Chapter 6
Agriculture, Forestry, and Waste Management

Overview of GHG Emissions

While the agriculture, forestry, and waste management (AFW) sectors are responsible for significant greenhouse gas emissions, the sector is also a significant sink for greenhouse gases in soils and in forest stocks. The gross AFW contribution to carbon dioxide equivalent (CO_2e) emissions in 2005 was 30 million metric tons (MMt), or about 25% of the state's total. However, the AFW contribution to net emissions in 2005 was only 3 $MMtCO_2e$ due to the net sequestration of carbon in the forestry and agriculture sectors. As described in the Iowa Inventory and Forecast (I&F) report, it is important to recognize that emissions from fossil fuel consumption within the AFW sectors are included within the residential, commercial, and industrial (RCI) sectors (particularly the industrial sector).

Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, agricultural soils management, and agriculture residue burning. These emissions were estimated to be about 28 $MMtCO_2e$ in 2005. As shown in Figure 6-1, emissions from soil carbon losses from agricultural soils, manure management, fertilizer application, and crop residues all make significant contributions to the sector totals. Emissions include CO_2 emissions from oxidized soil carbon, application of urea, and application of lime. Sector emissions also include N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic, organic, and livestock) application and production of nitrogen-fixing crops (legumes).

The largest source of emissions in the agricultural sector is the agricultural soils category, whose emissions are projected to hold steady from 1990 to 2025, accounting for 62% (15.7 $MMtCO_2e$) of total gross agricultural emissions in 1990 and 60% (15.3 $MMtCO_2e$) in 2025. In 1990, enteric fermentation accounted for about 20% (5.04 $MMtCO_2e$) of total gross agricultural emissions. Enteric fermentation emissions decreased slightly to 4.26 $MMtCO_2e$ between 1990 and 2005 due to the decline in livestock populations during this period. Both the dairy cattle and beef cattle populations are projected to decrease in the future, and enteric fermentation emissions are estimated to decrease to 2.98 $MMtCO_2e$ in 2025, or about 12% of agricultural emissions.

The manure management category accounted for 18% (4.49 $MMtCO_2e$) of total agricultural emissions in 1990 and increased to 24% (6.64 $MMtCO_2e$) by 2005. Manure management is projected to increase slightly by 2025, to account for 27% (7.01 $MMtCO_2e$) of total agricultural emissions at that time. This is largely due to the projection that the swine population will increase between 2005 and 2025.

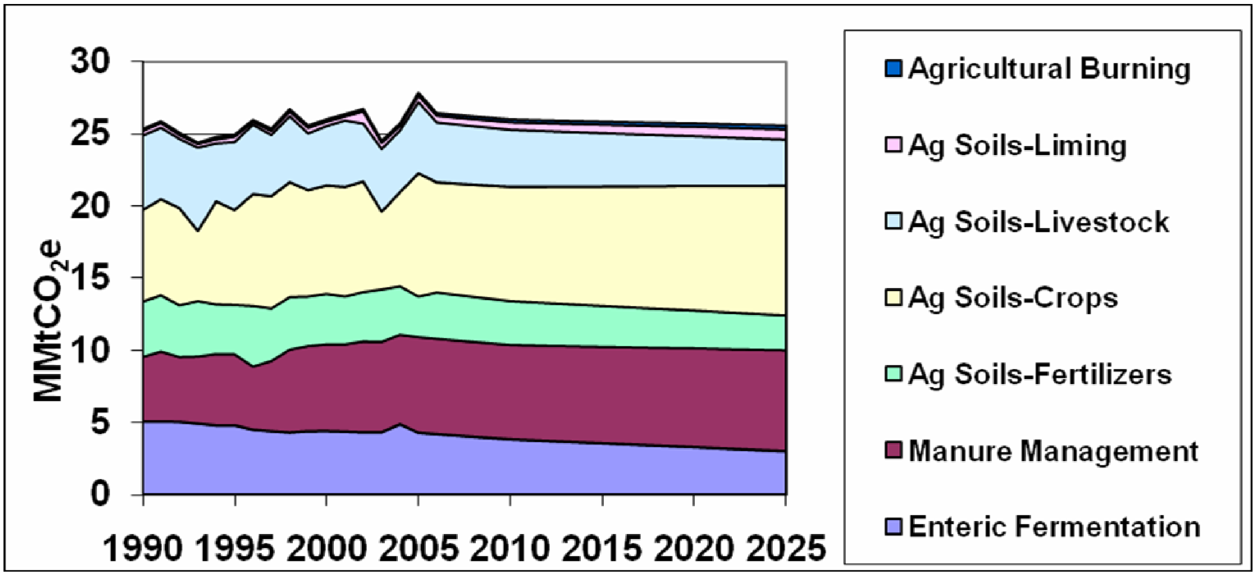
Forestland emissions refer to the net CO_2 flux[1] from forested lands in Iowa, which account for about 8% of the state's land area.[2] As shown in Table 6-1, U.S. Forest Service (USFS) data

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

[2] Total forested area and forest type percentages provided by P. Tauke, Iowa Department of Natural Resources [DNR]) to M. Stein (DNR) on March 21, 2008. The total land area in Iowa is 35.8 million acres (http://www.50states.com/iowa.htm).

suggest the total flux estimate including all forest pools is –12.2 $MMtCO_2e$/yr between 1990 and 2003, and is –24.4 $MMtCO_2e$/yr between 2003 and 2005.[3] These totals include large sink estimates for soil carbon (–4.3 and –9.2 $MMtCO_2$/yr). The negative trend in carbon flux (sequestration) is likely due to the increase in timberland between 1990 and 2005.

Figure 6-1. Historical and projected gross GHG emissions from the agriculture sector, Iowa, 1990–2025



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent

Notes: Ag Soils – Crops category includes: incorporation of crop residues and nitrogen-fixing crops (no cultivation of histosols estimated); emissions for agricultural residue burning are too small to be seen in this chart.

Table 6-1. Annual forest carbon fluxes for Iowa

Forest Pool	1990-2003 Flux ($MMtCO_2$)	2003-2005 Flux ($MMtCO_2$)
Forest Carbon Pools (non-soil)	–7.76	–15.1
Soil Organic Carbon	–4.28	–9.17
Harvested Wood Products	–0.12	–0.12
Totals	**–12.2**	**–24.4**
Totals (excluding soil carbon)	**–7.88**	**–15.3**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent

Note: Positive number indicates net emission. Based on U.S. Forest Service input, emissions from soil organic carbon are excluded from the forestry sector summary due to a high level of uncertainty.

Table 6-2, below, summarizes the estimated flux for the entire forestry and land use sector.

[3] Jim Smith, USFS, *US. Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (http://www.nrs.fs.fed.us/pubs/2394), December 2007.

Table 6-2. Forestry and land use flux and reference case projections ($MMtCO_2e$)

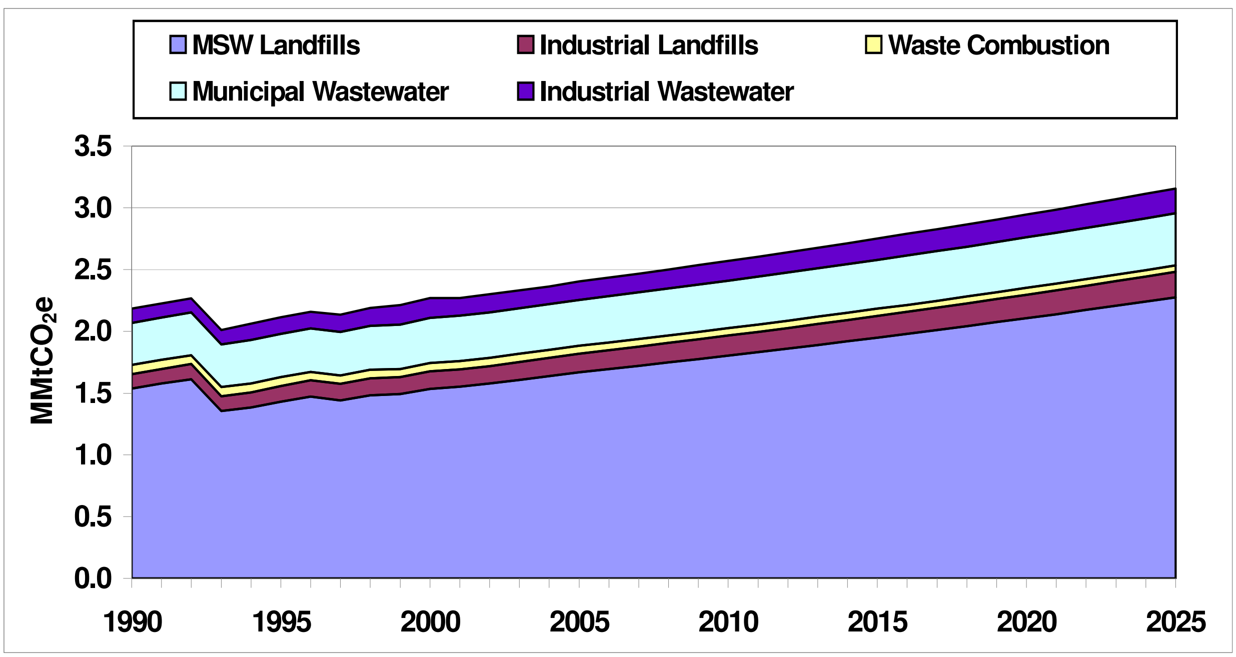
Subsector	1990	1995	2000	2005	2010	2020
Forested Landscape (excluding soil carbon)	–7.88	–7.88	–7.88	–15.3	–15.3	–15.3
Urban Forestry and Land Use	–2.59	–1.31	–0.65	–0.63	–0.63	–0.63
Forest Wildfires	N/A	N/A	N/A	N/A	N/A	N/A
Sector Total	**–10.5**	**–9.19**	**–8.53**	**–15.9**	**–15.9**	**–15.9**

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

Note: Positive numbers indicate net emission. N/A = not available.

Figure 6-2 shows estimated historical and projected emissions from the management and treatment of solid waste and wastewater. Emissions from waste management consist largely of CH_4 emitted from landfills, while emissions from wastewater treatment include both CH_4 and N_2O. Emissions are also included for municipal solid waste (MSW) combustion. Figure 6-2 illustrates that emissions from MSW landfills are projected to increase significantly through 2025. Overall, the waste management sector accounts for about 2% of Iowa's total gross emissions per year from 1990 through 2025.

Figure 6-2. Estimated historical and projected emissions from waste and wastewater management in Iowa



$MMtCO_2e$ = million metric tons carbon dioxide equivalent; MSW = municipal solid waste.

Opportunities for GHG mitigation in the AFW sector involve measures that can reduce emissions within the sector or in other sectors. Examples of reductions that can occur within the sector include changes in crop management practices that reduce GHG emissions by building soil carbon (indirectly sequestering carbon from the atmosphere); more efficient nutrient application (reducing N_2O emissions—note that emissions outside of the AFW sectors are also reduced here due to the embedded energy in nutrients and the potential for lower energy consumption during their application); reforestation projects that achieve GHG reductions by increasing the carbon sequestration capacity of the state's forests; and landfill gas collection and control, which reduces methane emissions from landfills.

For GHG reductions outside of the AFW sectors, actions taken within the sectors, such as production of liquid biofuels, can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply, residential, commercial, and industrial sectors. Similarly, actions that promote solid waste reduction or recycling can reduce emissions within the AFW sectors (future landfill CH_4), as well as emissions associated with the production of recycled products (recycled products often require less energy to produce than similar products from raw materials). Finally, urban forestry projects can reduce energy consumption within buildings through shading and wind protection.

Following are primary opportunities for GHG mitigation identified by the Iowa Climate Change Advisory Council (ICCAC).

- **Nutrient management:** Increasing the efficiency and improving the distribution of nutrient application can reduce on-field application of nitrogen and reduce formation of N_2O. Reductions may also occur when nitrogen runoff and leaching are reduced.
- **Wetlands and drainage:** Redesigning Iowa drainage systems with the consideration of GHG benefits can result in significant GHG benefits over the longer term through reduced nitrogen transport to water resources, which reduces N_2O emissions by reducing denitrification from wet and seasonally flooded croplands.
- **Expanded use of forest and agricultural biomass:** Expanding the use of biomass energy from residue removed from forested areas during treatments to reduce fire risk, from crop residues and purpose-grown crops, and from livestock manure/poultry litter can achieve GHG benefits by offsetting fossil fuel consumption (to produce either electricity or heat/steam). Programs to expand sustainably procured biomass fuel production will most likely be needed to supply a portion of the fuel mix for the renewable energy goals under the Energy Efficiency and Conservation (EEC) and Clean and Renewable Energy (CRE) Subcommittees.
- **Manure management and methane utilization:** The capture and utilization of methane from livestock manure can reduce GHG emissions through reduced methane emissions and through offsetting fossil fuel-based energy production and the associated GHG emissions. Additionally, implementing improved manure handling and storage programs, practices, and technologies can reduce methane emissions from animal operations.
- **Land management to promote sequestration benefits:** Significant opportunities exist through the adoption of a number of different land management practices that either reduce emissions or increase sequestration. These include increasing the use of conservation tillage practices, converting marginal agricultural land to higher-sequestration permanent cover, implementing conservation grazing practices, establishing afforestation programs, and increasing urban tree coverage.

- **Cellulosic biofuels:** Producing renewable fuels, such as ethanol from energy crops, crop residue, forestry residue, or municipal solid waste can produce significant reductions when they are used to offset consumption of fossil fuels (e.g., gasoline and diesel in the transportation sector). This is particularly true when these fuels are produced using processes and/or feedstocks that emit much lower GHG emissions than those from conventional sources (e.g., corn-based ethanol).
- **Improved on-farm (or first point of purchase) energy use and efficiency:** On-farm energy efficiency and renewable energy offer emission savings and reduced costs to land owners.
- **Changes in municipal solid waste management practices:** Concentrating on enhancing the source reduction, recycling, and organics management (e.g., composting practices) in the state can result in significant GHG emission reductions. Also, for waste remaining after full implementation of these "front-end" practices, appropriate GHG-beneficial "end-of-life" practices should be implemented, including enhanced landfill gas collection and utilization.

Key Challenges and Opportunities

Within the agriculture sector, the ICCAC recommends programs to promote farming practices that achieve GHG benefits, such as conservation tillage where soil management programs increase soil carbon levels, thereby indirectly sequestering carbon from the atmosphere. These programs were estimated to achieve reductions of approximately 9 $MMtCO_2e$ per year by 2020 through the implantation of conservation tillage practices on 75% of annual cropland by 2020.

Additionally, initiatives to reduce methane emissions from livestock manure through improved manure handling and storage practices and the capture and utilization of methane offer significant potential at low or negative costs. However, the feasibility of utilizing methane and displacing natural gas or electricity may be limited by the lack of sufficiently large dairy farms, seasonal variability, and the limited demand by nearby industries.

ICCAC policy option AFW-3 promotes the expanded use of biomass as an energy source for producing electricity, heat, or steam. Use of biomass to replace fossil fuels was estimated to reduce approximately 20 $MMtCO_2e$ by 2020. The ICCAC conducted a limited assessment of the available biomass resources in the state, which indicated that sufficient resources are available through 2020 to achieve the goals for both the cellulosic biofuels policy option (discussed below) and this biomass for energy option. A key challenge to the implementation of this policy is the proximity of the feedstock to the end user.

The ICCAC found significant opportunity in promoting biofuels production using feedstocks and production methods with superior GHG benefits (i.e., superior to conventional starch-based ethanol), almost 10 $MMtCO_2e$ by 2020. The ICCAC noted that there may be an overlap between the cellulosic biofuels option with agricultural options that seek to increase and maintain crop acreage in no-till production or in conservation management programs (i.e., in relation to using crop residue as an energy feedstock).

Within the forestry sector, afforestation, unmanaged grazed forested land, and urban forestry (all components of AFW-5) have the potential to deliver over 1 $MMtCO_2e$/year of GHG reductions in 2020. By 2020, these programs call for establishing 250,000 acres of new forestlands, improving management practices on 500,000 acres of unmanaged grazed forested land, and increasing the canopy cover of urban forest in Iowa communities by 25%.

AFW-8 and AFW-9 provide an integrated set of policy options for future management of municipal solid waste in Iowa. AFW-8 focuses on “front-end” waste management technologies—source reduction, recycling, and composting—while AFW-9 focuses on “end-of-use” waste management approaches. Source reduction and recycling will result in avoided landfill GHG emissions, as well as avoided product/packaging life-cycle GHG emissions. The combined front-end waste management elements produce substantial GHG savings—almost 5 $MMtCO_2e$ in 2020.

Overview of Policy Options and Estimated Impacts

As noted above, the nine policy options for the AFW sectors address a diverse array of activities. Taken as a whole, they offer significant cost-effective emission reductions, as shown in Table 6-3.

Figure 6-3 shows the breakdown of the cumulative emission reductions (2009–2020) anticipated from the recommended actions in the AFW sectors. The greatest emission reductions achieved (31%) come from implementation of land management to promote sequestration benefits (AFW-5). The majority of these reductions are associated with increasing the use of conservation tillage practices.

The expanded use of agriculture and forestry biomass feedstocks for electricity, heat, or steam production (AFW-3) also offers significant GHG reductions, even after accounting for overlap with the CRE Subcommittee policies. Significant reductions are also achieved through AFW-6 cellulosic fuel incentives (16%), AFW-8 waste management strategies (11%), and AFW-4 large-scale manure/methane management, capture, and utilization (9%). Emission reductions from waste management strategies are life-cycle GHG reductions that occur both within and outside of Iowa (resulting from lower energy use and GHG emissions to create, transport, and dispose of new products and packaging that are avoided through source reduction and recycling). It is important to note that AFW-3 and AFW-6 overlap with policy options under the Transportation and Land Use (TLU) and CRE Subcommittees, respectively. After accounting for overlap, these policies contribute a significantly smaller proportion to the AFW sector total.

Table 6-3, the summary list of policy options, and Figure 6-3, a pie chart showing the percentage of avoided greenhouse gas emissions by policy, are on the following two pages.

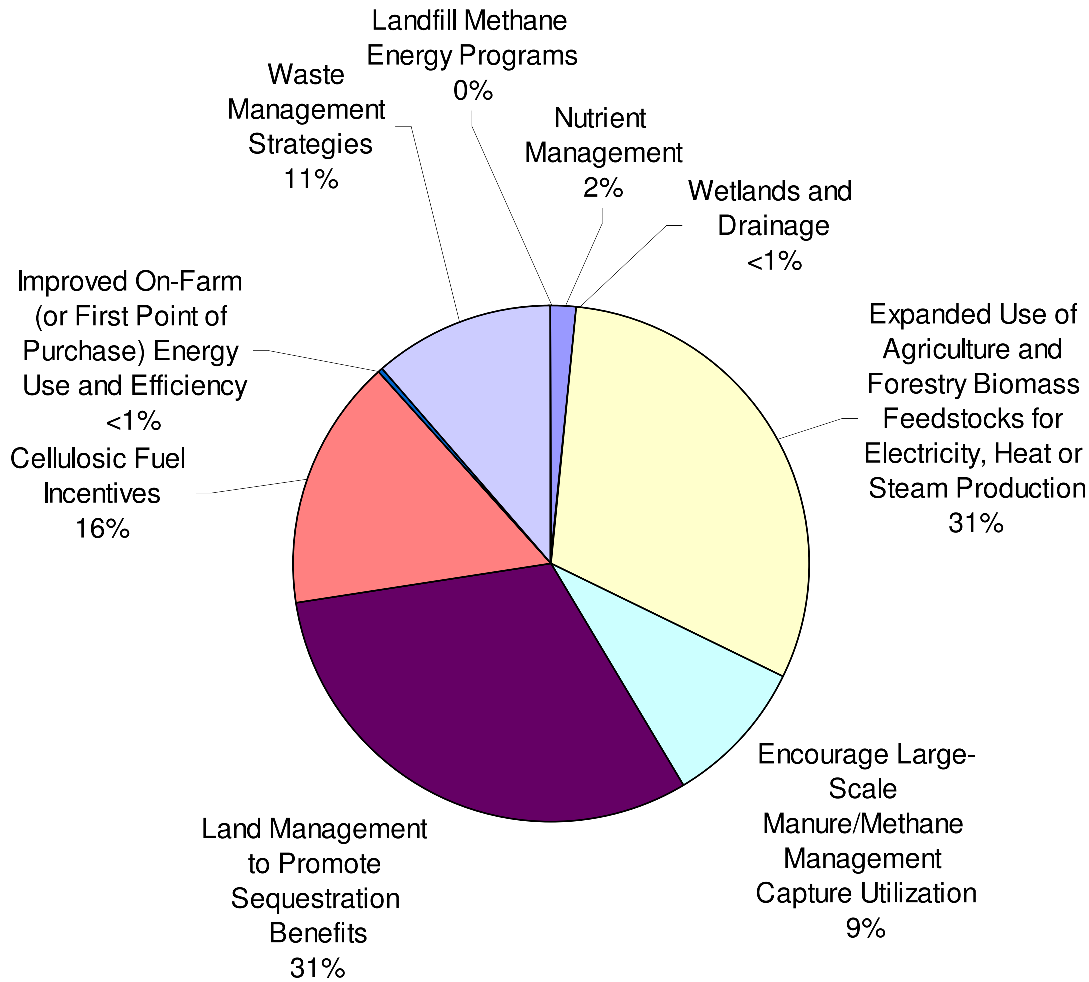
Table 6-3. Summary List of Policy Options

No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2012	2020	Total 2009–2020			
AFW-1	Nutrient Management						Majority (7 Objections)
	Increase Efficiency of Fertilizer	0.11	0.53	3.0	–$103	–$34	
	Seasonally Flooded Areas	0.002	0.009	0.05	$10	$194	
	Improved Nutrient Distribution	0.02	0.1	0.55	$373	$693	
AFW-2	Wetlands and Drainage	0.01	0.16	0.57	$120	$218	Super Majority (5 Objections)
AFW-3	Expanded Use of Agriculture and Forestry Biomass Feedstocks for Electricity, Heat, or Steam Production	4.4	20	113	$4,281	$38	Unanimous
AFW-4	Encourage Large-Scale Manure/Methane Management Capture Utilization						Unanimous
	Methane Management Capture Utilization	0.8	3	17	$63	$4	
	Manure Management	0.2	0.7	4.6	–$38	–$8	
AFW-5	Land Management to Promote Sequestration Benefits						Unanimous
	Conservation Tillage	2.9	9	56	–$6	–$0.1	
	Agriculture Land Conversion	0.1	0.4	2.6	$199	$76	
	Conservation Grazing	0.1	0.3	1.7	–$116	–$67	
	Afforestation	0.2	0.6	4.1	$216	$53	
	Unmanaged Grazed Forested Land	0.3	0.8	5.5	$93.7	$17	
	Urban Forestry	0.1	0.4	2.4	–$99	–$41	
AFW-6	Cellulosic Biofuel*	2.0	9.8	49	–$1,410	–$29	Unanimous
AFW-7	Improved On-Farm (or First Point of Purchase) Energy Use and Efficiency						Unanimous
	Renewable Energy	0.02	0.08	0.5	$23	$51	
	Energy Efficiency	0.2	0.9	5.9	–$610	–$104	
AFW-8	Waste Management Strategies	1.5	4.1	26.5	–$220	–$8	Unanimous
AFW-9	Landfill Methane Energy Programs	0.2	0.8	4.8	$4	$0.8	Unanimous
	Sector Total After Adjusting for Overlaps	**11**	**37**	**233**	**$2,139**	**$9**	
	Reductions From Recent Actions	**0.0**	**0.0**	**0.0**	**$0.0**	**$0.0**	
	Sector Total Plus Recent Actions	**11**	**37**	**233**	**$2,139**	**$9**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons carbon dioxide equivalent; $\$/tCO_2e$ = dollars per ton of carbon dioxide equivalent.

* Note that the costs/savings of this option include a $1.01/gallon federal subsidy for cellulosic ethanol.

Figure 6-3. Percentage of avoided greenhouse gas emissions by policy



Agriculture, Forestry, and Waste Management Sectors
Policy Descriptions

The AFW sectors include emission mitigation opportunities related to the use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, control of agricultural CH_4 and N_2O emissions, production of renewable liquid fuels, production of additional biomass energy, forestation on nonforested lands, and an increase in municipal solid waste source reduction, recycling, composting, and landfill gas collection.

AFW-1 Nutrient Management

This policy option promotes the use of improved manure management practices that reduce GHG emissions associated with manure handling and storage, including manure composting to reduce CH_4 emissions, movement of manure from nutrient-rich to nutrient-deficient areas, and improved methods for application to fields (for reduced N_2O emissions). Application improvements include incorporating manure into soil instead of surface spraying or spreading.

AFW-2 Wetlands and Drainage

This policy promotes the redesigning of drainage infrastructure over the next fifty years. Designing to reduce nitrogen transport to water resources also reduces N_2O emissions in Iowa and downstream, with significant global GHG benefits over the longer term. This is due to the function of strategically targeted and designed denitrification wetland systems and the long life of both the wetlands and the drainage systems.

AFW-3 Expanded Use of Agriculture and Forestry Biomass Feedstocks for Electricity, Heat, or Steam Production

This policy dedicates a sustainable quantity of biomass from agricultural industry residues, agricultural lands, wood industry process residues, unused forestry residues, agroforestry resources, and dedicated energy crops to efficient conversion to heat, steam, or electricity. This biomass should be collected and used in an environmentally acceptable manner, considering proper facility siting and feedstock use (e.g., proximity of users to biomass, impacts on water supply and quality, control of air emissions, cropping management, nutrient management, soil and nonsoil carbon management, and impacts on biodiversity and wildlife habitat). The objective is to create concurrent reduction of GHG emissions due to displacement of fossil fuel, considering life-cycle emissions associated with viable collection, hauling, and energy conversion and distribution systems. Local electricity or steam production yields the greatest net energy payoff.

Note: This option is linked with some Clean and Renewable Energy (CRE) options (e.g., CRE-2[4] and CRE-13). AFW-3 focuses on the supply elements of the implementation of a biomass-to-energy program (e.g., availability, collection, and distribution), while the CRE options focus on the demand side (e.g., generation infrastructure and purchasing for consumers).

AFW-4 Encourage Large-Scale Manure/Methane Management Capture Utilization

This policy is aimed at improving manure handling and storage practices; reducing methane emissions from livestock manure by installing large-scale anaerobic digester systems at concentrated animal feeding operations (CAFOs); and utilizing methane captured from the digesters to create heat or power, which offsets fossil fuel-based energy production and the associated GHG emissions. This option is focused on implementing these projects on a large scale (e.g., community-based systems or large CAFOs).

AFW-5 Land Management to Promote Sequestration Benefits

This policy option addresses a range of land management practices. On cultivated lands, the amount of carbon stored in the soil can be increased by the adoption of such practices as continuous conservation and no-till cultivation. By minimizing mechanical soil disturbance, these practices reduce the oxidation of soil carbon compounds and allow more stable aggregates to form. Converting marginal agricultural land used for annual crops to permanent cover (e.g., grassland/rangeland) increases the soil carbon or carbon in biomass. Rotational grazing, where animals are regularly moved from field to field, can reduce soil disturbance, improve plant vigor, and enhance soil carbon levels. Establishing forests on land that has not historically been forested (e.g., afforestation of agricultural land) and maintaining and improving the health and longevity of urban trees enhance the carbon stored in tree biomass. Indirect emission reductions from urban forestry may also occur by reducing heating and cooling needs as a result of planting shade trees.

AFW-6 Cellulosic Biofuels

This policy promotes sustainable in-state production of cellulosic biofuels from agriculture, forestry, and MSW feedstocks (raw materials) to displace the use of conventional petroleum-based fuels. It also promotes advanced biofuel production systems that improve the embedded energy content and carbon profile of biofuels. It focuses on feedstocks that favor energy production and are carbon neutral or carbon negative and that have multiple positive environmental benefits, such as maintaining carbon sequestration potential and soil productivity, and decreasing water and fossil fuel inputs during their production. This could help provide a strong economic market within the state and reduce GHG emissions through avoided fossil fuel consumption. This option also promotes the in-state development of cellulosic material and perennials that are able to be utilized.

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[4] CRE-2 incorporates or adjusts for biomass used by CRE-5 and CRE-8.

Note: This option is linked with option TLU-10. AFW-6 focuses on the supply elements of the implementation of a biofuels program, while TLU-10 focuses on the demand side (e.g., vehicle technology requirements, E10, E85).

AFW-7 Improved On-Farm (or First Point of Purchase) Energy Use and Efficiency

On-farm energy efficiency and renewable energy offer emission savings and reduced costs to landowners. Renewable energy can be produced and used on site at agriculture operations (e.g., installing solar or wind power, using hydropowered generators for irrigation, and converting diesel farm equipment to more efficient or renewable energy technology). The use of energy-efficient products, such as improved grain dryers, heat exchangers (dairy), electric motors, and energy-efficient building design, also offers significant potential for GHG reduction.

AFW-8 Waste Management Strategies

This policy option focuses on reducing the volume of waste from residential, commercial, and government sectors through programs that reduce the generation of waste. Reducing generation at the source reduces landfill emissions and upstream production emissions. Increasing recycling or reusing waste limits GHG emissions associated with landfill methane generation and with the production and transport of products and packaging from virgin materials (noting that different recycled materials will exhibit different costs and benefits on a life-cycle basis). Increasing recycling programs, creating new recycling programs, providing incentives for recycling construction materials, developing markets for recycled materials, and increasing average participation and recovery rates for all existing recycling programs can reduce overall emissions. Increasing organics management programs, such as composting, reduces GHG emissions associated with landfilled organic waste.

AFW-9 Landfill Methane Energy Programs

This policy promotes activities that further reduce GHG production by encouraging the use of energy recovery technologies. The focus is on the utilization of methane at landfills through the enabling of anaerobic digesters to capture and utilize that energy through electric power, heating, or liquefied natural gas. These technologies will help reduce GHG emissions from waste management, while producing cleaner energy. They make a twofold contribution to climate protection, by reducing emissions of methane and other GHGs into the atmosphere (via collection and control), and offsetting energy that would have otherwise come from fossil fuels. Methane gas generation by landfills is a GHG reduction strategy that may benefit from a cap-and-trade system, encouraging landfills to install flares at a minimum and possibly achieve electric generation if the economic incentives are sufficient.