Agriculture, Forestry, and Waste Management (AFW) Subcommittee

Summary List of Draft Priority Policy Options for Analysis

Policy No.	Policy Option		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2020 (Million $)	Cost-Effectiveness ($/t$CO_2$e)	Status of Option
			2012	2020	Total 2009–2020			
AFW-1	Nutrient Management		TBD	TBD	TBD	TBD	TBD	Pending
AFW-2	Wetlands and Drainage		TBD	TBD	TBD	TBD	TBD	Pending
AFW-3	Expanded Use of Agriculture and Forestry Biomass Feedstocks for Electricity, Heat or Steam Production		3.24	15.8	89.0	TBD	TBD	Pending
AFW-4	Encourage Large-Scale Manure/Methane Management Capture Utilization		0.96	2.64	18.00	135	0.96	Pending
AFW-5	Land Management to Promote Sequestration Benefits	Conservation Tillage	2.87	4.09	37.36	TBD	TBD	Pending
		Agriculture Land Conversion	TBD	TBD	TBD	TBD	TBD	Pending
		Conservation Grazing	TBD	TBD	TBD	TBD	TBD	Pending
		Afforestation and Reforestation	0.40	1.22	7.95	TBD	TBD	Pending
		Urban Forestry	0.23	0.70	4.55	TBD	TBD	Pending
		Biochar	TBD	TBD	TBD	TBD	TBD	Pending
AFW-6	Cellulosic Fuel Incentives		1.1	3.5	20.7	$1,020	$49	Pending
AFW-7	Improved On-Farm (or First Point of Purchase) Energy Use and Efficiency	Renewable Energy	0.07	0.40	2.18	$110	$50	Pending
		Energy Efficiency	0.17	0.93	5.10	TBD	TBD	Pending
AFW-8	Waste Management Strategies		0.4	1.2	7.7	-$4.5	-$0.6	Pending
AFW-9	Landfill Methane Energy Programs		TBD	TBD	TBD	TBD	TBD	Pending

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO2e = dollars per metric ton of carbon dioxide equivalent.

ICCAC policies: biomass supply and demand assessment

Biomass Resource	Annual Biomass Supply (dry tons)	Notes
Forest Residue	396,000	2005 NREL Report[1]. Estimated using USDA Forest Service's Timber Product Output database for 2002, includes logging residues and other removals.
Primary Mill Residue (Unused)	2,000	2005 NREL Report. Derived from the USDA Forest Service's Timber Product Output database for 2002, includes mill residues burned as waste or landfilled.
Secondary Mill Residue	32,000	2005 NREL Report. Includes wood scraps and sawdust from woodworking shops— furniture factories, wood container and pallet mills, and wholesale lumberyards. Estimated using number of businesses from the U.S. Census Bureau, 2002 County Business Patterns and assumptions on the wood waste generated.
Urban Wood Waste	353,000	2005 NREL Report. Includes MSW wood—wood chips, pallets, and yard waste; utility tree trimming and/or private tree companies; and construction/demolition wood. Data on the collected urban wood waste are not available; thus numerous assumptions were applied for estimation.
Agricultural Residue	26,003,000	2005 NREL Report. Estimated using 2002 total grain production, crop to residue ratio, moisture content, and taking into consideration the amount of residue left on the field for soil protection, grazing, and other agricultural activities.
Switchgrass		2005 NREL Report estimates a potential 11,297,000 tons of switchgrass could be grown on CRP lands.
Willow or Hybrid Poplar		2005 NREL Report estimates a potential 9,413,000 tons of willow or hybrid poplar could be grown on CRP lands.
Poultry Litter		
Municipal Solid Waste (MSW) Fiber		
Wood Pulp		
Yard & Landscape Waste Debris		
Total Annual Biomass Supply		
Policy Requiring Biomass	**2020 Annual Biomass Demand (dry tons)**	**Notes**
AFW-3	16,000,000	From goals: Annually harvest at least 5 million dry tons of dedicated energy crop production, 10 million tons of annual crop residue, and 1 million tons of forest products or wood residues.
AFW-6	10,000,000	From goals: Increase in-state cellulosic feedstock production by 10 million dry tons by 2020.

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[1] *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.

AFW-1. Nutrient Management

Policy Description

Demonstrate and encourage the implementation of GHG-beneficial management practices including: nutrient and soil management techniques to lower N2O emissions and increase soil carbon retention[2]; limit or restrict nitrogen fertilizer application on seasonally flooded field areas; and increase use of cover crops[3].

Improve the efficiency of fertilizer use and other nitrogen-based soil amendment use through implementation of improved management practices; development and use of crops and crop hybrids/varieties capable of improved nutrient uptake efficiency; and full accounting of nutrient applications through manure and other organic based nutrient sources.

Support research critical for identifying GHG emissions associated with different nutrient management practices and research identifying those practices leading to reduced net GHG emissions.

Policy Design

Goals:

Efficiency—Increase fertilizer use efficiency (in terms of N applied per crop yield) by 10% by 2020.

Seasonally Flooded Areas—Reduction of N application by 50% on 50% of seasonally flooded areas by 2020.

Improved Nutrient Distribution—Provide more of the state’s cropland nitrogen requirements through improved distribution of natural and organic nitrogen sources (manures). Replace 10 percent of manufactured nitrogen sources through better manure distribution by 2020.

Timing: Most of these are currently being considered and implemented for economic reasons, i.e. nutrient credit for manure (however all operators do not yet credit suitably). Restricting application from seasonally flooded areas will require additional technology capable of site specific applications based on land form in addition to that from soil test maps.

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[2] The dilemma relative to nutrient management, nitrogen in particular, involves balances. The Subcommittee is confident, for example, that mandating nitrogen application reductions would reduce N2O emissions and GHG emissions associated with nitrogen manufacture. However, reduced rates would very likely result in lower yields, lower plant biomass production, and net loss of soil organic matter and CO2 emissions. We have the science to understand direction of change, but do not have the scientific capability to quantify these input/output values on a highly variable landscape in a variable climate and thus determine whether or not a given recommendations would make us consistently winners or losers.

[3] Cover crops have been studied for decades with marginal advances and at this time seem somewhat risky as a required target mandate for this group. Research investment is needed to develop cropping systems in which cover crops are complimentary to rather than competitive with the primary crop.

Parties Involved: Industry, scientists, and producers

Other:

Implementation Mechanisms

To be determined (TBD).

Related Policies/Programs in Place

TBD.

Type(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

Data Sources:

Efficiency— Annual N_2O emissions from synthetic fertilizer and manure applications (Table H-5) were taken from the Iowa Inventory & Forecast. The average reduction in fertilizer usage resulting from implementation of nutrient management practices (15%) was taken from an EPA guidance document.[4] Cost information for synthetic fertilizers was taken from the USDA ERS.[5] The average cost of synthetic nitrogen fertilizers in the United States in 2007 was $370/ton.

Seasonally Flooded Areas—

Improved Nutrient Distribution—

Quantification Methods:

Efficiency GHG Benefits

A variety of programs can be used to improve nitrogen efficiency, such as soil testing and educational efforts. The potential benefits of a fertilizer efficiency program can be estimated based on the reduced costs of fertilizer not applied, and the GHG benefits of such a reduction in Nitrogen application (both from leaching and production).

Efficiency Costs

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[4] "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters," http://www.epa.gov/owow/nps/MMGI/Chapter2/ch2-2c.html#Practices, Table 2-14.

[5] http://www.ers.usda.gov/Data/FertilizerUse/Tables/Table7.xls.

The costs of such a program include the preparation of educational materials, as well as staffing and testing costs to help encourage reduced fertilizer useage. If the SC could provide estimates of the nitrogen fertilizer use in Iowa, that would be helpful.

Seasonally Flooded Areas—Does N application result in significantly greater N_2O formation? If the SC is aware of any particular studies on this phenomenon or its scope in Iowa, that would be very useful. Different possible approaches to quantify reductions in N2O would include: restriction on the use of nitrogen fertilizers in seasonally flooded areas (other fertilizer alternatives exist) or education programs to encourage best management practices, so as to avoid N2O formation as much as possible in seasonally flooded areas.

Improved Nutrient Distribution— Replacing 10% of manufactured nitrogen sources with locally produced manure will require estimates of the amount of locally produced manure available in the state. What is the current impediment to using more manure as opposed to commercial fertilizer? If fertilizer is less expensive, then financial incentives might provide the boost needed to make locally produced manure more economically viable. If farmers do not realize the benefits of manure as opposed to fertilizer use, then a government best practices educational programs would likely be effective. If manure is available but not in the proper locations, then government collection and distribution could the best possible approach. More input from the SC is needed to determine the best way of approaching and quantifying issue.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Subcommittee Suggestion:

Feasibility Issues

TBD – [as needed and approved by the subcommittees]

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

AFW-2. Wetlands and Drainage

Policy Description

Research: Research is needed to identify and quantify the greenhouse gas (GHG) implications, both from N_2O and CO_2, of

- Sub-surface drainage in agricultural croplands,
- Strategically located and designed nitrogen removal wetlands
- Denitrification in receiving streams and rivers.

Subsurface drainage: Improve subsurface drainage in poorly drained cropped lands to reduce denitrification and N_2O emissions.

Wetlands: Utilize strategically-located and designed nitrogen-removal wetlands to reduce N_2O emissions from nitrogen transported to receiving streams through subsurface drainage.

Integrated Drainage—Wetland Systems Initiative: Support policy development and public costs of this voluntary, market-driven private/public partnership which combines nitrogen-removal wetlands with improved subsurface drainage for enhanced crop production.

Policy Design

Goals:

By 2015—Support research needed to identify and quantify GHG implications of subsurface drainage, strategically-located and designed nitrate removal wetlands, and denitrification in receiving streams and rivers.

By 2050—Have fully supported the needed policy development and public sector costs for the voluntary Integrated Drainage-Wetland Systems Initiative and deployment of nitrogen-removal wetlands in Iowa's subsurface-drained row-cropped landscape.

Timing: As stated above.

Parties Involved: Involved parties include public conservation agencies, research institutions, existing Iowa drainage districts, and private landowners.

Other: While the research foundation is not adequate to quantify, improved subsurface drainage of row-cropped lands is felt to reduce N2O emissions by, reducing nitrogen losses through enhanced nitrogen uptake by plants as result of earlier crop planting, reducing in-field denitrification, and increasing feasibility of no-till cropping.

Permanent wetlands not being cropped are already protected under federal/state regulations and programs. Restoration of wetlands without significant nitrogen loadings have minimal GHG implications, with reductions primarily from surrounding grassed buffers that provide GHG reductions in linear relationship to land area converted from row-crop to grassed buffer.

Strategically located and designed wetlands for nitrogen removal – technology developed and adapted to row-cropped landscapes in the corn belt by Iowa State University, and currently being implemented through the Iowa Conservation Reserve Enhancement Program (CREP). Wetland pools of 0.5–2.0% of the contributing watershed area receive predominantly subsurface drainage from watersheds 500–4000 acres, and will remove 40-90% of nitrate through denitrification, primarily as elemental N_2 rather than N_2O. Nitrate-removal wetlands will significantly reduce GHG emissions over that of de-nitrification in receiving watercourses and the Gulf of Mexico.

Combining nitrate-removal wetlands through this voluntary Iowa initiative will reduce nitrate transport to water resources, protect drinking water supplies, reduce hypoxia in the Gulf of Mexico, and reduce emissions of GHG.

Implementation Mechanisms

TBD –

Related Policies/Programs in Place

TBD –

Type(s) of GHG Reductions

CO_2: Conservation of wetlands helps maintain the ability of the land to sequester carbon in soil and biomass.

CH_4: Improved drainage reduces anaerobic decomposition, thereby preventing methane creation.

Estimated GHG Reductions and Net Costs or Cost Savings

TBD

Data Sources: [TBD by CCS on subcommittee approval]

Quantification Methods:

Does the subcommittee want to estimate GHG benefits and costs of this option? If so the goal will need to be refined.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

TBD – [as needed and approved by the subcommittees]

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

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

Policy Description

Increase the amount of biomass (including biomass from forest sources) available for co-generation of electricity or for use in combined heat and power applications to displace the use of fossil energy sources recognizing that local electricity or heat production yields greatest net energy and carbon displacement payoff. Increase both the acreage and the yield of energy crop production and utilization through the planning of energy purpose

Note that this option is focused on the supply-side aspects of promoting biomass fuel, with an emphasis on the development of feedstocks, collection, processing and transport technologies. The demand-side aspects of renewable fuels (including biomass use) are being addressed through options in the CRE Subcommittee (Generation Portfolio Standards; Technology-Focused Initiatives).

Policy Design

Goals:

Energy Crop—Annually harvest at least 5 million dry tons of dedicated energy crop production materials by 2020, which includes

- Establishing 1 million acres of identified energy crop production by 2020; and
- Transitioning 50 percent of expiring CRP contracts to energy crop production.

Agriculture Crop Residue—Annually harvest at least 10 million tons of annual crop residue biomass for energy production by 2020.

Forest Biomass—Annually harvest at least 1 million tons of forest products or wood residues for biomass energy production by 2020.

Biomass Plant—Have at least one major industrial operation contracting with producers to use biomass as the primary energy source for plant operations by 2015.

Biofuels—Have at least one biofuels production plant contracting with producers to use biomass as the primary energy source by 2015.

Timing:

Parties Involved: Farmers and landowners.

Other: Energy conversion facilities.

Implementation Mechanisms

Voluntary Incentive programs:

- Section 476C tax incentives
- State and/or federal cost-share programs for energy crop establishment
- USDA value-added agriculture development grants

Federal Renewable Fuel Standard

Cellulosic fuel requirement standards and incentives

Research funding

State fuel standards and incentives

Related Policies/Programs in Place

Section 476C of the Iowa code provides for a renewable energy tax credit for biomass and other qualifying renewable energy sources that are used to generate electricity or heat for a commercial purpose.

A producer or purchaser of renewable energy may receive renewable energy tax credits under this chapter in an amount equal to one and one-half cents per kilowatt-hour of electricity, or four dollars and fifty cents per million British thermal units of heat for a commercial purpose, or four dollars and fifty cents per million British thermal units of methane gas or other biogas used to generate electricity, or one dollar and forty-four cents per one thousand standard cubic feet of hydrogen fuel generated by and purchased from an eligible renewable energy facility.

Alternative Energy Law (Iowa's Renewable Portfolio Standard)—Iowa requires its two investor-owned utilities—MidAmerican Energy and Alliant Energy Interstate Power and Light—to contract for a combined total of 105 megawatts (MW) of their generation from renewable-energy resources.

Fuel Mix Disclosure—Iowa's rate-regulated electric utilities must report annually to customers the percentage mix of fuel and energy used to produce electricity. The percentages for renewables must further be broken down into percentages of electricity generated by wind, solar, hydropower, biomass, and other resources. Each utility's annual report must also include an estimate of sulfur dioxide, nitrogen oxides, and carbon dioxide emissions for each fuel and resource.

Energy Research Grants—The Iowa Energy Center provides grants for energy research on topics that have strong relevance to Iowa.

Type(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

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

Data Sources:

- *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.
- Maryland DNR "The Potential for Biomass Cofiring in Maryland", March 2006. Prepared by Princeton Energy Resources International, LLC and Exeter Associates INC for the DNR Maryland Power Plant Research Program.
- Average Heat Content of Selected Biomass Fuels Table 10 EIA (2008) Annual Electric Generator, http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table10.html
- Heat Content of Selected fuels provided by Oak Ridge National Laboratory (ORNL) (6,000 to 8,000 BTU per pound for solid wood products), http://cta.ornl.gov/bedb/appendix_a/Approximate_Heat_Content_of_Selected_Fuels_for_Electric_Power_Generation.xls

Quantification Methods:

GHG Benefit

This analysis focuses on the incremental GHG benefits associated with the utilization of additional biomass to offset the consumption of fossil fuels. The analysis assumes that biomass will replace coal. This is based on the assumption that biomass will be used to replace coal in the RCI and electricity sector (where coal represents about 82% of electricity generated in Iowa).[6] Co-firing was used as a technology to provide an estimate of possible capital costs required to enable the utilization of biomass, recognizing that other technologies, such as gasification, potentially offer more significant opportunities but have higher associated costs.

The GHG benefits were calculated by the difference in emissions associated with each of the input fuels (0.0959 tCO_2e/MMBtu for sub-bituminous coal, 0.0539 tCO_2e/MMBtu for natural gas, and 0.0019 tCO_2e/MMBtu for biomass, including non-CH_4 and non-N_2O emissions).[7]

The amount of biomass utilized by each of the three components (Agriculture, Forest and Energy Crops) is illustrated in the three tables below: 3.1, 3.2 and 3.3. The tables below also show the corresponding GHG benefits for each of the components.

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[6] Based on eGRID data: Coal 82%, Nuclear 11%, Oil 0.3%, Natural Gas 2%, Wind 2%, Biomass 0.3%.

[7] Emission factors obtained from CCS Energy fuel emission factors.

Table 3.1: GHG Benefits From Agriculture Crop Residue.

Year	Percent of Utilization	Agriculture Crop Residue Feedstock (dry tons)	Agriculture Crop Residue Feedstock (MMBtu)[8]	Avoided Emissions Ag Residue (MMtCO2-e)
2009	7%	714,286	5,928,571	0.557
2010	14%	1,428,571	11,857,143	1.115
2011	21%	2,142,857	17,785,714	1.672
2012	29%	2,857,143	23,714,286	2.229
2013	36%	3,571,429	29,642,857	2.787
2014	43%	4,285,714	35,571,429	3.344
2015	50%	5,000,000	41,500,000	3.902
2016	60%	6,000,000	49,800,000	4.682
2017	70%	7,000,000	58,100,000	5.462
2018	80%	8,000,000	66,400,000	6.242
2019	90%	9,000,000	74,700,000	7.023
2020	100%	10,000,000	83,000,000	7.803
Cumulative				**46.818**

Table 3.2 GHG Benefits From Forestry Biomass.

Year	Percent of Utilization	Forest Biomass Feedstock (Dry Tons)	Forest Biomass Feedstock (MMBTU)[9]	Avoided Emissions from Forest Biomass Feedstocks (MMtCO2-e)
2009	7%	71,429	857,143	0.081
2010	14%	142,857	1,714,286	0.161
2011	21%	214,286	2,571,429	0.242
2012	29%	285,714	3,428,571	0.322
2013	36%	357,143	4,285,714	0.403
2014	43%	428,571	5,142,857	0.483
2015	50%	500,000	6,000,000	0.564
2016	60%	600,000	7,200,000	0.677
2017	70%	700,000	8,400,000	0.789
2018	80%	800,000	9,600,000	0.902
2019	90%	900,000	10,800,000	1.015

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[8] Agriculture Residue heat content is assumed to be 8.3 MMBtu/ton which is taken from Average Heat Content of Selected Biomass Fuels Table 10 EIA (2008) Annual Electric Generator, http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table10.html

[9] Forest biomass heat content is assumed to be 12 MMBtu/ton which is the low end of the range (6000 BTU/lb) taken from Heat Content of Selected fuels provided by Oak Ridge National Laboratory (ORNL) (6,000 to 8,000 BTU per pound for solid wood products), http://cta.ornl.gov/bedb/appendix_a/Approximate_Heat_Content_of_Selected_Fuels_for_Electric_Power_Generation.xls

2020	100%	1,000,000	12,000,000	1.128
Cumulative				**6.766**

Table 3.3 GHG Benefits From Dedicated Energy Crops.

Year	Percent of Utilization	Total Dedicated Energy Crop Available (Dry Tons)	Total Dedicated Energy Crop Available (MMBtu)[10]	Avoided Emissions, Energy Crops (MMtCO2e)
2009	4%	200,000	2,936,400	0.276
2010	6%	300,000	4,404,600	0.414
2011	8%	400,000	5,872,800	0.552
2012	10%	500,000	7,341,000	0.690
2013	21%	1,062,500	15,599,625	1.466
2014	33%	1,625,000	23,858,250	2.242
2015	44%	2,187,500	32,116,875	3.018
2016	55%	2,750,000	40,375,500	3.794
2017	66%	3,312,500	48,634,125	4.570
2018	78%	3,875,000	56,892,750	5.347
2019	89%	4,437,500	65,151,375	6.123
2020	100%	5,000,000	73,410,000	6.899
Cumulative				**35.39**

Costs

There are two main components to the cost calculation, the fuel costs and capital costs. The fuel component is based on the difference in costs between supply of biomass fuel and the assumed fossil fuel that it is replacing (i.e. coal). As an example, costs are identified in Table 3-1 below and have been taken from *The Potential for Biomass Co-firing in Maryland*.[11]

Table 3-4. Assumed costs of feedstocks

Fuel Type	Cost $/Ton Delivered	Cost $/MMBtu Delivered
Agricultural Byproducts	$ 40.00	$4.85

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[10] Energy heat content is assumed to be 14.7 MMBtu/ton., taken from Heat Content of Selected fuels provided by Oak Ridge National Laboratory (ORNL) (7,341 BTU per pound for switchgrass), http://cta.ornl.gov/bedb/appendix_a/Approximate_Heat_Content_of_Selected_Fuels_for_Electric_Power_Generation.xls

[11] Maryland DNR "The Potential for Biomass Cofiring in Maryland", March 2006. Prepared by Princeton Energy Resources International, LLC and Exeter Associates INC for the DNR Maryland Power Plant Research Program.

Urban waste wood	$17.00	$1.70
Switchgrass	$47.00	$3.20
Mill Residue (Dry)	$27.00	$1.93
Forest Residue	$35.00	$3.65
Bituminous Coal	$33.84	$1.41

The cost is calculated by assuming the replacement of coal with biomass. The difference in cost of supply between biomass and coal is calculated using the costs specific to Iowa, similar to those outlined in Table 3-4. The difference in costs (dollars per million British thermal units [$/MMBtu]) is multiplied by the amount of coal energy (MMBtu) being replaced by biomass. The assumed incremental capital costs are based on the capital costs associated with retrofitting an existing 300-700 MW capacity coal-fired boiler. An average capital cost of $180 per kW will be assumed, based on the range ($150–$200 per kilowatt [kW]) provided in *The Potential for Biomass Co-firing in Maryland*. While use of biomass may be pursued through other technology types (e.g. gasification) or end uses (e.g. heat or steam), the capital costs of co-firing will be used to provide an estimate of possible capital costs required to enable the utilization of biomass.[12]

The capital infrastructure lifespan is assumed to be 30 years, and the interest rate of is assumed to be 5%, giving a Capital Recovery Factor of 0.065 (i.e. $1 million plant is assumed to cost approximately $65,000 per year over the life of the project). For the purposes of this analysis, it is assumed that biomass plants do not require additional operating and maintenance costs (e.g. no additional emission control measures and ash disposal required).

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

TBD – [as needed and approved by the subcommittees]

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

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[12] The capital costs associated with using biomass as an alternative to fossil-based generation are dependent on many factors, including the end use (i.e. electricity, heat or steam), the design and size of the systems, the technology employed, and the configuration specifications of the system. Each system implemented under this policy would require a detailed analysis (incorporating specific engineering design and costs aspects) to provide a more accurate cost estimate of the system.

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

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

Policy Description

Reduce methane emissions from livestock manure by installing large-scale anaerobic digester systems at locations that can service multiple concentrated animal feeding operations (CAFOs).

Reduce methane emissions from livestock manure by installing anaerobic digester systems at larger individual concentrated animal feeding operations.

Methane captured from the digesters is used to create heat or power, which offsets fossil fuel-based energy production and the associated greenhouse gas GHG emissions. This option is focused on implementing these projects at the large-scale level (e.g., community-based systems or large CAFOs).

Reduce GHG emissions associated with manure handling and storage. Potential practices include but are not limited to manure composting (to reduce methane emissions) and improved methods for application of effluent to fields (for reduced nitrous oxide emissions). Application improvements include incorporation into soil instead of surface spray/spreading.

Policy Design

Goals:

Utilization—By 2020, utilize 50% of available methane from livestock manure (primarily dairy, swine and poultry) for renewable electricity, heat and steam generation or incorporation into natural gas distribution systems.

Management—By 2020, apply improved manure handling and storage practices on 50% of manure generated.

Timing:

Parties Involved:

Other:

Implementation Mechanisms

Tax Incentives

Grants

Loan Guarantees

Related Policies/Programs in Place

Section 476C of the Iowa code provides for a renewable energy tax credit for biomass and other qualifying renewable energy sources that are used to generate electricity or heat for a commercial purpose.

A producer or purchaser of renewable energy may receive renewable energy tax credits under this chapter in an amount equal to one and one-half cents per kilowatt-hour of electricity, or four dollars and fifty cents per million British thermal units of heat for a commercial purpose, or four dollars and fifty cents per million British thermal units of methane gas or other biogas used to generate electricity, or one dollar and forty-four cents per one thousand standard cubic feet of hydrogen fuel generated by and purchased from an eligible renewable energy facility.

Alternate Energy Revolving Loan Program (AERLP)—The Iowa Energy Center provides zero-percent interest loans for up to half of the project cost, up to a maximum of $250,000. http://www.energy.iastate.edu/AERLP/index.htm

Energy Research Grants—The Iowa Energy Center provides grants for energy research on topics that have strong relevance to Iowa. http://www.energy.iastate.edu/Funding/gp-research.htm

Alternative Fuel Production Loans—The Value-Added Agricultural Products and Processes Financial Assistance Program offers a combination of forgivable and traditional low-interest loans for business projects involving the production of biomass or alternative fuels. http://www.iowalifechanging.com/business/vaapfap.html

Iowa DNR Anaerobic Digestion Outreach Program—Recognizing the enormous opportunity for the wide-scale implementation of farm-scale and community-based anaerobic digester systems in Iowa, the Iowa Department of Natural Resources Energy and Waste Management Bureau set about promoting the digester concept to Iowa Communities having large concentrations of livestock production, large volumes of organic wastes, and large energy users.

Type(s) of GHG Reductions

- **CO_2, N_2O, CH_4:** Displaces emissions from fossil fuel combustion.
- **CH_4:** Capture and utilization or preventing the creation of methane.
- **N_2O:** Reductions occur when nitrogen run-off and leaching are reduced, which leads to the formation and emission of N_2O.

Estimated GHG Reductions and Net Costs or Cost Savings

TBD

Data Sources: [TBD by CCS on subcommittee approval]

Quantification Methods:

Utilization GHG Benefits

Methane emissions (in $MMtCO_2e$) data from the Iowa Inventory and Forecast was used as the starting point to estimate the GHG benefits of utilizing the volumes of methane targeted by the policy and to add in the additional benefit of electricity generation using this captured methane (through offsetting fossil-based generation). The first portion of GHG benefit is obtained through reduced methane emissions through the capture of emissions from manure and poultry litter. An assumed collection efficiency of 75%[13] is applied to methane emissions from manure and poultry litter which is then multiplied by the assumed policy target ramping up to achieve 50% utilization by 2020.

The second portion of the GHG benefit is through the offsetting of fossil-based electricity generation. This was estimated by converting the methane captured in each year to its heat content (in BTUs) and then multiplying by an natural gas heat rate of 11,664 Btu per kilowatt-hour (kWh) to estimate the electricity produced[14]. The CO_2e associated with this amount of electricity in each year is estimated by converting the kWh to megawatt hours (MWh) and then multiplying this value by the Iowa-specific emission factor for electricity production from the inventory and forecast (0.69 metric tons CO2-e per MWh)[15].

The total GHG benefit is estimated as the sum of both portions of the benefit described above.

Utilization Costs

The costs for the dairy and swine components are estimated using an analysis by Natural Resources Conservation Service (NRCS), *An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities.*[16] The production costs are assumed to be $0.11 per kWh for swine anaerobic digesters and $0.05 per kWh for dairy anaerobic digesters[17]. These costs were converted to 2005 dollars (from 2006 dollars) and assume a 30% thermal efficiency. The costs include annualized capital costs for the digester, generator, and Operation and Maintenance costs[18]. The assumed costs for the poultry component were taken from a Study in South Carolina (noting that Iowa specific data is preferable) *Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production* by Joseph R.V. Flora, Ph.D., P.E. and Cyrus Riahi-Nezhad ($0.103 per kWh in 2005 dollars using of Anaerobic Digestion).[19] The value of electricity produced is taken from the projected all

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[13] The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on methane collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).

[14] Energy Information Administration – Department of Energy (2007) Table A.6 Average Heat Rates by Prime Mover and Energy Source. http://www.eia.doe.gov/cneaf/electricity/epa/epata6.html

[15] Total electricity emissions were divided by total electricity sales to determine the electricity emissions factor for Iowa.

[16] Beddoes, Bracmort, Burns and Lazarus (2007) *An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities*, NRCS, Technical Note No. 1, October 2007.

[17] It is assumed that the technology employed for both swine and dairy anaerobic digesters are covered anaerobic lagoon. Cost were obtained from table 1 of the NRCS paper sited above.

[18] The economic analysis conducted by Beddoes et al does not include feedstock and digester effluent transportation costs. The technical note does not address the economics of centralized digesters where biomass is collected from several farms and then processed in a single unit.

[19] Availability Of Poultry Manure As A Potential Bio-Fuel Feedstock For Energy Production By Joseph R.V. Flora,

sector average electricity price for the Mid-Continent Area Power Pool prices[20]. This price represents the value to the farmer for the electricity produced (to offset on-farm use) and is netted out from the production costs to estimate net costs.

Management GHG Benefits

Management of manure reduces methane emissions from a wider pool of animals than the utilization component of this option and includes manure from Dairy Cattle, Beef Cattle, Swine, poultry, Sheep, Goats and horses. Methane emissions (in $MMtCO_2e$) data from the Iowa Inventory and Forecast is used as the starting point to estimate the GHG benefits of reduced methane resulting from improved manure management through estimating the volumes of methane targeted by the policy. The GHG benefit is obtained through reduced methane emissions through the improved management of manure. An efficiency improvement of manure management is assumed to be of 25% (need reference?). This efficiency gain is applied to methane emissions from manure and poultry litter which is then multiplied by the assumed policy target ramping up to achieve improved management to 50% of manure generated by 2020.

Management Costs

Implementation Mechanisms Required – examples include: BMP programs for utilization, incentives for reduced methane and better management, penalties for non-compliance or others?

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

TBD – [as needed and approved by the subcommittees]

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Ph.D., P.E. and Cyrus Riahi-Nezhad Department of Civil and Environmental Engineering University of South Carolina, August 2006.

[20] DOE Energy Information Administration (EIA) Annual Energy Outlook http://www.eia.doe.gov/oiaf/aeo/supplement/index.html, accessed May 12 2008.

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

AFW-5. Land Management to Promote Sequestration Benefits

Policy Description

On cultivated lands, the amount of carbon stored in the soil can also be increased by the adoption of practices such 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. Other benefits include reduced wind and water erosion, reduced fuel consumption, and improved wildlife habitat.

Convert marginal agricultural land used for annual crops to permanent cover such as grassland/rangeland, orchard, or forest where the soil carbon and/or carbon in biomass is higher under the new land use. Adopt mechanisms to discourage theses acres from either returning to conventionally tilled production or to suburban/urban development.

Heavy grazing can cause significant soil disturbance and result in carbon losses from soils. Rotational grazing where animals are moved from field to field on a regular basis can reduce soil disturbance, improve plant vigor and enhance soil carbon levels.

Establish forests on land that has not historically been forested (e.g., afforestation of agricultural land) and promote forest cover and associated carbon stocks by regenerating or establishing forests in areas with little or no present forest cover ("reforestation"). Maintain and improve the health and longevity of trees in urban and residential areas to protect and enhance the carbon stored in tree biomass. Indirect emissions reductions may also occur by reducing heating and cooling needs as a result of planting shade trees.

Apply biochar to crop production fields to increase soil productivity and increase soil carbon levels.

Policy Design

Goals:

Conservation Tillage—By 2020, 75 percent of annual cropland will be managed with continuous no-till or low-till production practices

Agriculture Land Conversion—By 2020, convert 1 million acres of marginal agricultural land to higher sequestration permanent cover (including grassland, rangeland, orchard, or forest).

Conservation Grazing—By 2020, apply conservation grazing practices including rotational grazing to 50 percent of Iowa grazing lands.

Reforestation—By 2020, establish 250,000 acres of new forest lands and 500,000 acres of reforestation.

Urban Forestry—By 2020, increase the canopy cover of urban forest in Iowa communities by 25%.

Biochar—By 2020, apply biochar to 5 million acres of Iowa land annually.

Timing:

Parties Involved:

Other:

Implementation Mechanisms

TBD – [CCS drafts based on subcommittee 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 subcommittee approval]

Related Policies/Programs in Place

Type(s) of GHG Reductions

CO_2: Increase the sequestration of carbon, as well as preventing carbon currently stored in Iowa's forests and farm land from being released. Reductions also 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

Data Sources:

Reforestation and Afforestation:

- USDA Forest Service (USFS) Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program).
- USFS Forest Inventory Analysis data (Mapmaker 3.0, available at http://www.ncrs2.fs.fed.us/4801/fiadb/fim30/wcfim30.asp).
- Walker et al. 2007. Terrestrial carbon sequestration in the Northeast: Opportunities and Costs, Part 3A: Opportunities for Improving Carbon Storage through Afforestation of Agricultural Lands.

Urban Forestry:

- Nowak et al., USDA Forest Service, Northern Research Station, Urban Forest Effects on Environmental Quality State Summary data for Iowa (http://www.fs.fed.us/ne/syracuse/Data/State/data_IA.htm)
- McPherson and Simpson (1999), *Carbon Dioxide Reduction Through Urban Forestry*, USFS PSW-GTR-171. E. Gregory McPherson and James R. Simpson, *Carbon Dioxide Reduction Through Urban Forestry: Guidelines for Professional and Volunteer Tree Planters*, Gen. Tech. Rep. PSW-GTR-171, Washington, DC: U.S. Department of Agriculture, U.S. Forest Service, 1999. Available at: http://www.treesearch.fs.fed.us/pubs/6779

Quantification Methods:

Conservation Tillage GHG Benefits

Total cropland in Iowa is estimated at about 23 million acres[21] in 1998. For the purposes of this analysis, conservation tillage is defined as any system that leaves 50% or more of the soil covered with residue.[22]

Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation is displayed in Table 5-1. This table represents the percentage of cropland required by the policy, less the area currently implementing conservation tillage. In 1998, according to Conservation Technology Information Center (CTIC)[23], almost 4 million acres were using conservation tillage practices in Iowa. This represents approximately 17 percent of total cropland in Iowa.

For the policy period, it is assumed that the sequestration rate provided by the Chicago Climate Exchange (CCX) for the carbon credit program (0.6 metric tons of carbon dioxide per acre [$MtCO_2$/acre] per year as Iowa is considered to be in "Zone A") is indicative of the sequestration that would occur as a result of improved tillage practices.[24] As such 0.6 $MtCO_2$/acre/year was used to estimate the amount of carbon to be sequestered per acre. The issuance rates are viewed as a discounted average that could be expected to occur for the entire pool of enrolled acreage over the five-year contract period[25]. As such it was assumed that carbon accumulation occurred for 5 years and after this time immediately levels off. This is indicated in Table 5-1 as "Acres still accumulating carbon". To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in still accumulating carbon each year. The CCX program currently runs until 2010 and while it is likely that the program will be extended, at this stage it is unknown.

Additional GHG savings from reduced fossil fuel consumption are estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate. The reduction in fossil

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[21] 1998 Iowa total crop land from the Conservation Technology Information Center Iowa Crop Residue Management Survey (see http://www.conservationinformation.org/index.asp?site=1&action=crm_results)

[22] The definitions of tillage practices from Conservation Technology Information Center are used under this policy. However, only no-till/strip-till and ridge-till are considered "conservation tillage" practices. No-till means leaving the residue from last year's crop undisturbed until planting. Strip-till means no more than a third of the row width is disturbed with a coulter, residue manager, or specialized shank that creates a strip. If shanks are used, nutrients may be injected at the same time. Ridge-till means that 4–6-inch-high ridges are formed at cultivation. Planters using specialized attachments scrape off the top 2 inches of the ridge before placing the seed in the ground.

[23] From 1998 Conservation Technology Information Center data, at: http://www.conservationinformation.org

[24] From Chicago Climate Exchange (CCX) Agricultural Soil Carbon Offsets, at: http://www.chicagoclimatex.com/content.jsf?id=781

[25] Chicago Climate Exchange Offsets for Carbon Capture and Storage in Agricultural Soils FAQs (see http://www.chicagoclimateexchange.com/docs/offsets/Soil_Carbon_Offsets_faq.pdf)

diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.[26] The life-cycle fossil diesel GHG emission factor of 12.31 $MtCO_2e/1,000$ gallons was used.[27] Results are shown in Table 5-1, along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

Table 5-1. GHG Reductions From Conservation Tillage Practices

Year	percent of total cropland in program	Acres in Program ("new" acres)	Acres still accumulating carbon	MMtCO2e Sequestered	Diesel Saved (1,000 gal)	MMtCO2e from Diesel avoided	Total MMtCO2e saved per annum
2009	22%	1,114,784	1,114,784	0.669	3,902	0.048	0.717
2010	27%	2,229,569	2,229,569	1.34	7,803	0.096	1.43
2011	31%	3,344,353	3,344,353	2.01	11,705	0.144	2.15
2012	36%	4,459,138	4,459,138	2.68	15,607	0.192	2.87
2013	41%	5,573,922	5,573,922	3.34	19,509	0.240	3.58
2014	46%	6,688,707	5,573,922	3.34	23,410	0.288	3.63
2015	51%	7,803,491	5,573,922	3.34	27,312	0.336	3.68
2016	56%	8,918,276	5,573,922	3.34	31,214	0.384	3.73
2017	60%	10,033,060	5,573,922	3.34	35,116	0.432	3.78
2018	65%	11,147,844	5,573,922	3.34	39,017	0.480	3.82
2019	70%	12,262,629	5,573,922	3.34	42,919	0.528	3.87
2020	75%	13,377,413	5,573,922	3.34	60,447	0.744	4.09
						cumulative Benefit	37.4

Conservation Tillage Costs

The estimated cost savings related to the adoption of no-till farming is derived from the low end of the range provided in a North Carolina Study "Economic Comparison of Three Cotton Tillage Systems in Three NC Regions," by S. Walton and G. Bullen ($2.75/acre).[28] The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.[29] The life cycle fossil diesel GHG emission factor is assumed to be 12.31 $MtCO_2e/1,000$ gallons.[30]

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

[27] Life-cycle emissions factor for fossil diesel from J. Hill et al., "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels," *Proceedings of the National Academy of Sciences*, 103(30):11206–11210. From the assessment used to evaluate U.S. soybean-based biodiesel life-cycle impacts. See http://www.pnas.org/cgi/content/full/103/30/11099

[28] See www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt, accessed February 2000.

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

[30] Life-cycle emissions factor for fossil diesel from J. Hill et al., "Environmental, Economic, and Energetic Costs

Costs savings are estimated by multiplying the estimated savings per acre cited above ($2.75/acre) 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.

The costs of adopting soil management practices (e.g., conservation tillage/no-till practices) are based on the financial incentives provided through the Minnesota] Agriculture Best Management Practices (AgBMP) program.[31] This program provides farmers a low-interest loan as an incentive to initiate or improve their current tillage practices. The equipment funded is generally specialized tillage or planting implements that leave crop residues covering at least 15%–30% of the ground after planting. The average total cost for this equipment is $23,000, though the average loan for tillage equipment is $16,000. The average-size farm using an AgBMP loan to purchase conservation tillage equipment is 984 acres. Based on the average loan size ($16,000) and the average size of the farm utilizing the loan (984 acres), it is assumed that a once-off loan of $16.26/acre is required to incentivize the adoption of conservation tillage practices. This loan payment is applied to each new acre entering the program to determine an approximate cost of encouraging the use of soil management practices.

Agriculture Land Conversion GHG Benefits

The number of acres of marginal crop land (1 million acres by 2020) will be multiplied by the carbon change between conventional crop production and higher sequestration activities.

Agriculture Land Conversion Costs

Costs will estimated by applying the cumulative number of acres being converted by the annual rental payment (based on conservation easement costs or other sources).

Conservation Grazing GHG Benefits

The GHG benefits of rotational grazing will be compared to BAU practices. Fore example, in Montana the soil sequestration rates currently established for sustainable grazing systems range from 0.12 $MtCO_2$/acre to 0.40 $MtCO_2$/acre. The sequestration rate depends on the determination of whether the range is in a non-degraded or degraded condition. The NRCS has established indicators of degraded rangeland that are published in the 2005 “Interpreting Indicators of Rangeland Health.” NRCS Field Office Technical Guides publish guidelines for managing the controlled harvest of vegetation with grazing animals. Stocking rates and livestock distribution criteria are defined according to county and state in the NRCS “Prescribed Grazing Specification” code.

Conservation Grazing Costs

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and Benefits of Biodiesel and Ethanol Biofuels," *Proceedings of the National Academy of Sciences*, 103(30):11206–11210. From the assessment used to evaluate U.S. soybean-based biodiesel life-cycle impacts. See http://www.pnas.org/cgi/content/full/103/30/11099.

[31] Minnesota Department of Agriculture (2006), Agricultural Best Management Practices Loan Program State Revolving Fund Status Report, February 28, 2006.

Implementation Mechanisms required: E.g. Payments to Farmers, BMPs, Education programs, Penalties, others??

Afforestation and Reforestation GHG Benefits

Forests grown or planted on land not currently in forest cover will likely accumulate carbon at a rate consistent with the accumulation rates of average forest in the region. Therefore, C sequestered by afforestation and reforestation activities can be assumed to occur at the same rate as C sequestration in average IA forests.

Average C storage was found using methods described in USFS GTR-NE-343, assuming that reforestation and afforestation activity would occur on forests that were consistent with the existing forest type distribution in IA. This distribution was based on USDA Forest Service Forest Inventory and Analysis data. Afforestation and reforestation statewide were assumed to occur on 50% oak/hickory, 25% elm/ash/cottonwood, and 25% maple/beech/birch forests.

For afforestation calculations, annual carbon sequestration rates in each forest type group were calculated by subtracting carbon stocks in new stands (0 years) from carbon stocks in 35-year old stands and dividing by 35 years. A weighted statewide average C sequestration rate for afforestation activity was calculated, taking into account the variation in carbon sequestration across forest types (Table xx). The 35 year period was chosen to reflect the average length of an afforestation project period. In this afforestation calculation, soil C was taken into account. Soil C was assumed to accumulate at a rate consistent with soil C accumulation in afforested stands in GTR-NE-343.

The methods described in GTR-NE-343 for quantifying C storage following reforestation activity assume that forests established on land that was once forested are first clearcut, then replanted or allowed to regrow. This harvesting activity results in substantial decomposition for the first 5 years after harvest. For the current analysis, it was assumed that forests were replanted on land that had once been forested, but that at least five years had passed since the most recent harvest. Thus, annual carbon sequestration rates in reforested stands for each forest type group were calculated by subtracting carbon stocks in 5-year-old stands from carbon stocks in 35-year old stands and dividing by 30 years. A weighted statewide average C sequestration rate for afforestation activity was calculated, taking into account the variation in carbon sequestration across forest types (Table 5-2). The 30 year period was chosen to reflect the average length of a project period. In this reforestation calculation, soil C remained constant because soil C does not change with time in reforestation activity in GTR-NE-343.

Table 5-2. Forest Carbon Sequestration Rates for Afforestation and Reforestation Activity (source: Smith et al. 2006, NE-GTR-343)

Afforestation	t CO2e/ac (0 yr)	t CO2e/ac (35 yr)	t CO2e/ac/yr (average)
Oak/Hickory Afforestation (NR-GTR-343 Table B15)	53.9	136.0	2.3
Elm/Ash/Cottonwood Afforestation (NR-GTR-343 Table B13)	97.2	187.4	2.6

Maple/Beech/Birch Afforestation (NR-GTR-343 Table B14)	75.5	164.3	2.5
Average C accumulation rate for afforestation:			**2.5**

Reforestation	t CO2e/ac (5 yr)	t CO2e/ac (35 yr)	t CO2e/ac/yr (average)
Oak/Hickory Reforestation (NR-GTR-343 Table A15)	105.6	148.1	1.4
Elm/Ash/Cottonwood Reforestation (NR-GTR-343 Table A13)	176.7	208.3	1.1
Maple/Beech/Birch Reforestation (NR-GTR-343 Table A14)	151.1	180.8	1.0
Average C accumulation rate for reforestation:			**1.2**

To achieve the goal of afforesting 250,000 acres by 2020, it was assumed that 20,833 acres would be planted each year from 2009 to 2020. Similarly, to achieve the goal of reforesting 500,000 acres by 2020, it was assumed that 41,667 acres would be planted each year from 2009 to 2020. Forests planted in one year continue to sequester carbon in subsequent years. Thus C storage in a given year was calculated as the sum of annual C sequestration on cumulative planted acreage. To determine total amount of C sequestered from 2009 to 2020, the number of acres planted in that year and all prior years was multiplied by the average annual C sequestration rate for each land use type (Table 5-3, Table 5-4).

Table 5-3. Calculation of annual carbon sequestration from and costs to implement afforestation from 2009 to 2020.

Year	Acres planted this year (ac/yr)	Acres planted in prior years	Carbon sequestered in cumulative planted acreage (MMtCO2e/yr)	Annual cost	Discounted cost	Levelized cost effectiveness
2009	20,833	0	0.051			
2010	20,833	20,833	0.102			
2011	20,833	41,666	0.153			
2012	20,833	62,499	0.204			
2013	20,833	83,332	0.255			
2014	20,833	104,165	0.306			
2015	20,833	124,998	0.357			
2016	20,833	145,831	0.409			
2017	20,833	166,664	0.460			
2018	20,833	187,497	0.511			
2019	20,833	208,330	0.562			
2020	20,837	229,163	0.613			
Total	**250,000**		**3.984**			

Table 5-4. Calculation of annual carbon sequestration from and costs to implement reforestation from 2008 to 2020.

Year	Acres planted this year (ac/yr)	Acres planted in prior years	Carbon sequestered in cumulative planted acreage (MMtCO2e/yr)	Cost	Discounted cost	Levelized cost effectiveness
2009	41,667	0	0.051			
2010	41,667	41,667	0.102			
2011	41,667	83,333	0.152			
2012	41,667	125,000	0.203			
2013	41,667	166,667	0.254			
2014	41,667	208,333	0.305			
2015	41,667	250,000	0.356			
2016	41,667	291,667	0.406			
2017	41,667	333,333	0.457			
2018	41,667	375,000	0.508			
2019	41,667	416,667	0.559			
2020	41,667	458,333	0.610			
Total	**500,000**		**3.962**			

Reforestation and Afforestation Costs

Cost analyses of vegetation planting costs typically employ four categories: opportunity cost (of planting forest rather than another, potentially more lucrative land use), conversion cost, maintenance cost, and measuring/monitoring costs (Walker et al. 2007). For this analysis, opportunity cost will be assumed to be zero because the land considered for afforestation and reforestation is currently underutilized.

One-time costs of vegetation establishment include site preparation and vegetation planting. These costs are incurred in the year of planting, one time only. Ongoing costs of maintenance and monitoring are incurred annually on all acreage planted in all years of policy implementation. Costs will vary, depending on the specific goals of the tree-planting project, species planted, and site conditions. If natural growth rather than planting occurs on a site, many of these costs may not be incurred.

Discounted costs to 2020 will be calculated using a 5% discount rate. Net present value (NPV) is the sum of the discounted costs—in other words, the economic cost or benefit of implementing the option between 2009 and 2020, calculated in today's dollars. Levelized cost-effectiveness is the NPV of a scenario divided by the cumulative GHG benefit of that scenario. This will be expressed in \$/tCO_2e sequestered or avoided, and is intended to give a sense for the cost of each scenario standardized for its actual GHG benefit across numerous scenarios and options that vary in terms of overall cost and cumulative GHG benefit.

Urban Forestry GHG Benefit

Carbon Sequestration in Urban Trees

Approximately 52,474,000 urban trees are currently growing in Iowa.[32] A 25% increase in tree cover would require planting approximately 25% more, or a total of 13,118,500 trees. To achieve an increase in urban tree cover of this many trees by 2020, approximately 1,009,115 trees per year would need to be planted in Iowa communities beginning in 2009, assuming a constant planting rate to 2020. The average annual per-tree carbon sequestration value for urban trees was found by dividing the total estimated annual carbon sequestration in IA urban trees (313,000 t C/yr) by the total number of urban trees. Annual carbon sequestration per urban tree was thus calculated as 0.006 tons C per tree per year. Since trees planted in one year continue to accumulate carbon in subsequent years, annual carbon sequestration in any given year was calculated as the sum of carbon stored in trees planted in that year, plus sequestration by trees that were planted in prior years. Because it takes the difference between total live C stocks at two points in time, this stock change approach accounts for normal tree mortality.

Avoided Fossil Fuel Emissions

GHG reductions from avoided fossil fuel use for heating and cooling can occur as a result of planting trees that provide additional shade and wind protection to buildings. The total benefits are a function of three different types of impacts: reduced cooling demand, reduced demand for heating due to wind reduction, and increased demand for heating due to wintertime shading. An average annual per tree GHG reduction factor of 0.03 tonnes CO_2e/tree/year was calculated from data in McPherson et al. in GTR-PSW-171 (Table 5-5). The estimate assumed that the trees planted are split among residential settings with pre-1950, 1950–1980, and post-1980 homes using the default distribution provided by McPherson et al. of 42%, 48%, and 10% respectively.

To calculate total avoided GHG emissions due to increased shading, it was assumed that all of the new urban trees are planted where they can have shading effects. Medium-sized trees (half evergreen, half deciduous) planted and average tree distribution around buildings were also assumed (i.e., these fossil fuel reduction factors are average for existing buildings, and do not necessarily assume that trees are optimally placed around buildings to maximize energy efficiency). These factors are also dependent on the fuel mix (coal, hydroelectric, nuclear, etc.) in the regions of interest, and may thus change if the electricity mix changes.

Table 5-5. Net GHG emission reductions from shade trees planted in the North Central climate region (from PSW-GTR-171, Appendix A, Tables V.3. and 11).

Housing age	Proportion of urban trees in this housing age category	Cooling (tonnes CO2 saved per tree)	Heating (tonnes CO2 emitted per tree)	Wind (tonnes of CO2 saved per tree)	Net effect (tCO2e/ tree)
Pre-1950	0.42	0.0175	-0.0267	0.0435	0.0343
1950-1980	0.48	0.0127	-0.0239	0.0396	0.0283
Post-1980	0.1	0.0190	-0.0282	0.0431	0.0339

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[32] USDA Forest Service Northern Research Station, USDA Forest Service, Northern Research Station, Urban Forest Effects on Environmental Quality State Summary data for Iowa (http://www.fs.fed.us/ne/syracuse/Data/State/data_IA.htm)

Weighted average (t CO2e/tree/y)	**0.03138**

The shading benefits occur in the year a tree is planted and every year thereafter. Thus, the GHG emissions reduction factor was multiplied by the cumulative number of trees planted each year to estimate annual avoided fossil fuel emissions. Total GHG benefit was calculated as the sum of direct C sequestration plus fossil fuel offset from reduced cooling demand and wind reduction. The avoided emissions and carbon sequestration benefits are summed in Table 5-6 to show the total net benefits of urban tree planting.

Table 5-6. Summary of GHG Benefits from Urban Tree Planting.

Year	Number of Trees Planted This Year	Number of Trees Planted in Prior Years	Carbon Sequestered in Cumulative Trees Planted (t C/yr)	Carbon sequestered (MMtCO2e/yr)	C Savings From Shading Effects (MMtCO2e/yr)	Total C Savings (MMtCO2e/yr)
2009	1,093,208	0	6,559	0.024	0.034	0.058
2010	1,093,208	1,093,208	13,119	0.048	0.069	0.117
2011	1,093,208	2,186,417	19,678	0.072	0.103	0.175
2012	1,093,208	3,279,625	26,237	0.096	0.137	0.233
2013	1,093,208	4,372,833	32,796	0.120	0.172	0.292
2014	1,093,208	5,466,042	39,356	0.144	0.206	0.350
2015	1,093,208	6,559,250	45,915	0.168	0.240	0.408
2016	1,093,208	7,652,458	52,474	0.192	0.274	0.467
2017	1,093,208	8,745,667	59,033	0.216	0.309	0.525
2018	1,093,208	9,838,875	65,593	0.241	0.343	0.584
2019	1,093,208	10,932,083	72,152	0.265	0.377	0.642
2020	1,093,208	12,025,292	78,711	0.289	0.412	0.700
Total	**13,118,500**			**1.876**	**2.676**	**4.552**

Urban Forestry Costs

The economic costs included in this analysis will be the costs of planting and annual maintenance, including the costs of program administration and waste disposal. The economic benefits of tree planting will include the cost avoided from reduced energy use. Data are available on the estimated economic benefits of such services as provision of clean air, hydrologic benefits (e.g., stormwater control), and aesthetic enhancement, but these indirect co-benefits will not explicitly quantified.

Costs and cost savings will be estimated from average annual costs and cost savings over 40 years for a range of tree sizes. The cost estimate used in this analysis will be calculated as the average of small, medium, and large trees under public and private management. The cost savings will also be calculated as the average of small, medium, and large trees under public and private management. The cost savings will be estimated using 40-year averages; thus, it will represent lifetime costs applicable in the year planted and every year thereafter during the time frame of the analysis. To estimate total cost savings, cost per tree will be multiplied by the cumulative number of trees planted each year.

Biochar GHG Benefits

Need information and data sources for GHG benefits of biochar.

Biochar Costs

Need information and data sources for GHG benefits of biochar.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

TBD – [as needed and approved by the subcommittees]

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

AFW-6. Cellulosic Fuel Incentives

Policy Description

Promote research and production of sustainable in-state fuels derived from cellulose (biomass) to displace the use of conventional petroleum-based fuels. Promote the in-state development of cellulosic feedstocks (including perennials) that are able to be utilized for the production of cellulosic fuels. Promote research into conversion technologies, such as thermo-chemical Fischer-Tropsch processes and enzymatic conversion, to facilitate their development.

Promote cellulosic biofuel 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. This could help provide a strong economic market within the state and reduce GHG emissions through avoided fossil fuel consumption.

Note that this option is focused on the supply-side aspects of promoting biofuels, with an emphasis on the development of feedstocks and production technologies. The demand-side aspects of renewable fuels (including cellulosic biofuels) are being addressed through the Transportation and Land Use subcommittee through TLU-8.

Policy Design

Goals:

Increase in-state cellulosic feedstock production by 10 million dry tons by 2020.

Timing: Full implementation by 2020.

Parties Involved:

State of Iowa, farmers, biofuels producers, distributors, fuel retailers, fuel wholesalers, business owners, and relevant agriculture and trade associations.

Other:

Implementation Mechanisms

TBD – [CCS drafts based on subcommittee 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 subcommittee approval]

Related Policies/Programs in Place

Question for Sub-committee: Are there plans currently in place for any cellulosic ethanol facilities in the state of Iowa? If so, what is their planned capacity, estimated time of opening, etc.?

Type(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 biofuels 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

Estimated GHG reductions: 20.7 $MMtCO_2e$ cumulative by 2020

Estimated cost: $1,020 (2007 MM$) cumulative by 2020

Data Sources:

What feedstock sources would be used – Switchgrass and energy crops? Residue from current agricultural production? Wood residue? Will energy crops be grown on CRP or marginal land?

Quantification Methods:

Biofuel GHG Reductions

For ethanol the benefits for this option are dependent on developing in-state production capacity that achieves benefits beyond petroleum fuels.

Based on the emission factors listed above, the incremental benefit of cellulosic production targeted by this policy over gasoline is 8.46 $MtCO_2$ reduced/1,000 gallons minus the land use cost of converting land to cellulose production of 4.93 Mt CO_2/1,000 gallons[33]. The emission factor value is based on the difference between the lifecycle CO_2e emission factor of gasoline (11.74 metric tons/1,000 gallons) and the lifecycle CO_2e emission factor of cellulosic ethanol (3.28 metric tons/1,000 gallons).[34] The cellulosic benefit value will be used along with the production in each year to estimate GHG reductions.

GHG reductions are estimated by assuming a linear increase in cellulose production to 10,000,000 tons in 2020. Annual cellulose production is multiplied by the estimated ethanol yield per ton biomass. The ethanol yield is then multiplied by 8.46 Mt CO_2e reduced/1,000 gallons ethanol to determine GHG reductions.

Biofuel Costs

For ethanol, costs for the incentives needed by this policy option are based on the estimated production costs of cellulosic ethanol. Estimates taken from an NREL-sponsored industry forum

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[33] This one-half the value suggested by Searchinger, et al, 2008, of the land use cost of cellulosic ethanol over gasoline.

[34] DOE/EIA, http://www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 9, 2008. ANLGreet model emission factor in g/mi x GREET model average fuel economy (100 mi/4.7 gal).

estimate a production cost differential of $0.69 per gallon for cellulose-based over corn-based ethanol. [note to TWG: this number may change pending review of new studies from DOE] (for more information on these costs, please see the Key Uncertainties section below).[35] This is used to estimate the incentive necessary to ramp up in-state cellulosic ethanol production. These estimates include capitals costs so additional incentives for capital and R&D are not included in this analysis. These incentives are considered necessary in the near term to help commercialize technologies that produce ethanol from cellulose. The incentives should also help to establish the infrastructure to deliver biomass to biorefineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives could be discontinued beginning in 2015. Note that federal legislation has been proposed to offer cellulose an incentive of $0.765/gallon compared to the $0.51/gallon currently offered for ethanol production.[36] If enacted, this $0.255/gallon premium could cover the additional incentives that are assumed to be needed by the State of Iowa. The federal incentives do not assure, however, that production facilities would locate in Iowa, hence these federal incentives have not been factored into the cost estimates for this option.

To estimate the cost of cellulosic ethanol incentives, estimated ethanol yield from biomass is multiplied by $0.69 per gallon. Costs were discounted to 2007 dollars.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

Cost competitiveness of biofuels will depend on cost of oil.

Carbon emissions from land use change: Recent publications such as Searchinger, *et al*, 2008, have attempted to estimate the carbon emissions that result from land use being converted to cropland to grow crops for fuel. This is based on the argument that the conversion of current cropland from food/feed/fiber production in one part of the world will drop the food/feed/fiber supply on the market and drive grassland or forest conversion to cropland in other parts of the world. There is still significant uncertainty regarding the value of carbon emissions due to land use change. Additionally, conversion of cropland to fuel production may have impacts on food prices and supply.

Cost of cellulosic ethanol production: The Energy Information Administration (EIA) has stated "Capital costs for a first-of-a-kind cellulosic ethanol plant with a capacity of 50 million gallon per year are estimated by one leading producer to be $375 million (2005 dollars), as compared with $67 million for a corn-based plant of similar size, and investment risk is high for a large-scale cellulosic ethanol production facility. Other studies have provided lower cost estimates. A detailed study by the National Renewable Energy Laboratory in 2002 estimated total capital costs for a cellulosic ethanol plant with a capacity of 69.3 million gallons per year at $200

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[35] http://www.nrel.gov/technologytransfer/entrepreneurs/pdfs/19_forum/braemar_cellulosic.pdf, slide 21, accessed December 2007

[36] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

million."[37]

In June 2006, a U.S. Senate hearing was told that the current cost of producing cellulosic ethanol is US $2.25 per US gallon (US $0.59/litre). This is primarily due to the current poor conversion efficiency. At that price it would cost about $120 to substitute a barrel of oil (42 gallons), taking into account the lower energy content of ethanol. However, the Department of Energy is optimistic and has requested a doubling of research funding. The same Senate hearing was told that the research target was to reduce the cost of production to US $1.07 per US gallon (US $0.28/litre) by 2012.

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

Implementation of this option requires additional research and development in cellulosic ethanol production methods, development of feedstock collection and delivery infrastructure, successful negotiations with cellulosic technology leaders to establish pilot and commercial-scale plants in the state. Sourcing of feedstocks and the size and location of facilities (both crushing and biodiesel production) must be addressed for optimization and planning. Trade-offs between food and fuel crops will be an important issue.

There may be an overlap among agricultural options that seek to increase/maintain crop acreage in no-till production or in conservation management programs. This could be in conflict with the higher levels of crop production proposed in this option.

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

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[37] http://www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed December 2007

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

Policy Description

Renewable energy can be produced and used on-site at agriculture operations. For example, installation of solar or wind power, use of hydro-powered generators for irrigation, and converting diesel farm equipment to more efficient or renewable energy technology will reduce carbon dioxide emissions. The use of energy efficient products should also be promoted. This could include improved grain dryers, heat exchangers (dairy), electric motors, and energy efficient building design.

Policy Design

Goals:

Renewable Energy—Increase renewable energy use at agriculture operations by 10% by 2020.

Energy Efficiency—Increase energy efficiency of on-farm operations by 30% by 2020.

Timing:

Parties Involved:

Other:

Implementation Mechanisms

TBD – [CCS drafts based on subcommittee 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 subcommittee approval]

Related Policies/Programs in Place

TBD

Type(s) of GHG Reductions

CO_2: Improved efficiency can reduce electricity and fuel consumption and the associated GHGs.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

Renewable Energy: Iowa Renewable Energy Guide[38] may be valuable in estimating costs of various renewable energy technologies on a small scale. If this policy is more intended to install on-farm renewable energy on a large scale, then different cost estimates will be used, such as the Energy Information Agency Report entitled: "Assumptions for the Annual Energy Outlook 2006:

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[38] http://www.iowadnr.gov/energy/renewable/files/renewableguide.pdf

with projections to 2025", 2006.

Energy Efficiency: Consumption of distillate fuel by the agriculture sector in Iowa was projected from historical data provided by the Energy Information Administration (EIA).[39] The petro-diesel emissions factor used is consistent with the California Climate Action Registry (10.05 $MtCO_2e$/1,000 gal)[40]. The agricultural sector electricity consumption was derived from the National Agriculture Statistics Service (NASS)[41] and historical electricity prices from the EIA.[42]

Quantification Methods:

Renewable Energy GHG Benefits

Potential renewable energy options available for Iowa farmers include wind, solar photovoltaics, solar thermal heating and geothermal. Methane utilization is considered under AFW-4 and will not be covered here. A reasonable mix of these technologies will be based on Iowa's specific circumstances and will be informed by the state-wide energy portfolio. An example from Colorado is provided below in Tables 7-1 and 7-2. These numbers are being used as a stand-in, but will be updated for Iowa after consultation with the Energy Supply Subcommittee.

Table 7-1. Annualized cost of renewable generation

Year	Annualized Wind Cost (2005$/MW-hr)	Annualized PV Cost (2005$/MW-hr)	Annualized Solar Thermal Cost (2005$/MW-hr)	Annualized Geothermal Cost (2005$/MW-hr)
2009	50	576	254	-
2010	50	576	254	-
2011	49	543	252	78
2012	48	509	250	78
2013	47	476	247	78
2014	46	442	245	78
2015	45	409	243	78
2016	45	409	243	77
2017	45	409	243	76
2018	45	409	243	76
2019	45	409	243	75
2020	45	409	243	74

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[39] Energy Information Administration. "Colorado Total Distillate Sales/Deliveries to Farm Consumers." 1984–2006. Accessed on 4/25/08, at http://tonto.eia.doe.gov/dnav/pet/hist/kd0vfmsia1a.htm

[40] California Climate Action Registry. "General Reporting Protocol" March 2007.

[41] National Agricultural Statistics Service. "Iowa Agriculture: A Profile." 2005 data. Accessed on April 25, 2008, at http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/

[42] Energy Information Administration. "Current and Historical Monthly Retail Sales, Revenues, and Average Retail Price by State and by Sector (Form EIA-826)." Table accessed on 4/25/08, at www.eia.doe.gov/cneaf/electricity/page/sales_revenue.xls.

Table 7-2. Assumed mix of generation

Year	Share of Wind	Share of Solar PV	Share of Solar Thermal	Share of Geothermal
2009	98%	1%	1%	0%
2010	98%	1%	1%	0%
2011	97%	1%	1%	0%
2012	96%	2%	2%	1%
2013	94%	2%	2%	1%
2014	93%	3%	3%	2%
2015	92%	3%	3%	2%
2016	92%	3%	3%	2%
2017	92%	3%	3%	2%
2018	91%	3%	3%	3%
2019	91%	3%	3%	3%
2020	91%	3%	3%	3%

If the on-farm mix in Iowa is likely to be different from that provided by the ES SC, then the AFW subcommittee should provide information on reasonable percentages of each technology to use. The GHG benefits were quantified based on the emission differences between the renewable portfolio and the grid electricity that it is replacing. The analysis assumes that renewable energy will be used to replace 10% of on-farm electricity. The business as usual projections of electricity use come from the IA Inventory and Forecast, using the electricity consumption estimates between 2005-2020. The share being consumed in on-farm use was calculated by taking the national agricultural electricity use and multiplying that by IA's share of total agricultural emissions.

Renewable Energy Costs

The costs/benefits of incentivizing each technology were considered. If the SC wants the analysis to pursue renewable energy in any manner other than state incentivizing, they should be clear on how that is meant to be implemented. Costs were based on the portfolio of technologies considered, and the different costs of each, as seen in Table 7.1.

Energy Efficiency GHG Benefits

This analysis also considered various technology possibilities available to reduce on-farm energy consumption. Potential options include: education programs to optimize tire inflation, improving efficiency of water pumps, more efficient lighting, and incentives for more efficient tractors. If other technologies are to be considered in the analysis, subcommittee members should provide examples of information on how these technologies could be used in Iowa. The GHG benefits were calculated based on the emissions that have been avoided because of the new technologies. This could come in the form of fuel savings or reduced electricity consumption. The total GHG benefit was calculated based on the emissions factors of the various fuels (CO2e/BTU or gallon) or electricity (CO2e/kWh). The business as usual projections of electricity use come from the IA Inventory and Forecast, using the electricity consumption estimates between 2005-2020. The share being consumed in on-farm use was calculated by taking the national agricultural electricity use and multiplying that by IA's share of total agricultural emissions. The business as usual fuel use was derived by dividing the amount sold in agricultural use in Iowa by the cost of a gallon of diesel fuel in 2006 (both figures from the USDA). No growth in diesel fuel consumption was assumed because of conflicting growth estimates.

Efficiency Costs

This analysis will be done by examining the cost of installing or optimally using various technologies (for example more efficient pumps). In order to maximize pump efficiency, they must be tested and replaced periodically, which requires a capital investment.

Using estimates of the total number of pumps potentially available in Iowa, we can determine the total costs of this project. This total cost figure will be balanced against the fuel/ electricity savings which occur with such an efficiency investment. Costs and savings for each year will be discounted back to 2005 dollars.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

Implementing renewable projects at a small scale (e.g. on-farm operations) can often be difficult and/or expensive. This may be a limiting factor in the implementation of this option.

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

AFW-8. Waste Management Strategies

Policy Description

Reduce the volume of waste from residential, commercial, and government sectors through programs that reduce the generation of wastes. Reduction of generation at the source reduces both landfill emissions and upstream production emissions.

Increase recycling or reuse of waste in order to limit GHG emissions associated with landfill methane generation and with the production and transport of products/packaging from virgin materials (noting that different recycled materials will exhibit different costs and benefits on a life cycle basis). Increase recycling programs, create new recycling programs, provide incentives for recycling construction materials, develop markets for recycled materials, and increase average participation/recovery rates for all existing recycling programs.

Increase organics management programs, such as composting, in order to reduce GHG emissions associated with land-filled organic waste.

Policy Design

Three approaches are possible: recycling approach, waste prevention approach, market driven approach, i.e., producer responsibility (voluntary systems and mandatory systems).

Goals:

Waste Prevention—Achieve a 0% per capita increase in waste production (as compared to 2005), from residential commercial, and government sectors by 2020.

Reuse and Recycling—Increase statewide recycling rate average to 35% by 2020 as compared to the amount of waste produced. (If waste is minimized, then there will be less materials to recycle.)

Extended Producer Responsibility—Reach an agreement with manufacturers, producers, and retailers to reduce by 10 percent the quantity of packaging on the market and pursue more environmentally friendly packaging.

Work with U.S. industry to achieve life cycle product stewardship, so that products are designed for reuse, repair (not planned obsolescence), and recycling. Alternatively, shift the responsibility for managing discarded products and packaging from local government to producers of products. (non-quantified goal)

Timing:

Parties Involved:

Other:

In 2005, Iowa diverted 29.3% of generated municipal solid waste from landfills (see Table 1 below). The recycling rate was 27.1% and the composting rate was 2.1%. Compostable organics comprised 9.8% of the total waste generated, setting the upper bound for the Subcommittee's composting goal.[43]

Table 1. 2005 Baseline Waste Generation and Diversion

Item	2005
Total Generation (tons)	**3,775,550**
Iowa Population	2,955,587
MSW Generation per Capita	1.28
Landfill Disposal (tons)	2,679,700
Total Diversion (tons)	1,108,531
Diversion %	29.3%
Recycling (tons)	1,028,077
Recycling %	27.1%
Composting (tons)	80,454
Composting %	2.1%

Data needed to estimate the future generation of MSW in Iowa are not available from the resources on the DNR website. Therefore, CCS assumed that the per capita MSW generation rate would follow the same trend as the national MSW generation. Table 2 below identifies the average annual increase in per-capita generation as 0.14%.[44] This results in an increase in waste generation from 1.28 tons/person/year in Iowa in 2005 to 1.30 tons/person/year in 2020.

Table 2. National MSW Generation Rates

Year	Generation (tons)	Population	Generation (tons/cap/year)	Generation (lb/cap/day)	Annual % Change in Generation per Capita
1990	205,210,000	249,907,000	0.82	4.50	
2000	238,260,000	281,422,000	0.85	4.64	0.31%
2002	239,390,000	287,985,000	0.83	4.55	-0.91%
2004	249,180,000	293,660,000	0.85	4.65	1.04%
2005	248,150,000	296,410,000	0.84	4.59	-1.34%
2006	251,340,000	299,398,000	0.84	4.60	0.27%
				Avg. Annual Change 1990-2006	**0.14%**

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[43] Iowa Department of Natural Resources. "Economic Impacts of Recycling in Iowa." December 2007. Accessed on March 7, 2008 from; http://www.iowadnr.com/waste/recycling/files/ecofullreport.pdf. The 2005 baseline data is estimated from Table 7.1 of the "Economic Impacts of Recycling in Iowa" report.

[44] http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf

Waste Prevention

The route to waste prevention requires a combination of initiatives by manufacturers and retailers, governmental intervention, as well as better informed consumers.

Waste prevention and recycling are at different ends of the spectrum. Recycling programs do not further the goals of waste prevention.

The incentive for manufacturers, producers, and consumers to minimize waste is greatly reduced when the emphasis is on municipal recycling programs.

There is insufficient awareness and understanding of the benefits and methodology of waste prevention. There is predominantly an emphasis in both the public and private sectors on "end-of-pipe" waste treatment rather than prevention.

With waste prevention, greenhouse gas emissions associated with waste disposal are not only avoided, but also all the emissions associated with extraction, manufacturing and transport. Waste prevention is genuinely sustainable resource management.

Manufacturing take back programs create an incentive for waste minimization.

Consumer education on waste-related purchase behavior results in little impact as consumers have a tendency to rank price, convenience and brand name as more critical than environmental considerations.

EPA estimates that for each person participating in a PAYT program, greenhouse gas emissions are reduced by an average of 0.088 metric tons of carbon equivalent. (EPA, 1999) A community of 100,000 people could potentially reduce GHG emissions by 8,800 metric tons of carbon equivalent.

Recycling

Goals of ever higher recycling targets will have higher costs. There is increasing demand for more materials to be added to recycling programs, which will further escalate costs and add to risks of being able to market the materials collected.

High recycling rates inadvertently justify high consumption rates. Statutory recycling targets do not prevent waste but force the focus on recycling.

Providing garbage collection more frequently than recycling collection encourages disposal rather than recycling.

The development of integrated waste management facilities such as commercial MRFs and biodegradable waste composting facilities are complex and expensive and siting such facilities is problematic if not impossible.

Flow control will become an issue if Iowa establishes waste rules and regulations that are more stringent, onerous, and more costly than surrounding states.

The overriding goal should be on climate change; we should evaluate the potential of source reduction or recycling to achieve the goal of reducing greenhouse gas emissions.

As the principal generator of waste, industry is a crucial stakeholder in the effective implementation of waste reduction and recycling.

Implementation Mechanisms

Assist in the creation and expansion of sustainable markets to support diversion and recycling efforts.

Introduce appropriate financial, legal and policy incentives and sanctions to induce waste generators to prevent waste and recycle.

Focus local government efforts to require multi-family recycling.

Focus local government efforts to require construction and demolition recycling.

Make recycling more convenient and cost-effective when compared to waste disposal, e.g., implement curbside single stream recycling systems and food waste collection. (all organics?)

Implement incentives for customers to reduce waste through meaningful Unit Based Pricing systems for waste disposal in all regions with combined populations above XXXXX.

Establish composting programs for yard waste and food waste in all regions with combined populations above XXXXX.

Pilot Commercial Material Recovery Facilities (COMM MRFs) through which all commercial waste will be processed before residuals are disposed of (not front-end).

Require mandatory life cycle product stewardship (extended producer responsibility) which is designed, financed, and managed by manufacturers of consumer goods.

Hold manufacturers responsible for the waste and environmental impact of their products and packaging (producer responsibility) rather than passing that responsibility to the consumer.

Place a tax on plastic bags.

Establish statewide landfill bans for select materials that can be reused, recycled, or otherwise recovered.

Expand the materials collected through the Bottle Bill and increase financial incentives for collectors.

Educate the community about the consequences of generating waste and responsible consumerism.

Clearly define waste reduction and establish as a priority.

Distribute information on how to reduce unwanted mail and catalogues.

Encourage use of reusable shopping bags.

Promote "simple living," local purchasing

Promote an economic environment that favors the use of recycled materials.

Related Policies/Programs in Place

Waste Management Programs: The State of Iowa runs several programs to promote waste reduction, recycling, and composting. These programs include Iowa DNR's Solid Waste Alternatives Program, Pollution Prevention Services Program, and Iowa Waste Exchange, as well as Iowa Waste Reduction Center at the University of Northern Iowa.

Landfill Diversion Goals: The State of Iowa adopted the goal of diverting 50% of waste from landfills by the year 2000 from year 1988 levels.

Type(s) of GHG Reductions

CO_2: Upstream Energy Use Reductions—The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.

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 2012, 2020 (MMtCO_2e): 0.44, 1.17, respectively.

Net Cost per tCO_2e: –$0.6.

Data Sources: [TBD by CCS on subcommittee approval]

Quantification Methods:

The waste management profile in Iowa presented in the "Policy Design" section was used as a baseline to project business as usual (BAU) and policy scenarios, which form the basis for this quantitative analysis. The average annual increase in per capita waste generation is assumed to be 0.14% (see Table 2). The share of waste management comprised of recycling and composting is assumed not to change throughout the policy period. Therefore, the assumed recycling rate was 27.1% and the assumed composting rate was 2.1%.[45] The population projection for Iowa through 2020 is consistent with the projection used by the Draft Iowa GHG Inventory and Forecast. Table 3 outlines the projected BAU waste management scenario for Iowa.

Table 3. BAU Waste Management, 2005-2020.

Item	2005	2010	2012	2015	2020
MSW Generation per capita (tons/person)	1.28	1.29	1.29	1.30	1.30
IA Population (from I&F)	2,955,587	3,009,907	3,016,485	3,026,380	3,020,496

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[45] As a result of modeling constraints, all organic material that is "recycled" is considered to be "composted." As recycling and composting have different implications on the analysis of the GHG benefit and cost effectiveness of this option, the two management methods will be treated separately, with the total diversion equal to the TWG target of 35%. Please note that the term "diversion" refers to the combination of recycling and composting.

Item	2005	2010	2012	2015	2020
MSW Generation (tons)	3,775,550	3,871,850	3,891,152	3,920,286	3,940,048
MSW Recycled (tons, 27.2% of generation, not including organics)	1,024,636	1,050,770	1,056,008	1,063,915	1,069,278
Organic Composting (tons, 2.1% of generation)	80,185	82,230	82,640	83,259	83,678
MSW Disposed in landfills (tons)	2,670,730	2,738,850	2,752,504	2,773,113	2,787,092

The policy scenario was determined by applying the TWG targets to the BAU waste management projection in Table 3. Interim targets for 2012 were estimated, assuming that recycling and composting each comprise a constant proportion of the goal. The 2012 targets for recycling and composting are 29.6% and 2.3%, respectively. The 2020 targets for recycling and composting are 32.5% and 2.5%, respectively. The waste reduction goal (zero increase in waste per capita by 2020) is applied by assuming a constant reduction in the difference between the BAU projected annual increase in generation per capita and the 2005 baseline generation per capita rate. Table 4 outlines the policy waste management scenario.

Table 4. Policy Waste Management, 2005-2020

Item	2005	2010	2012	2015	2020
MSW Generation Per Capita (tons/person)	1.28	1.284	1.283	1.281	1.277
IA Population (from I&F)	2,955,587	3,009,907	3,016,485	3,026,380	3,020,496
MSW Generation (tons)	3,775,550	3,864,497	3,869,023	3,875,815	3,858,467
MSW Recycled (tons)	1,024,636	1,101,331	1,153,363	1,201,045	1,280,516
Organic Composting (tons)	80,185	85,539	88,963	92,540	98,501
MSW Disposed in landfills (tons)	2,670,730	2,677,627	2,626,698	2,582,231	2,479,450

Table 5 displays the incremental changes in waste management, or the difference between the BAU and policy scenarios. These numbers represent the changes in waste management as a result of this option. They are the basis for the GHG benefit and cost effectiveness measurements.

Table 5. Incremental Changes in Waste Management, 2005-2020

Item	2005	2010	2012	2015	2020
MSW Generation (tons, Source Reduction)	-	7,353	22,129	44,471	81,582
Recycling (tons)	-	50,561	97,354	137,130	211,237
Organic Composting (tons)	-	3,309	6,323	9,281	14,823
Landfill Disposal (tons)	-	-61,223	-125,806	-190,882	-307,642

GHG Benefits

GHG benefits were determined using the EPA's WAste Reduction Model (WARM).[46] WARM uses information for specific material inputs and disposal/diversion methods to estimate GHG emission reductions based on a business-as-usual (BAU) and policy scenario. Table 6 below describes the 2005 Data Inputs for the WARM model.[47] These numbers will represent the baseline scenario.

Table 6. Baseline WARM Model Inputs for Iowa, 2005.

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	28,411	21,979	6,432		NA
Steel Cans	31,418	10,516	20,902		NA
Copper Wire					NA
Glass	99,872	63,428	36,444		NA
HDPE	26,438	5,000	21,438		NA
LDPE	610	610			NA
PET	25,139	11,740	13,399		NA
Corrugated Cardboard	330,237	149,625	180,612		NA
Magazines/Third-class Mail	186,775		186,775		NA
Newspaper	325,214	240,000	85,214		NA
Office Paper	55,004	2,750	52,254		NA
Phonebooks					NA
Textbooks					NA
Dimensional Lumber	344,525	167,665	176,860		NA
Medium-density Fiberboard					NA
Food Scraps	225,595	NA	225,095		500
Yard Trimmings	101,573	NA	34,300		67,273
Grass		NA			

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[46] WAste Reduction Model (WARM)." Version 8, May 2006. Available at: http://www.epa.gov/climatechange//wycd/waste/calculators/WARM_home.html. EPA created WARM to help solid waste planners and organizations track and voluntarily report GHG emission 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 tCe, tCO_2e, and energy units (MMBtu) across a wide range of material types commonly found in MSW. For an explanation of the methodology, see the EPA report *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, EPA530-R-02-006, available at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html

[47] Iowa Department of Natural Resources. "Economic Impacts of Recycling in Iowa." December 2007. Accessed on March 7, 2008 from; http://www.iowadnr.com/waste/recycling/files/ecofullreport.pdf. The 2005 baseline data is estimated from Table 7.1 of the "Economic Impacts of Recycling in Iowa" report.

Material	**Tons Generated**	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**
Leaves		NA			
Branches		NA			
Mixed Paper (general)	349,636	153,214	196,422		NA
Mixed Paper (primarily residential)					NA
Mixed Paper (primarily from offices)					NA
Mixed Metals	250,620	178,000	72,620		NA
Mixed Plastics	298,059	16,959	281,100		NA
Mixed Recyclables					NA
Mixed Organics	44,301	NA	31,620		12,681
Mixed MSW	1,007,566	NA	1,007,566		NA
Carpet	575	575			NA
Personal Computers	51,281	634	50,647		NA
Clay Bricks		NA		NA	NA
Concrete	5,382	5,382		NA	NA
Fly Ash				NA	NA
Tires					NA
Totals	3,788,231	1,028,077	2,679,700	-	67,773

The WARM model was run for the years 2012 and 2020, in order to produce GHG reduction estimates for the policy target years. GHG benefits are assumed to increase linearly between policy initiation (2010) and between modeled years. The proportional generation and recycling are assumed to stay the same throughout the policy period. The exceptions, however, are those categories for which source reduction is an acceptable input for the policy scenario. It is assumed that source reduction offsets landfilled waste, with the amount of waste recycled generally increasing for these categories. The breakdown of source reduction for each waste category is shown in Table 7.[48]

Table 7. Share of Source Reduction for WARM Input

Tons Source Reduced	**100%**
HDPE	4.5%
LDPE	0.5%

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[48] This breakdown is similar to the one used for the Minnesota CCS process. These percentages may be adjusted according to the Subcommittee's input.

Tons Source Reduced	100%
PET	25.0%
Corrugated Cardboard	30.0%
Magazines/Third Class Mail	30.0%
Office Paper	10.0%

Tables 8 and 9 display the BAU and policy WARM modeling for 2020.

Table 8. 2020 BAU WARM Inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	29,550	22,860	6,690		NA
Steel Cans	32,677	10,937	21,740		NA
Copper Wire					NA
Glass	103,874	65,970	37,905		NA
HDPE	27,498	5,200	22,297		NA
LDPE	634	634	-		NA
PET	26,146	12,210	13,936		NA
Corrugated Cardboard	343,472	155,621	187,850		NA
Magazines/Third-class Mail	194,260	-	194,260		NA
Newspaper	338,247	249,618	88,629		NA
Office Paper	57,208	2,860	54,348		NA
Phonebooks					NA
Textbooks					NA
Dimensional Lumber	358,332	174,384	183,948		NA
Medium-density Fiberboard					NA
Food Scraps	234,636	NA	234,116		520
Yard Trimmings	105,644	NA	35,675		69,969
Grass		NA			
Leaves		NA			
Branches		NA			
Mixed Paper (general)	363,648	159,354	204,294		NA
Mixed Paper (primarily residential)					NA
Mixed Paper (primarily from offices)					NA

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Mixed Metals	260,664	185,134	75,530		NA
Mixed Plastics	310,004	17,639	292,365		NA
Mixed Recyclables					NA
Mixed Organics	46,076	NA	32,887		13,189
Mixed MSW	1,047,945	NA	1,047,945		NA
Carpet	598	598	-		NA
Personal Computers	53,336	659	52,677		NA
Clay Bricks		NA		NA	NA
Concrete[1]	5,598	5,598	-	NA	NA
Fly Ash[2]				NA	NA
Tires[3]					NA
Totals	3,940,048	1,069,278	2,787,092	-	83,678

Table 9. 2020 Policy WARM Inputs

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	29,550		27,607	1,942		
Steel Cans	32,677		13,209	19,468		
Copper Wire						
Glass	103,874		79,670	24,204		
HDPE	27,498	3,671	6,280	17,546		
LDPE	634	408	227	-		
PET	26,146	20,395	5,751	-		
Corrugated Cardboard	343,472	24,474	187,940	131,058		
Magazines/Third-class Mail	194,260	24,474	-	169,786		
Newspaper	338,247		301,457	36,790		
Office Paper	57,208	8,158	3,454	45,596		
Phonebooks						
Textbooks						
Dimensional Lumber	358,332		210,599	147,733		
Medium-density Fiberboard						
Food Scraps	234,636			234,024		612
Yard Trimmings	105,644			23,280		82,363

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Grass						
Leaves						
Branches						
Mixed Paper, Broad	363,648		192,448	171,200		
Mixed Paper, Resid.						
Mixed Paper, Office						
Mixed Metals	260,664		223,581	37,083		
Mixed Plastics	310,004		21,302	288,702		
Mixed Recyclables						
Mixed Organics	46,076			30,551		15,526
Mixed MSW	1,047,945			1,047,945		
Carpet	598		598	-		
Personal Computers	53,336		796	52,540		
Clay Bricks						
Concrete[1]	5,598		5,598	-		
Fly Ash[2]						
Tires[3]						
Totals	3,940,048	81,582	1,280,516	2,479,450	-	98,501

The resulting output for the 2012 and 2020 WARM model runs predict the GHG reductions for these years to be 0.44 and 1.17 MM tCO_2e, respectively. The cumulative GHG reductions are calculated to be 7.7 $MMtCO_2e$.Table 10 displays a summary of the waste diversion, reduction, and GHG benefits of this option.

Table 10. Overall Policy Results – GHG Benefits

Year	Avoided Emissions (MMtCO2e)	Incremental Waste Diversion (tons)	Source Reduction (tons)	Incremental Recycling (tons)	Incremental Composting (tons)	Avoided Landfill Emplacement (tons)
2009	-	-	-	-	-	-
2010	0.15	61,223	7,353	50,561	3,309	-61,223
2011	0.29	121,233	14,729	99,977	6,528	-121,233
2012	0.44	125,806	22,129	97,354	6,323	-125,806
2013	0.53	147,481	29,553	110,619	7,309	-147,481
2014	0.62	169,173	37,000	123,878	8,295	-169,173

Year	Avoided Emissions (MMtCO2e)	Incremental Waste Diversion (tons)	Source Reduction (tons)	Incremental Recycling (tons)	Incremental Composting (tons)	Avoided Landfill Emplacement (tons)
2015	0.72	190,882	44,471	137,130	9,281	-190,882
2016	0.81	214,233	51,890	151,954	10,390	-214,233
2017	0.90	237,584	59,310	166,776	11,498	-237,584
2018	0.99	260,936	66,732	181,598	12,606	-260,936
2019	1.08	284,289	74,156	196,418	13,715	-284,289
2020	1.17	307,642	81,582	211,237	14,823	-307,642
Totals	7.7	2,120,482	488,904	1,527,502	104,077	-2,120,482

Cost Effectiveness

***Source Reduction*—**The total amount of waste managed in Iowa under the policy scenario is reduced, due to the goal requiring a zero percent increase in the per capita waste generation rate by 2020. The cost effectiveness estimate for source reduction in Iowa is comprised of three elements; the cost of program implementation, the avoided cost of waste collection, and the avoided cost of waste disposal.

The cost of program implementation is assumed to be $1 per capita per year.[49] The cost figure uses the population projection consistent with that used for the Iowa Inventory and Forecast. These funds are assumed to cover any education and marketing programs necessary to implement the source reduction goal.

Source reduction is expected to save money by reducing the amount of waste that has to be collected and disposed of in landfills. The avoided collection cost is $80/ton[50] and the avoided landfill disposal fee is $40/ton.[51]

The analysis assumes that costs begin to be incurred in 2010. The estimated cost savings result in an NPV of –$16 million. Cumulative GHG reductions attributed to recycling are 2.7 MMtCO$_2$e, and the estimated cost-effectiveness is –$6/tCO$_2$e, as shown in Table 11.

Table 11. Cost Analysis for Source Recution

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[49] The source reduction program cost is a preliminary estimate that is consistent with costs assumed in similar options considered by CCS projects in WA and CO.

[50] IA DNR Evaluation of Recycling Programs. Average of case studies from Cedar Rapids, Marion, Iowa City, and Central City.

[51] Average of tip fee of landfills in Iowa reporting a per-ton tip fee. http://www.iowadnr.com/waste/sw/files/tp_survey.pdf

Year	Tons Reduced	Avoided Landfill Tipping Fee (2006$MM)	Program Costs (2006$MM)	Net Source Reduction Costs (2006$MM)	Discounted Costs (2006$MM)	GHG Reductions (MMtCO$_2$e)	Cost Effectiveness ($/tCO$_2$e)
2009	-	$0	$0	$0	$0	0.00	
2010	7,353	$1	$3	$2	$2	0.04	
2011	14,729	$2	$3	$1	$1	0.08	
2012	22,129	$3	$3	$0	$0	0.12	
2013	29,553	$4	$3	-$1	$0	0.17	
2014	37,000	$4	$3	-$1	-$1	0.21	
2015	44,471	$5	$3	-$2	-$2	0.25	
2016	51,890	$6	$3	-$3	-$2	0.29	
2017	59,310	$7	$3	-$4	-$3	0.33	
2018	66,732	$8	$3	-$5	-$3	0.38	
2019	74,156	$9	$3	-$6	-$4	0.42	
2020	81,582	$10	$3	-$7	-$4	0.46	
				-$25	**-$16**	**2.7**	**-$6**

***Recycling*—**The net cost of increased recycling rates in Iowa was estimated by adding the increased costs of collection for two-stream recycling, revenue obtained for the value of recycled materials, and avoided landfill tipping fees. The additional cost for separate curbside collection of recyclables is $133/ton.[52] The capital cost of additional recycling facilities in Iowa is $148 million.[53] Annualized over the 10-year policy period at 5% interest, the capital cost is $9.6 million/year. The avoided cost for landfill tipping is $40/ton.[54] CCS also factored in the commodity value of recycled materials with a value of $156/ton.[55] Table 12 provides the results of the cost analysis. The analysis assumes that costs begin to be incurred in 2010. The estimated cost savings result in an NPV of –$0.7 million. Cumulative GHG reductions attributed to recycling are 5 MMtCO$_2$e, and the estimated cost-effectiveness is –$0.1/tCO$_2$e.

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[52] IA DNR Evaluation of Recycling Programs. Average of case studies from Cedar Rapids, Marion, Iowa City, and Central City.

[53] Based upon the ratio of capital cost per household used in the Vermont analysis. Vermont capital cost a result of personal communication between P. Calabrese (Cassella Waste Management) and S. Roe (CCS).

[54] Average of tip fee of landfills in Iowa reporting a per-ton tip fee. http://www.iowadnr.com/waste/sw/files/tp_survey.pdf

[55] Calculated by dividing the receipts from recyclables collected in IA from the amount of recyclables collected in IA. IA DNR Economic Impacts of Recycling Report.

Table 12. Cost analysis results for recycling

Year	Tons Recycled	Annual Collection Cost (MM\$)	Annual Capital Cost (MM\$)	Annual Recycled Material Revenue (MM\$)	Landfill Tip Fees Avoided (MM\$)	Net Policy Cost (Recycling) (MM\$)	Discounted Costs (MM\$)	GHG Reductions ($MMtCO_2e$)	Cost-Effectiveness ($\$/tCO_2e$)
2009	-	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	
2010	50,561	\$6.7	\$9.6	\$7.9	\$2.5	\$5.9	\$5.6	\$0.1	
2011	99,977	\$13.3	\$9.6	\$15.6	\$5.0	\$2.3	\$2.0	\$0.2	
2012	97,354	\$12.9	\$9.6	\$15.2	\$4.9	\$2.4	\$2.1	\$0.3	
2013	110,619	\$14.7	\$9.6	\$17.2	\$5.5	\$1.5	\$1.2	\$0.4	
2014	123,878	\$16.4	\$9.6	\$19.3	\$6.2	\$0.5	\$0.4	\$0.4	
2015	137,130	\$18.2	\$9.6	\$21.4	\$6.9	-\$0.5	-\$0.3	\$0.5	
2016	151,954	\$20.2	\$9.6	\$23.7	\$7.6	-\$1.6	-\$1.1	\$0.5	
2017	166,776	\$22.1	\$9.6	\$26.0	\$8.3	-\$2.6	-\$1.8	\$0.6	
2018	181,598	\$24.1	\$9.6	\$28.3	\$9.1	-\$3.7	-\$2.4	\$0.6	
2019	196,418	\$26.1	\$9.6	\$30.6	\$9.8	-\$4.8	-\$3.0	\$0.7	
2020	211,237	\$28.0	\$9.6	\$32.9	\$10.6	-\$5.9	-\$3.4	\$0.7	
Total						**-\$6.5**	**-\$0.7**	**\$5.0**	**-\$0.1**

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

Composting—Composting is included in the total recycling volume in the *Economic Impacts of Recycling in Iowa Final Report*. However, as WARM considers the sole form of diversion for yard trimmings and food waste to be composting, the tons of these items that are "recycled" are assumed to be composted. The net costs for increased composting in Iowa were estimated by adding the additional costs for collection (same calculation as recycling) and the net cost for composting operations. The net cost for composting operations is the sum of the annualized capital and operating costs of composting, increased collection fees, revenue generated through the sale of compost, and the avoided tipping fees for landfilling. 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.[56] These data are summarized in Table 13.

Table 13. Capital and operating costs of composting facilities

Annual Volume (tons)	Capital Cost (\$1,000)	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

As the maximum level of incremental composting is just over 14,000 tons, CCS assumed that the

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[56] P. Calabrese (Cassella Waste Management), personal communication with S. Roe (CCS) June 5, 2007. Because the cost was not originally specified in terms of 2007\$, assume the cost to be valid for 2005.

composting facilities to be built within the policy period would tend to be from the second largest category (a capital cost of $2 million, and O&M cost of $40/ton) shown in Table 13. The composting volumes in 2012 and 2020 shown in Table 89 suggest the need for one additional large composting operation by 2010. To annualize the capital costs of these facilities, CCS assumed a 15-year operating life and a 5% interest rate. Other cost assumptions include an assumed landfill tipping fee of $40/ton,[57] an additional source-separated organics collection fee of $113/ton (as used above in the recycling element), a compost facility tipping fee of $15/ton,[58] and a compost value of $11.75/ton.[59]

Table 14 presents the results of the cost analysis for composting. GHG reductions were assumed not to begin until 2010, and the cumulative reductions estimated were 0.4 MMtCO$_2$e. An NPV of $12 million was estimated, along with a cost-effectiveness of $886/tCO$_2$e.

Table 14. Cost analysis results for composting

Year	Annual Cost O&M ($MM)	Annualized Capital Cost ($MM)	Annual Collection Cost ($MM)	Avoided Landfill Tipping Fees ($MM)	Value of Composted Material ($MM)	Tons of Waste Composted	Total Annual Composting Cost ($MM)	Discounted Costs ($MM)	GHG Reductions (MMtCO$_2$e)	Cost-Effectiveness ($/t)
2009	$0	$0	$0	$0	$0	-	$0	$0	-	
2010	$0	$0	$0	$0	$0	3,309	$1	$1	0.00	
2011	$0	$0	$1	$0	$0	6,528	$1	$1	0.00	
2012	$0	$0	$1	$0	$0	6,323	$1	$1	0.00	
2013	$0	$0	$1	$0	$0	7,309	$1	$1	0.00	
2014	$0	$0	$1	$0	$0	8,295	$1	$1	0.00	
2015	$0	$0	$1	$0	$0	9,281	$1	$1	0.00	
2016	$0	$0	$1	$0	$0	10,390	$2	$1	0.00	
2017	$0	$0	$2	$0	$0	11,498	$2	$1	0.00	
2018	$1	$0	$2	$0	$0	12,606	$2	$1	0.00	
2019	$1	$0	$2	$0	$0	13,715	$2	$1	0.00	
2020	$1	$0	$2	$0	$0	14,823	$2	$1	0.00	
Total								**$12**	**0.01**	**$886**

MM = million; MMtCO$_2$e = million metric tons of carbon dioxide equivalent; $/t = dollars per metric ton.

The overall cost analysis, as seen in Table 15, yields an NPV of –$4.5 million and a cost-effectiveness of –$0.6, based on the cumulative emission reductions of 7.7 MMtCO$_2$e.

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[57] IA DNR Evaluation of Recycling Programs. Average of case studies from Cedar Rapids, Marion, Iowa City, and Central City.

[58] http://hs.environmental-expert.com/resultEachArticle.aspx?cid=6042&codi=5723&idproducttype=6

[59] The 2004 price of $10/yard was obtained from a case study of the City of Davenport, IA (http://www.cityofdavenportiowa.com/department/division.asp?fDD=28-375). Assuming a dry solids content of 55% and a bulk density of 0.5 tons/yard, the value of composted material was calculated to be $11/ton of initial feedstock.

Table 15. Overall policy results—cost-effectiveness

Year	Net Program Cost: Source Reduction ($MM)	Net Program Cost: Recycling ($MM)	Net Program Cost: Composting ($MM)	Total Net Program Cost ($MM)	Discounted Cost ($MM)	Cost-Effectiveness ($/tCO$_2$e)
2009	$0.0	$0.0	$0.0	$0.0	$0.0	
2010	$2.1	$5.9	$0.6	$8.6	$8.2	
2011	$1.2	$2.3	$1.1	$4.6	$4.2	
2012	$0.4	$2.4	$1.1	$3.9	$3.3	
2013	-$0.5	$1.5	$1.2	$2.1	$1.8	
2014	-$1.4	$0.5	$1.3	$0.4	$0.3	
2015	-$2.3	-$0.5	$1.5	-$1.3	-$1.0	
2016	-$3.2	-$1.6	$1.6	-$3.1	-$2.2	
2017	-$4.1	-$2.6	$1.8	-$5.0	-$3.4	
2018	-$5.0	-$3.7	$1.9	-$6.8	-$4.4	
2019	-$5.9	-$4.8	$2.1	-$8.6	-$5.3	
2020	-$6.8	-$5.9	$2.2	-$10.4	-$6.1	
Total					**-$4.5**	**-$0.6**

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 fully or partly achieve the goals of this policy, the GHG reductions estimated would be lower (no additional penetration from the current Iowa recycling and composting campaigns has been incorporated into the BAU assumptions for this analysis). Therefore, the most important assumption relates to the assumed BAU projection for solid waste management. This BAU forecast is based on current practices and does not factor in the effects of further gains in recycling or composting rates during the policy period. The BAU assumptions are needed to tie into the assumptions used to develop the GHG forecast for the waste management sector, which does not factor in these changes in waste management practices during the policy period (2008–2020). To the extent that these gains in recycling and composting would occur without this policy, the benefits and costs are overstated.

The other key assumptions relate to the use of WARM in estimating life cycle GHG benefits and the use of the stated assumptions regarding costs for increased source reduction, recycling, and organics recovery (composting in this example) programs.

Another important assumption is that under BAU, the waste directed to landfilling would include methane recovery (75% collection efficiency) and utilization. The need for this assumption is partly based on limitations of WARM (which doesn't allow for management of landfilled waste into both controlled and uncontrolled landfills), but is also based on the overall direction of the policy recommendations of AFW-8.

Additionally, transportation emissions for WARM are taken as default. This analysis has not considered the impacts of reduced exports as a result of the goals in this option's Policy Design section.

The cost estimates do not include cost savings that would be achieved through avoiding the need for additional waste-to-energy (WTE) plants.

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

Sufficient political commitment?

Budget constraints

Sufficient regulatory/financial incentives?

Inconsistent enforcement

Insufficient data

Low landfill disposal costs result in less interest in waste prevention/recycling

Resistance to change

Must have sufficient local capacity for collected recyclables

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]

AFW-9. Landfill Methane Energy Programs

Policy Description

Use the renewable energy within landfills gas (methane) to make electric power, space heat, or liquefied natural gas. 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.

Policy Design

Goals: TBD

Control—Increase the number of landfills from recovering methane as an energy source wherever it is economically feasible to do so. By 2020, ensure that all large landfills (i.e. sites accepting over XX TPD of waste) are fully controlling the release of methane, such that *60%* of the landfill gas being generated is controlled by 2020. This can be done through development of additional landfill gas to energy (LFGTE) projects. For sites where LFGTE is not feasible, implement flaring controls to achieve the goal.

Technology Research and Evaluation—Since conversion technologies hold promise for environmentally managing waste and producing energy, annually examine the experience and costs of emerging technologies for waste management with a goal to determine feasibility of the technology for Iowa. (non-quantified goal)

Education—Begin to educate the public about the impact and costs of various waste to energy technologies. (non-quantified goal)

Timing:

Parties Involved:

Other:

Iowa currently has four landfill operations which are recovering methane (2 generate electricity). EPA Land-fill Methane Outreach Program (LMOP) identifies 17 facilities that may have the opportunity to recover methane. These landfills have the potential to capture an additional 35% of methane beyond the baseline methane capture of 40%.

Methane Energy Programs

The capture of one ton of methane from landfill gas (LFG) is equivalent to reducing approximately 20 tons of CO2e. (Benefits of LFG Energy, Landfill Methane Outreach Program, USEPA, www.epa.gov/lmop/benefits.htm)

According to the EPA Landfill Methane Outreach Program (WMW Review Issue 2006) landfills generate about 26% of the U.S. methane emissions. Methane is the second most important greenhouse gas (GHG).

If landfilling of organic materials is to be continued, future landfills must be fully controlled bioreactors where most of the methane generated is captured and used to produce energy. (Capture and Utilization of Landfill Gas, Nickolas Themelis and Priscilla Ulloa, Easrth Engineering Center and Department of Earth and Environmental Engineering, Columbia University, New York, NY 10027, USA).

Actual emissions of CH4 from landfills are sensitive to dozens of site-specific factors and can vary over a wide range, but we do not have either the direct measurement data or the detailed site data that would be required to conduct more than an approximate estimate of CH4 emissions from Iowa landfills. (from a North Carolina study)

Waste to Energy (WTE) Mass Burn

Incineration, the combustion of organic material such as waste, with energy recovery is the most common WTE implementation.

Other than removing oversized items and HHW, little preprocessing is necessary.

Depending on the location, size and other factors, the capital costs range from $110,000 to $140,000 per daily ton of capacity. Therefore, a plant that processes 1,000 tons of municipal solid wastes per day may cost between $110 and $140 million. In addition to the capital costs, a 1000-ton-per-day plant would engage personnel of about 60. Other costs are services, materials, and supplies and the cost of disposal of ash. (The ABC of Integrated Waste Management, Waste-to-Energy Research and Technology Council, www.seas.columbia.edu/earth/wtert/faq.html)

Tipping fees at WTE plants, based on 15 respondents, ranged from $40/ton in North Carolina (1 facility) to $98/ton (3 facilities). (Biocycle, April 2006, The State of Garbage in America)

Experts and local community groups are concerned with modern incinerators because of fine particulate emissions, metal, trace dioxins and acid gas emissions, toxic fly ash, bottom ash management as well as waste resource ethics such as valuable resource destruction and low energy efficiency.

Incineration or combustion in any form is rejected in the zero waste movement as a viable, sustainable or ethical solution to waste management. Public acceptability, or rather lack of it, remains a barrier to emerging waste management technologies.

Emerging Technologies for MSW (Gasification, plasma arc, thermal depolymerization, ethanol production from waste, anaerobic digestion)

Currently long-term experience with alternative technologies is unavailable. Waste conversion technologies have very high costs, and the vast majority have not been proven on a commercial scale or as full scale plants using municipal solid waste. More than 90% of these technologies are still in the experimental, development, small-scale, or pilot project stage, i.e., they are not mature technologies. Experts agree that they are not currently a reliable, cost-effective alternative.

Only gasification and plasma arc can handle the entire MSW waste stream with limited residuals.

Most other processes require preprocessing and/or pretreatment, either by separating out incompatible and recyclable materials, homogenizing and shredding. This means that materials must either be separated at the source or processed through an MRF.

Some processes produce an ash containing constituents of lead, cadmium and mercury which need to be managed in a manner that is environmentally responsible.

Proponents for conversion technologies report them to produce not only energy but usable products and by-products, e.g., slag. The slag bonds metals, halogen and sulfur atoms with silicate to make leaching of the materials difficult. The profitability of products and by-products is dependent on viable markets and the value of the products produced. There are risks with constructing such facilities with a goal of profiting from products and by-products.

Implementation Mechanisms

TBD – [CCS drafts based on subcommittee 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 subcommittee approval]

Related Policies/Programs in Place

Methane Gas Conversion Property Tax Exemption: Under Iowa's Methane Gas Conversion Property Tax Exemption, property used for methane gas collection and conversion into energy and connected with, or in conjunction with, a publicly owned sanitary landfill, is exempt from property tax. If other fuels are burned as well, the exemption is equal to the ratio of methane in the overall fuel mix.

Type(s) of GHG Reductions

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

CH_4: Methane reductions via collection and control (via flaring, or preferentially via energy utilization).

Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

Data Sources:

Gasification Project in Greve (1,200 TPD of RDF) ($1,996)

$170 million capital costs

$35.6 million O&M costs

$16.3 million/year in revenues

Plasma Arc – Green Power Systems

$182 million capital costs

$18 million/year revenue

Quantification Methods:

Below is an outline of expected quantification methods that may be used by CCS to estimate the GHG reduction potential of this option. While some text may be left in for the final version of the Policy Options Document, this outline will be removed once the draft quantification has been completed.

- GHG Benefits
  - The first step in determining the GHG benefits for this option is to set the annual WIP threshold, above which landfills will begin instituting landfill-gas-to-energy (LFGTE) controls.
  - If the goal is based on a percentage reduction in emissions, the total municipal landfill emissions from the Iowa I&F will be multiplied by this percentage to determine the GHG reduction.
  - However, if the goal is based on a certain number of landfills, an EPA model, LandGEM, will be used to determine the GHG reductions from this option.
- Cost-Effectiveness
  - The cost effectiveness of this option is determined using the LFGcost model. The current model inputs assume an 8% interest rate over 10 years for capital and energy prices of $4.50/MMBtu and $0.045/kWh.
  - Based on the current utilization of LFGTE, assumptions will be made to determine the proportion of landfill gas captured by small engines (less than 800 kW capacity), large engines, and direct use. Then, the total emissions captured by each technology will be multiplied by the respective cost effectiveness estimates from the LFGcost model to determine an overall cost effectiveness for this option.

Key Assumptions: [TBD, as needed on subcommittee approval]

Key Uncertainties

TBD – [as needed and approved by the subcommittees]

Additional Benefits and Costs

TBD – [as needed and approved by the subcommittees]

Feasibility Issues

There is a danger of over committing on infrastructure to recover value.

Status of Group Approval

Pending –

Level of Group Support

TBD – [blank until ICCAC meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the ICCAC]