list-style-type: none"> <li>Benefit dependent on the amount of residue diverted to fuel production</li> <li>Also included under AFW-1.6</li> </ul>	<ul style="list-style-type: none"> <li>New portable technology shows potential for ethanol production in the field.</li> </ul>
<b>AFW-9</b>	<b>WASTE MANAGEMENT – WASTE MANAGEMENT STRATEGIES</b>					
9.1	Advanced/Expanded Recycling and Composting		Low	Low to Medium	<ul style="list-style-type: none"> <li>Important element is the amount of additional energy required by the program</li> </ul>	<ul style="list-style-type: none"> <li>Could include expansion of recycling programs to rural areas.</li> </ul>
9.2	Advanced Municipal Solid Waste Management Practices (e.g., bioreactors)		Low	Neg to Low	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
9.3	Source Reduction Strategies		Low	Low	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Could include life-cycle requirements for manufacturers requiring them to take back the product after its useful life</li> </ul>
9.4	Resource Management Contracting		?	?	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Requires waste haulers to recycle portions of the waste collected.</li> </ul>

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9.5	Manure Digesters		Low	Neg to Low	•	• Also under Agriculture (Option AFW1.1)
9.6	Pricing Programs to Reduce Waste Generation		Low	?	•	• Pricing programs for waste paper cups, plastic bags, etc. to reduce generation and promote alternatives.
<b>AFW-10</b>	<b>WASTE MANAGEMENT – LANDFILL GAS STRATEGIES</b>					
10.1	Flare Landfill Methane at non-NSPS (smaller) sites		Low	Med to High	• Federal New Source Performance Standards and Emissions Guidelines require methane capture at larger landfills.	• Should be limited to consideration at sites where energy can not be recovered feasibly; • Need to consider energy required to collect CH4.
10.2	Convert Landfill Methane to Electric Power, Space Heat, or LNG		Low	Neg to Med	• Methane conversion to motor fuels, electricity, steam, or space heat are examples	•
<b>AFW-11</b>	<b>WASTE MANAGEMENT – WASTEWATER ACTIVITIES</b>					
11.1	Energy Efficiency Improvements		Low	Neg to Low	•	•
11.2	Lower Waste Processing Needs (lower water consumption, waste production)		Low	?	• Costs are industry and technology specific	•
11.3	Install Anaerobic Digesters and Engines/Turbines		Low	Med to High	• Can be used where sludge is anaerobically digested	•
11.4	Install Fuel Cells		Low	Med	• Can be used where sludge is anaerobically digested	•