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Forestry, Agriculture, and Waste Management (FAW) Technical Work Group

Summary List of Pending Priority Options

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2010–2025 (Million 2005$)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2010–2025			
FAW-1	Forest Management Strategies for Carbon Sequestration	TBD	TBD	TBD	TBD	TBD	Pending
FAW-2	Expanded Use of Biomass Feedstocks for Energy Production	0.1	0.4	3.3	-25	-8	Pending
FAW-3	Advanced Waste Reduction and Recycling	0.2	0.5	4.0	-$7.3	-$29	Pending

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; TBD = to be determined; NQ = not quantified; N/A = not applicable

Note that negative costs represent a monetary savings.

Note to TWG:

FAW-3 is currently under review by the FAW-3 sub-group volunteers. The documentation and results for this recommendation will be revised once all comments on the first draft have been submitted. The biomass supply/demand table will also be updated.

Biomass Resource Supply and Demand Assessment

The table below is a preliminary table that has been developed for AK on biomass availability. The source/reference for the value is indicated in the notes section. CCS will work with the FAW TWG to continue development of this table for AK, which will be needed to address not only FAW policy options, but biomass related options in other TWGs as well.

An assessment of biomass resources available to meet the feedstock requirements of the CCMAG policies is presented in Table 1 below. The table presents a total estimated potential availability of biomass in dry tons based on business as usual in AK across the forestry , agriculture, and waste management sectors. Potential availability is defined as the amount available if the resource were managed according to its current demonstrated productive capacity; and social, ecological, administrative and technical constraints were managed to minimize their impact on utilization.[1] For the purpose of defining a reference point, the stated potential assumes all constraints can be lifted and does not consider economic considerations limiting supply (e.g. distance to end user). The only items that are not based on business as usual are MSW Fiber and Yard and Landscape Waste Debris, which assume that the diversion goals of FAW-3 will be met.

After the analysis of recommendations from all TWGs is complete, the annual biomass demand for 2025 will be calculated in order to assess whether or not sufficient biomass supply exists to achieve the goals set forth in the policy recommendations made by the CCMAG.

Table 1. Potential Annual Biomass Resource Supply and Demand

Biomass Resource	Annual Biomass Supply (dry short tons)	2025 Annual Biomass Demand (dry short tons)	Notes
Logging Residue	738,000	TBD	2005 NREL Report.[2] Derived from the USDA Forest Service's Timber Product Output database for 2002.
Primary Mill Residue (Unused)	131,000	TBD	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	2,000	TBD	2005 NREL Report. Derived from data on the number of businesses that was gathered from the U.S. Census Bureau, 2002 County Business Patterns. Includes woods scraps and sawdust from woodworking shops – furniture factories, container and pallet mills, and wholesale lumberyards.

[1] Robert Froese, Version 1.0 - 18 August 2008. Biomass for Bioenergy in Michigan: Actual Versus Potential Availability, Unpublished.

[2] A. Milbrandt. *A Geographic Perspective on the Current Biomass Resource Availability in the United States.* Technical Report NREL/TP-560-39181. Golden, CO: U.S. Department of Energy, National Renewable Energy Laboratory, December 2005. Available at: www.nrel.gov/docs/fy06osti/39181.pdf.

Biomass Resource	Annual Biomass Supply (dry short tons)	2025 Annual Biomass Demand (dry short tons)	Notes
Urban Wood Waste	65,000	TBD	2005 NREL Report. Includes MSW wood, utility tree trimming and/or private tree companies, and construction/demolition wood.
Municipal Solid Waste (MSW) Fiber	315,653	TBD	Other than Urban Wood Waste. Will be forecast to 2025 based on input from TWG and DEC
Yard and Landscape Waste Debris	106,605	TBD	Other than Urban Wood Waste. Will be forecast to 2025 based on input from TWG and DEC
Total Annual Biomass Supply	**1,357,958**	**TBD**	

FAW-1 Forest Management for Carbon Sequestration

Policy Description

Alaska forests can play a unique role in both preventing and reducing GHG emissions while providing for a wide range of social and environmental benefits. These benefits include clean air and water, wildlife habitat, recreation, subsistence activities, forest products and a host of other uses and values. Carbon is stored in the above ground biomass and in the organic and mineral soil components of the soil. Permafrost soils add an additional dimension and complication to the role soils play in the boreal, sub-arctic and arctic ecosystems and the potential impacts of increased wildland fire in these regions has wide ranging implications. Additionally the state has two distinct forest ecosystems, the boreal and coastal forests and the types of forest management activities that may apply to each from a carbon management perspective may also differ.

Coastal Forest Options:

- Increase the amount of carbon durable products produced from managed forests. Examples of management practices could be:
    - Extended rotations
    - Pre-commercial or commercial thinning of young growth stands of timber
    - Fertilization treatments
    - Other silvicultural treatments that would meet the intent of the policy option

Boreal Forest Options:

- Fuel reduction projects that utilize both prescribed fire and mechanical treatments to reduce fuel loads which will reduce burn intensity and overall GHG emissions in a wildland fire event.
- Complete Community Wildfire Protection Plans (CWPP) to identify fuel types and community risks to aid in prioritization of fuel treatment work.
- Rapidly reforest sites impacted by fire or insect and disease outbreaks to ensure full stocking and a quick return to forest cover.

Policy Design

Goals:

Coastal Forest Carbon Management Pre-commercial thinning:

- By 2010 thin 4,000 acres annually across all ownerships (both public and private)
- By 2015 thin 8,000 – 10,000 acres annually
- By 2025 thin 6,000 acres annually

Boreal Forest Mechanical Fuels Treatment Projects:

- By 2010 treat 1,000 acres annually across all ownerships
- By 2020 treat 2,000 acres annually
- By 2025 treat 2,500 acres annually

(Note if we include fire use and prescribed fire treatments, these numbers could be increased significantly)

Community Wildfire Protection Plans:

- By 2010 complete 15 plans
- By 2015 complete 25 additional plans
- By 2025 complete 35 additional plans

Boreal Forest Reforestation after fire or insect and disease mortality:

- By 2010 reforest 5% of high site class lands
- By 2015 reforest 15% of high site class lands
- By 2025 reforest 25% of high site class lands

Timing:

Forest Carbon Management: Increase funding levels to ramp up program to meet goals at various increments and establish a viable carbon trading program to capture revenue stream from the CO_2 sequestration perspective.

Mechanical Fuel Treatment Projects: Based on CWPP recommendations utilize village Type II fire crews and agency Type I fire crews to complete projects in their communities. Funding for these projects will be a key aspect and programs at the national level may help with this need.

Community Wildfire Protection Plans: Establish statewide coordinator by 2010, conduct training workshops for communities by 2011-2012

Reforestation: Increase seed collection efforts by 2010-2015, especially when there are good seed years, to ensure enough seed is on hand to meet goals. Funding for this item will be a critical aspect of this item.

Parties Involved: Alaska Department of Natural Resources, Division of Forestry, Alaska Native Corporations, University of Alaska, Southeast Conference, Cooperative Extension Service, Natural Resource Conservations Service, Resource Development Council, Alaska Forest Association, U.S. Forest Service, State and Private Forestry, State Board of Forestry, Soil and Water Conservation Districts.

Other: For reforestation projects some work needs to be done on the recommended species mix for conifers. Should lodge pole pine or Siberian larch be considered for a portion of the mix? White spruce 75% and lodge pole pine 25% per unit area planted. (Adaptation measure)

Research Needs:

- Continue work to develop the science and process to better quantify beneficial and negative outcomes of silvicultural treatments from a carbon sequestration perspective. Opportunities in this area are currently limited by the science.
- Develop an accepted protocol for determining the “carbon life” of various forest products. This relates to the current assumption that the point of tree harvest is an emission of CO_2.

Implementation Mechanisms

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

Related Policies/Programs in Place

TBD – No recent policies or programs have been identified as of yet. The TWG and DEC can work with CCS to identify existing or planned programs that address issues raised in this option.

Types(s) of GHG Reductions

TBD

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: [**TBD by CCS on TWG approval]
- **Quantification Methods: [e.g.** Full life-cycle analysis with supply/demand equilibrium adjustments on TWG approval]
- **Key Assumptions: [**TBD, as needed on TWG approval]

Key Uncertainties

TBD – [as needed and approved by the TWGs]

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

TBD – [as needed and approved by the TWGs]

Status of Group Approval

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

Level of Group Support

TBD – [blank until CCMAG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the CCMAG]

FAW-2 Expanded Use of Biomass Feedstocks for Energy Production

Policy Description

Increase the amount of biomass available from forestry, municipal solid waste, and agriculture for generating heat/electricity and liquid/gaseous biofuels to displace the use of fossil energy sources. Foster the development of the following where they are compliant with environmental requirements:

- wood biomass alternative fuel products or heat and electric generation from sawmill by-products;
- methods to economically utilize that portion of harvested trees not being used to make conventional forest products to make wood biomass alternative fuel products or heat and electric generation;
- methods to economically utilize biomass generated from silvicultural treatments and wildland fire fuel reduction treatments in the production of biomass alternative fuel products or heat and electric generation;
- methods to economically utilize feedstocks from municipal solid waste (e.g. urban wood waste, waste vegetable oil) and agricultural sources (e.g. manure management);
- large and small scale technologies that generate heat and electricity and the production of synthetic fuels from biomass;
- both conventional and emerging technologies (e.g. cellulosic ethanol/other liquid fuel; pyrolisis; gasification) for biomass utilization; and
- Opportunities for industry, communities and individuals to use biomass alternative fuel products to substitute for fossil fuels for heat or transportation. This should be done either using 100% biomass or through co-firing with other fuels.

Policy Design

Goals:

- By 2025, utilize biomass feedstocks to produce 5% of the state's electricity.
- By 2025, utilize biomass feedstocks to offset 10% of the state's heating oil use.
- By 2025, utilize biomass feedstocks to offset 5% of the state's fossil transportation fuels.

Timing:

- By 2010, establish a demonstration pilot facility to produce biomass electricity, heat generation, synthetic fuels or biomass alternate fuel products.

- By 2015, utilize 50% of practical and available resource.
- By 2025, achieve the full policy goals.

Coverage of Parties:

Executive and Legislative Branches of State Government, Alaska Department of Natural Resources, Alaska Department of Environmental Conservation, Alaska Energy Authority, Alaska Native Corporations, University of Alaska, Southeast Conference, Alaska Industrial Development Authority, Cooperative Extension Service and Agencies, Natural Resource Conservation Service, Alaska State Chamber of Commerce, Resource Development Council, Alaska Forest Association, Alaska Public Service Commission, Alaska Department of Revenue, Alaska electric utilities and electric cooperatives, crop producers, and timberland owners.

Other: Not Provided.

Implementation Mechanisms

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

Related Policies/Programs in Place

TBD – No recent policies or programs have been identified as of yet. The TWG and DEC can work with CCS to identify existing or planned programs that address issues raised in this option.

Types(s) of GHG Reductions

TBD

Estimated GHG Reductions and Net Costs or Cost Savings

Biomass to Electricity

The goal was determined using baseline data from the Center for Climate Strategies (CCS) Inventory and Forecast.[3] BAU electricity generation grows over the policy period from about 6.5 terawatt-hours (TWh) in 2009 to approximately 8.6 TWh in 2025. Biomass usage over the period is based on the existing biomass generation capacity, although the current estimate is for no significant biomass contribution to electricity production between 2009 and 2025. This baseline information, along with the projected target, is illustrated in Table 2-1.

Table 2-1. Expanded use of biomass goal determination

Year	Total BAU Projected generation (GWh)	Policy Goal proportion of total in-state electricity generation (%)	Additional Biomass generation to meet policy goals (GWh)	Estimated biomass required (MMBTU) The assumed heat rate for biomass plant is 10,000

[3] The CCS Alaska Energy Supply Inventory and Forecast (Appendix A).

				BTU/kWh
2009	6,504	0.0%	-	-
2010	6,617	0.3%	21	206,795
2011	6,733	0.6%	42	420,816
2012	6,851	0.9%	64	642,252
2013	6,970	1.3%	87	871,296
2014	7,092	1.6%	111	1,108,148
2015	7,216	1.9%	135	1,353,010
2016	7,342	2.2%	161	1,606,089
2017	7,470	2.5%	187	1,867,598
2018	7,601	2.8%	214	2,137,754
2019	7,734	3.1%	242	2,416,780
2020	7,869	3.4%	270	2,704,902
2021	8,006	3.8%	300	3,002,355
2022	8,146	4.1%	331	3,309,375
2023	8,288	4.4%	363	3,626,206
2024	8,433	4.7%	395	3,953,098
2025	8,581	5.0%	429	4,290,305

BAU = business as usual; GWh = gigawatt-hours; MMBtu = millions of British thermal units.

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 biomass will be used to replace electricity.

The GHG benefits from electricity were calculated by assuming that using biomass reduces emissions (in carbon dioxide equivalents [CO_2e]) by the Alaska-specific emissions factor. The CO_2e associated with this amount of electricity in each year is estimated by multiplying the megawatt-hours (MWh) produced by the Alaska-specific emission factor for electricity production from the Alaska GHG inventory and forecast (I&F) (these values in metric tons (t) of CO_2e/MWh vary in each year of the forecast).[4] See Table 2-2 for more details.

[4] Total electricity emissions per MWh were provided by the ES TWG, and range from 0.53 tCO_2e/MWh in 2009 to 0.44 tCO_2e/MWh in 2025.

Energy From Biomass Costs

Table 2-2. Expanded use of biomass GHG benefits and approximate biomass demand

Year	Policy Goal Proportion of Total In-State Electricity Generation (%)	Additional Biomass generation to meet policy goals (GWh)	Electricity Emissions Factor (tCO2e/MWh)	Avoided emissions from electricity Production (MMtCO2-e)	Avoided emissions from offsetting heat/steam (MMtCO2-e)	Total emissions Reductions (MMtCO2-e)	Approximate amount of biomass required to meet goal - assuming 12 MMbtu/ton (Dry Tons)
2009	0.0%	-	0.532020457			0.000	-
2010	0.3%	21	0.541407939	0.01	0.00	0.01	8,965
2011	0.6%	42	0.534047412	0.01	0.00	0.02	18,451
2012	0.9%	64	0.526813271	0.02	0.00	0.04	28,471
2013	1.3%	87	0.519703343	0.02	0.00	0.05	39,040
2014	1.6%	111	0.512715498	0.03	0.00	0.06	50,173
2015	1.9%	135	0.505847637	0.04	0.00	0.08	61,960
2016	2.2%	161	0.499097702	0.04	0.00	0.09	74,369
2017	2.5%	187	0.492463667	0.05	0.01	0.10	87,419
2018	2.8%	214	0.485943543	0.06	0.01	0.11	101,126
2019	3.1%	242	0.479535373	0.07	0.01	0.13	115,508
2020	3.4%	270	0.473237234	0.07	0.01	0.14	131,599
2021	3.8%	300	0.467047239	0.08	0.01	0.16	148,585
2022	4.1%	331	0.460963529	0.09	0.01	0.17	166,485
2023	4.4%	363	0.454984281	0.10	0.01	0.18	185,318
2024	4.7%	395	0.449107699	0.11	0.01	0.20	205,106
2025	5.0%	429	0.443332022	0.12	0.01	0.21	225,799
		Cumulative		0.9	0.1	1.0	

GWh = gigawatt-hours; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

The breakdown of biomass being utilized will influence the costs for FAW-2, as the costs are dependent on the feedstock being utilized. The proportion of each biomass feedstock used to meet the goal was based on the proportion of availability for each feedstock. The relative proportion of feedstocks is indicated in Table 2-3. The totals do not add up to 100% because not all available biomass is being used in FAW-2.

Table 1-3. Relative proportion of feedstocks assumed to meet the goal based on availability

Biomass Fuel Type	Proportion
Total Agriculture Residue	24%
Energy Crop	13%
Forest Feedstocks	17%

The cost calculation has two main components: fuel costs and capital/operational/maintenance 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. The assumed biomass fuel cost used in this analysis is indicated in Table 2-4, and the assumed fossil fuel costs are indicated in Table 2-5. While municipal solid waste (MSW) has been identified as a potential feedstock, it has not been included in the cost analysis. It is possible that MSW energy feedstocks have a very low or negative cost. This is because in the current market, waste haulers pay a tipping fee to the landfill or transfer station that receives the waste, and haulers could possibly forego this payment through delivery as an energy feedstock. However, currently there is not an established market in Alaska for utilizing MSW as an energy feedstock, and there is significant uncertainty regarding the processing costs (e.g., uncertain separation, processing, storage, and transportation costs).

Table 2-4. Assumed costs of biomass feedstocks

Biomass Fuel Type	Cost ($/dry ton delivered)	Heat Content (MMBtu/ton)	Cost ($/MMBtu delivered)	Source
Total agriculture residue	42.50	12.9	3.29	"The Economics of Biomass Collection, Transportation, and Supply to Indiana Cellulosic and Electric Utility Facilities," Sarah C. Brechbill and Wallace E. Tyner, Department of Agricultural Economics, Purdue University (April 2008). Any Alaska-Specific information available should be provided to improve this analysis. These numbers are meant to provide information as a stand-in.
Energy crop (switchgrass)	60.00	14.7	4.09	"The Economics of Biomass Collection, Transportation, and Supply to Indiana Cellulosic and Electric Utility Facilities," Sarah C. Brechbill and Wallace E. Tyner, Department of Agricultural Economics, Purdue University (April 2008). Any Alaska-Specific information available should be provided to improve this analysis. These numbers are meant to provide information as a stand-in.
Forest feedstocks	65.00	15.4	4.23	The basis for the cost per ton comes from summaries on Michigan pulpwood costs in a document titled: *Michigan Timber Market Analysis. Final Report* Any Alaska-Specific information available should be provided to improve this analysis. These numbers are meant to provide information as a stand-in.

lb = pound; MMBtu = millions of British thermal units.

Note: The above cost information is consistent with the information produced for the Wolverine Clean Energy Venture study.[5]

The cost of implementing the policy option is estimated by assuming the replacement of fossil fuel-generated electricity with biomass-generated electricity. In this case, it is the relative proportion of fuel mixes required under the BAU scenario (i.e., coal, natural gas, or oil in MMBtu) as defined by eGRID: i.e., 72% coal, 13% natural gas, and 15% oil (it is assumed that biomass would not replace hydropower), as indicated in Table 1-5.[6]

[5] Froese, R., and Miller, C., *Biomass Co-Firing for the Wolverine Clean Energy Venture: An Assessment of Potential Supply, Environmental Limitations, and Co-Benefits Through Carbon Sequestration*, School of Forest Resources and Environmental Science, Michigan Technological University, January 30, 2008.

[6] Based on eGRID data for Alaska: Coal, 56%; Nuclear, 0%; Oil, 12%; Natural Gas, 10%; Hydro, 23%, Wind, 0%; and Biomass, 0.1% (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html).

Table 2-5. Assumed costs of fossil fuel feedstocks[7]

Year	Coal	Natural Gas	Residual Fuel Oil ($/MMBTU)
2009	$1.20	$6.82	$13.25
2010	$1.24	$6.36	$12.65
2011	$1.24	$6.07	$12.11
2012	$1.23	$5.86	$11.33
2013	$1.22	$5.60	$10.68
2014	$1.23	$5.43	$10.41
2015	$1.22	$5.32	$9.83
2016	$1.21	$5.29	$9.42
2017	$1.22	$5.34	$9.43
2018	$1.25	$5.39	$9.57
2019	$1.25	$5.42	$9.71
2020	$1.26	$5.24	$9.81
2021	$1.26	$5.24	$9.81
2022	$1.26	$5.24	$9.81
2023	$1.26	$5.24	$9.81
2024	$1.26	$5.24	$9.81
2025	$1.26	$5.24	$9.81

MMBtu = millions of British thermal units.

The difference in cost of feedstock supply between biomass and coal is calculated using the costs outlined in Table 2-4 and Table 2-5. The difference in costs ($/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 establishing a biomass plant compared to a coal plant. Capital costs and operation and maintenance costs were taken from Table 38 of the U.S. Department of Energy (DOE) Energy Information Administration's (EIA) *Annual Energy Outlook 2008* (AEO 2008). While use of biomass may be pursued through other technology types (e.g., gasification) or end uses (e.g., heat or steam), this methodology was used to provide an estimate of possible capital costs required to enable the utilization of biomass.[8] The results of the cost analysis are outlined in Table 2-6.

[7] Fossil fuel costs ($/MMBtu) for 2009–2020 come from the Quantification Memo. Costs for 2021-2025 were held constant at 2020 levels.

[8] 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.

Table 2-6. Costs of generating electricity from biomass

Year	Estimated electricity output (MWh)	Estimated cumulative Capacity (MW)	Annualized capital costs (million $2005)	Estimated additional variable Operational and Maintenance costs (million 2005$)	Estimated additional fixed Operational and Maintenance costs (2005$)	Fuel costs (Ag Residue, Forest Feedstocks and Energy Crops) Million 2005$	Total Costs (Million 2005$)
2009	-	-	$0	$0.0	$0	$0.0	$0.0
2010	10,758	1	$0.1	$0.0	$0.0	$0.0	$0.2
2011	22,141	3	$0.2	$0.0	$0.1	$0.1	$0.5
2012	34,165	5	$0.4	$0.1	$0.2	$0.2	$0.8
2013	46,848	6	$0.5	$0.1	$0.2	$0.3	$1.1
2014	60,207	8	$0.7	$0.1	$0.3	$0.4	$1.5
2015	74,352	10	$0.8	$0.2	$0.3	$0.6	$1.9
2016	89,243	12	$1.0	$0.2	$0.4	$0.8	$2.4
2017	104,903	14	$1.1	$0.2	$0.5	$0.9	$2.8
2018	121,351	16	$1.3	$0.3	$0.6	$1.0	$3.1
2019	138,609	19	$1.5	$0.3	$0.6	$1.1	$3.5
2020	157,919	21	$1.7	$0.4	$0.7	$1.2	$4.0
2021	178,302	24	$2.0	$0.4	$0.8	$1.4	$4.6
2022	199,782	27	$2.2	$0.4	$0.9	$1.6	$5.1
2023	222,382	30	$2.4	$0.5	$1.0	$1.7	$5.7
2024	246,127	33	$2.7	$0.6	$1.1	$1.9	$6.3
2025	270,959	36	$3.0	$0.6	$1.2	$2.1	$6.9
						Cumulative	**$50**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MW = megawatt; MWh = megawatt-hour.

The capital infrastructure lifespan is assumed to be 30 years, and the interest rate is assumed to be 5%, giving a capital recovery factor of 0.065 (i.e., a $1 million plant is assumed to cost approximately $65,000 per year over the life of the project).

Biomass for Biofuels

Biofuel GHG Reductions

The benefits for this option are dependent on developing in-state production capacity that achieves GHG benefits beyond petroleum fuels. This option quantifies the benefits and costs of producing sufficient renewable liquid cellulosic ethanol to meet the policy goal. Other biofuels exist, from currently available fuels such as biodiesel and corn ethanol to more advanced fuels such as ethanol derived from algae and other (non-cellulosic) feedstocks. This analysis focuses on cellulosic ethanol as an example of the potential for GHG reduction through biofuel use. While large scale cellulosic ethanol plants are under construction throughout the United States, the technology remains in its early stages, and the costs of cellulosic ethanol are not yet certain. Table 2-7, below, lists the quantity of biofuels required in each year to meet the goals of FAW-2.

Table 2-7. Quantity of biofuel required in FAW-2

Year	Implementation Path (percent of biofuels replaced)	BAU AK Gasoline Consumption (million gallons)	Diesel Demand (million gals)	Displacement Goal (million gals)
2009	0%	231		0
2010	0%	231		1
2011	1%	232		1
2012	1%	234		2
2013	1%	235		3
2014	2%	236		4
2015	2%	237		4
2016	2%	239		5
2017	3%	240		6
2018	3%	241		7
2019	3%	243		8
2020	3%	244		8
2021	4%	245		9
2022	4%	246		10
2023	4%	247		11
2024	5%	248		12
2025	5%	249		12

The incremental benefit of cellulosic production over gasoline from all other feedstocks targeted by this policy is 9.74 tCO_2e reduced/1,000 gallons (gal), based on the difference between the life-cycle CO_2e emission factor of gasoline and the life-cycle CO_2e emission factor of cellulosic ethanol (1.51 t/1,000 gal).[9] The incremental benefit values will be used along with the production

[9] ANL GREET Model 1.8b emission factor for mixed feedstock cellulosic E100 for flex-fuel vehicle in grams per mile (g/mi) x GREET model average fuel economy (100 mi/4.3 gal).

in each year to estimate GHG reductions. Annual cellulose production is multiplied by the estimated ethanol yield per ton of biomass, based on the projection that ethanol yield will increase from 70 gal/ton biomass to 90 gal/ton biomass by 2012 and to 100 gal/ton biomass by 2020.[10]

Table 2-8 shows the number of 3 million gal/year cellulosic plants that will need to go on line in Alaska to convert the available biomass feedstock to ethanol, and summarizes the quantity of other biofuels that can be produced with the Alaska feedstock supply, assuming that food crops will not be utilized for fuel.

Table 2-8. Projected biofuel production and emission reductions

Year	Cellulosic Ethanol Production Plants Required	Cellulosic Feedstock Used (million short tons annually)	Cellulosic Ethanol Production (million gallons annually)	Biodiesel Production (million gallons annually)	Total Life-Cycle Emissions Reduction ($MMtCO_2e$)	Total In-State Emissions Reduction ($MMtCO_2e$)
2009	0	0.00	0		0.00	0.00
2010	0	0.01	1		0.01	0.01
2011	0	0.02	1		0.01	0.01
2012	1	0.02	2		0.02	0.02
2013	1	0.03	3		0.03	0.02
2014	1	0.04	4		0.04	0.03
2015	1	0.05	4		0.04	0.03
2016	2	0.06	5		0.05	0.04
2017	2	0.07	6		0.06	0.05
2018	2	0.08	7		0.07	0.05
2019	3	0.08	8		0.07	0.06
2020	3	0.08	8		0.08	0.06
2021	3	0.09	9		0.09	0.07
2022	3	0.10	10		0.10	0.08
2023	4	0.11	11		0.11	0.08
2024	4	0.12	12		0.11	0.09
2025	4	0.12	12		0.12	0.09
Totals					**1.0**	**0.8**

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

Note: Cellulosic plants required are not whole numbers. The analysis assumes that these plants will be going on line mid-year or are operating at less than full capacity.

In-state emission reductions consider only GHG benefits that will happen in the state of Alaska. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this policy option document.

[10] J. Ashworth, US Department of Energy, National Renewable Energy Laboratory, personal communication, S. Roe, CCS, April 2007.

Biofuel Costs

Cellulosic Ethanol Costs

The cellulosic ethanol costs of this option are estimated based on the capital and operating costs of cellulosic ethanol production plants. A study by the National Renewable Energy Laboratory (NREL) was used to estimate the operation and maintenance costs of a 70-million-gallon/year cellulosic ethanol plant.[11] These costs were scaled down to accommodate the smaller cellulosic plants in Alaska. Cellulosic plants in this analysis are assumed to produce 3 million gallons ethanol/year, and the annual labor and maintenance costs have been scaled down accordingly. The capital costs of a cellulosic plant came from an average of the capital cost estimates for six biofuels plants across the country. Using this method, the average capital cost of a new cellulosic ethanol plant is $21.5 million. A new plant will need to be built for every 3 million gallons of annual ethanol production needed. It was assumed that the capital costs will be paid according to a cost recovery factor over the 20-year lifetime of the plant. The cost of biomass feedstocks made up a significant portion (~60%) of variable costs. Therefore, we replaced the NREL estimate of feedstock costs ($30/ton) with more current estimates of the cost of delivered biomass: $60/ton for agricultural feedstocks and $65/ton for woody feedstocks.[12] The plant proposed by the NREL study produces some excess electricity, although the costs and benefits of generating this electricity are not considered in this analysis. The revenue source for the ethanol plant is the value of the ethanol being produced (from AEO 2009). The costs of cellulosic ethanol production are shown in Table 2-9.

[11] National Renewable Energy Laboratory, *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*, NREL/ TP-510-32438 (Golden, CO, June 2002), www. nrel.gov/docs/fy02osti/32438.pdf, accessed June 2008.

[12] The basis for this is related to summaries on Michigan pulpwood costs in a document titled: *Michigan Timber Market Analysis*, Final Report, prepared for the Michigan Department of Natural Resources by Prentiss and Carlisle, March 10, 2008. Alaska Biomass Costs will be substituted once they are available.

Table 2-9. Cost summary for cellulosic ethanol plants

Year	Cellulosic Ethanol Production (million gallons)	Cost of Feedstock (2005$ Million)	Other Annual Costs (Million $)	Total Annual Costs (million $)	Annualized Capital Costs (million $)	Value of Cellulosic Ethanol Produced (million $)	Total cellulosic ethanol net costs (million $)
2009	0	$0	$0	$0	$0	$0	$0
2010	1	$1	$0	$1	$0	$1	$0
2011	1	$1	$1	$2	$1	$3	$0
2012	2	$2	$1	$2	$1	$5	-$1
2013	3	$2	$1	$3	$2	$7	-$2
2014	4	$3	$2	$4	$2	$7	-$1
2015	4	$3	$2	$5	$3	$8	-$1
2016	5	$4	$2	$6	$3	$10	-$1
2017	6	$4	$2	$7	$3	$13	-$3
2018	7	$5	$3	$8	$4	$15	-$3
2019	8	$5	$3	$9	$4	$17	-$4
2020	8	$5	$3	$9	$5	$19	-$5
2021	9	$6	$4	$10	$5	$21	-$6
2022	10	$7	$4	$11	$6	$22	-$6
2023	11	$7	$4	$11	$6	$25	-$7
2024	12	$8	$5	$12	$7	$27	-$7
2025	12	$8	$5	$13	$7	$28	-$8

gal = gallon; $MM = million dollars.

Biomass for Heating

To quantify the cogeneration component on large scale electricity producers, it is assumed that 25% of generation under the policy utilizes waste heat at the local level. For these CHP plants, it is assumed that in addition to the electricity generation, 40% of the biomass feedstock energy is converted into usable steam/heat (in MMBtu).[13] It is also assumed that this waste heat is used to offset energy that would have otherwise been generated from natural gas. The GHG benefits were calculated by the difference in emissions associated with each of the input fuels (0.054 tCO_2e/MMBtu for natural gas, and 0.002 tCO_2e/MMBtu for biomass, including non-methane (CH_4) and non-nitrous oxide (N_2O) emissions).[14] These large-scale generators produced approximately 25% of the necessary heat for the FAW-2 goal.

Small scale generators can provide both electricity and heat through combined heat and power. The electricity goes towards the 5% state electricity goal. Likewise, the large-scale biomass to

[13] The assumed thermal efficiency rate of a biomass cogeneration facility is 80%, with 40% being converted into electricity and 40% being derived from the waste heat. This assumption is based on advice from the AFW TWG.

[14] Emission factors obtained from the Alaska Quantification Memo.

electricity CHP is going towards the overall goal of 10% of the state's heating needs being met from biomass. The remainder came from small-scale CHP generators. The heating requirements for FAW-2 can be seen in Table 2-10.

Table 2-10 Heating Needs to meet 10% Biomass for Heating Goal

Year	Goal	Billion BTU replaced with biomass (Coal)	Billion BTU replaced with biomass (Petroleum)	Billion BTU replaced with biomass (Nat. Gas)	Billion BTUs needed, Total	Billion BTUs from Large-scale Electricity	Billion BTUs needed
2009	0.0%	0	0	0	0		
2010	0.6%	12	28	60	101	21	80
2011	1.3%	24	56	122	203	42	161
2012	1.9%	37	85	186	307	64	243
2013	2.5%	49	113	251	412	87	325
2014	3.1%	61	141	317	519	111	409
2015	3.8%	73	171	384	627	135	492
2016	4.4%	84	201	451	737	161	576
2017	5.0%	96	232	519	848	187	661
2018	5.6%	108	264	588	960	214	746
2019	6.3%	119	296	659	1,074	242	832
2020	6.9%	131	321	727	1,179	270	909
2021	7.5%	142	346	796	1,285	300	984
2022	8.1%	153	371	866	1,390	331	1,059
2023	8.8%	164	394	936	1,495	362	1,132
2024	9.4%	175	417	1,007	1,600	395	1,204
2025	10.0%	186	442	1,077	1,705	429	1,276

To meet the remaining needs for FAW-2, small scale generators similar to the ones produced by Community Power Corporation (CPC) will be required. The CPC generators are used as an example, and this is in no way an endorsement of this technology over similar CHP generators. These are 66 KW generators, which if used as directed, would consume 442 dry tons of biomass feedstock annually, providing a little over 3,900 MMBTUs of useable heat, and 443 MWh of electricity (all figures annual)[15]. The number of CHP units was determined based on the number that would be required to meet Alaska's 10% goal. The 1,276 billion BTUs of heat required were divided by the number of BTUs provided by a single generator. The capital costs for these generators were estimated to be $4,000/KW of capacity or about $264,000 per unit. The biomass feedstocks required comes from the amount of biomass needed to keep the number of generators in operation. Table 2-11 outlines the costs of the small scale CHP units required in this option.

Table 2-11: Number and Costs of Small Scale CHP Units Required

[15] Based on information provided by Community Power Corporation by Art Lilley, 2/14/09.

Year	Total Units Installed	Capital Cost of Installation	Annual Fuel Requirements (dry tons biomass)	Cost of biomass feedstocks (million$)
2009	0	$0	0	$0.0
2010	23	$6.0	10,113	$0.7
2011	46	$6.1	20,326	$1.3
2012	69	$6.2	30,641	$2.0
2013	93	$6.2	41,060	$2.7
2014	117	$6.3	51,586	$3.4
2015	141	$6.3	62,127	$4.0
2016	165	$6.3	72,745	$4.7
2017	189	$6.4	83,439	$5.4
2018	213	$6.4	94,211	$6.1
2019	238	$6.5	105,061	$6.8
2020	260	$5.8	114,747	$7.5
2021	281	$5.7	124,290	$8.1
2022	302	$5.6	133,691	$8.7
2023	323	$5.5	142,949	$9.3
2024	344	$5.4	152,066	$9.9
2025	365	$5.4	161,126	$10.5

The electricity emissions factor used comes from the Alaska Inventory and Forecast. The amount of electricity generated was calculated based on the number of generators in operation. The GHG emissions from biomass comes from multiplying the BTUs of biomass going into the generator by the emissions factor for biomass (0.002 tCO2e/MMBTU). The electricity cost ($/kWh) comes from the Alaska Quantification Memo. See Table 2-12 for more details.

Table 2-12 Electricity Produced and GHG savings from Small Scale CHP

Year	Electricity Generated (MWh)	GHG Emissions from Biomass (tCo2e)	GHG Emissions Savings Electricity (tCO2e)	Electricity Emissions Factor (tCO2e/MWh)	Electricity Cost ($/kWh)	Electricity Savings (million $)
2009	0	0	0	0.53	0.1	0.0
2010	9,921	311	5,372	0.54	0.1	1.0
2011	19,941	625	10,649	0.53	0.1	2.0
2012	30,060	943	15,836	0.53	0.1	3.0
2013	40,282	1,263	20,935	0.52	0.09	3.6
2014	50,608	1,587	25,947	0.51	0.09	4.6
2015	60,949	1,911	30,831	0.51	0.09	5.5
2016	71,366	2,238	35,618	0.50	0.09	6.4
2017	81,857	2,567	40,312	0.49	0.09	7.4
2018	92,425	2,898	44,913	0.49	0.09	8.3

2019	103,069	3,232	49,425	0.48	0.09	9.3
2020	112,572	3,530	53,273	0.47	0.09	10.1
2021	121,934	3,823	56,949	0.47	0.09	11.0
2022	131,156	4,112	60,458	0.46	0.09	11.8
2023	140,239	4,397	63,806	0.45	0.09	12.6
2024	149,183	4,678	66,999	0.45	0.09	13.4
2025	158,072	4,956	70,078	0.44	0.09	14.2

The heat produced from combined heat and power is shown in Table 2-13 below. The GHG savings were calculated based on the assumption that diesel generators would be replaced with biomass. The diesel fuel costs and emissions factor comes from the Alaska Quantification memo. An assumed transportation efficiency of 92% was assumed to move the heat from the generator to the place where heating is required (be it residential or commercial)[16]. This accounts for the difference seen between heat generated and heat delivered.

Table 2-13 Heat Produced and GHG Savings from Small Scale CHP

Year	Heat Generated (Billion BTU)	Heat Delivered (Billion BTU)	Diesel Fuel Costs ($/MMBTU)	Diesel Fuel Savings - Heat(Million $)	GHG emissions saved Heat (tCO2e)
2009	0	0	$13.25	$0.00	0
2010	90	83	$12.65	$1.05	6,459
2011	181	166	$12.11	$2.02	12,982
2012	273	251	$11.33	$2.84	19,571
2013	365	336	$10.68	$3.59	26,225
2014	459	422	$10.41	$4.40	32,948
2015	553	509	$9.83	$5.00	39,681
2016	647	596	$9.42	$5.61	46,462
2017	743	683	$9.43	$6.44	53,293
2018	839	771	$9.57	$7.38	60,173
2019	935	860	$9.71	$8.35	67,102
2020	1,021	940	$9.81	$9.22	73,289
2021	1,106	1,018	$9.81	$9.98	79,384
2022	1,190	1,095	$9.81	$10.74	85,388
2023	1,272	1,171	$9.81	$11.48	91,302
2024	1,353	1,245	$9.81	$12.22	97,125
2025	1,434	1,319	$9.81	$12.94	102,912

The total costs and GHG benefits of small scale CHP is outlined in Table 2-14 below.

Table 2-14 Net Costs and GHG Savings from Small-Scale CHP

[16] Hannes Schwaiger and Gerfried Jungmeier. "Overview of CHP plants in Europe and Life Cycle Assessment (LCA) of GHG Emissions for Biomass and Fossil Fuel CHP Systems." Institute of Energy Research. September 2007. Available at: http://www.atee.fr/cp/37/6-%2018-09%20SCHWAIGER%20JOANNEUM%20R.pdf.

Year	Net Costs	Net GHG Emissions Avoided (tCO2e)
2009	$0.0	0
2010	$4.7	11,520
2011	$3.4	23,007
2012	$2.3	34,464
2013	$1.7	45,897
2014	$0.7	57,308
2015	($0.2)	68,601
2016	($1.0)	79,843
2017	($2.0)	91,038
2018	($3.1)	102,188
2019	($4.3)	113,296
2020	($6.1)	123,033
2021	($7.2)	132,510
2022	($8.2)	141,734
2023	($9.3)	150,711
2024	($10.3)	159,446
2025	($11.3)	168,034

To provide an overview of the entire option, Table 2-15 summarizes the GHG savings and net costs of all three elements of FAW-2.

Table 2-15: Costs and GHG Savings of FAW-2

Year	MMtCO2e Saved, Electricity	MMtCO2e Saved, Biofuels	MMtCO2e Saved, CHP	MMtCO2e Saved Total	Net Costs, Electricity (MM$)	Net Costs, Biofuel (MM$)	Net Costs, CHP (MM$)	Net Savings (MM$)
2009	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
2010	0.01	0.01	0.01	0.02	0.2	0.0	4.7	4.9
2011	0.01	0.01	0.02	0.05	0.5	-0.2	3.4	3.7
2012	0.02	0.02	0.03	0.07	0.8	-0.7	2.3	2.3
2013	0.03	0.02	0.05	0.10	1.1	-1.1	1.7	1.7
2014	0.03	0.03	0.06	0.12	1.5	-0.7	0.7	1.5
2015	0.04	0.03	0.07	0.14	1.9	-0.4	-0.2	1.3
2016	0.05	0.04	0.08	0.17	2.4	-0.7	-1.0	0.7
2017	0.06	0.05	0.09	0.19	2.8	-1.5	-2.0	-0.7
2018	0.07	0.05	0.10	0.22	3.1	-1.8	-3.1	-1.8
2019	0.07	0.06	0.11	0.24	3.5	-2.0	-4.3	-2.8
2020	0.08	0.06	0.12	0.27	4.0	-2.4	-6.1	-4.5
2021	0.09	0.07	0.13	0.29	4.6	-2.5	-7.2	-5.2
2022	0.10	0.08	0.14	0.32	5.1	-2.7	-8.2	-5.8

2023	0.11	0.08	0.15	0.35	5.7	-2.9	-9.3	-6.5
2024	0.12	0.09	0.16	0.37	6.3	-3.0	-10.3	-7.0
2025	0.13	0.09	0.17	0.40	6.9	-3.0	-11.3	-7.3
Total				**3.3**				**-25**

- **Data Sources: [**TBD by CCS on TWG approval]
- **Quantification Methods: [e.g.** Full life-cycle analysis with supply/demand equilibrium adjustments on TWG approval]
- **Key Assumptions:**

Biofuels: Annual cellulosic plant costs are $40 million per year for a 69-million-gallon/year plant, and include labor, general overhead, maintenance, taxes, insurance, and other operational costs, not including feedstock costs. Capital costs are $497 million per plant and assume an interest rate of 5% and a project life of 20 years.

Key Uncertainties

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

Additional Benefits and Costs

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

Feasibility Issues

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

Status of Group Approval

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

Level of Group Support

TBD **–** [blank until CCMAG meeting #5]

Barriers to Consensus

TBD **–** [blank until final vote by the CCMAG]

FAW-3 Advanced Waste Reduction and Recycling (first draft – awaiting further TWG comment prior to revision).

Policy Description

Reduce waste generation and increase recycling and organics management and in order to limit GHG emissions upstream from material production, through transportation and on the downstream end associated with landfill methane generation. Reduction of generation at the source reduces both landfill emissions and upstream production and transportation emissions. Increase economically-sustainable recycling programs, create new recycling programs, provide incentives for the recycling of construction materials, develop markets for recycled materials, and increase average participation and recovery rates for all existing recycling programs.

Policy Design

Goals: Quantify current waste generation rates (pounds per capita per day) for rural and urban areas. Reduce waste stream, including diverted waste, 10% in 2012, 15% by 2015, and 25% by 2025.

Timing: Startup in 2010 and ramp up to higher levels in 2012 and 2015, consistent with goals

Parties Involved: Consumers, manufacturers, relevant trade associations, consumer's associations, all state and local agencies, retail outlets, non-profit organizations, shippers, waste management industry

Other: Urban areas are considered to be Anchorage, Mat-Su Valley, Fairbanks, and Juneau. Rural areas are all other communities in the state.

Implementation Mechanisms

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

Related Policies/Programs in Place

The four largest communities in Alaska are embarking on new recycling programs. In Anchorage, the Municipality has dedicated a fund for recycling and is planning to build on private efforts by expansion of drop-off sites, school district recycling and public outreach. The Municipal collection utility, which serves approximately 20% of Anchorage residences, has implemented a Pay As You Throw (PAYT) and curbside recycling program beginning in October 2008. The residential waste hauler, Alaska Waste, is offering curbside recycling service to a third of Anchorage and Eagle River residences.

The Fairbanks North Star Borough (FNSB) is soliciting proposals for optimizing the Municipal Solid Waste (MSW) stream. The FNSB is seeking a long-term partnership to implement a method for economical disposal of the community's municipal solid waste while returning energy savings to the Borough; with a particular emphasis on waste reduction, recycling and waste to energy options.

The City and Borough of Juneau has just completed an evaluation by a consultant for a long range solid waste management strategy and analysis. Alaska's capital city is targeting the implementation of a curbside recycling program in 2009.

In the Matanuska-Susitna Valley, Valley Community for Recycling Solutions is securing funds and moving forward for the construction and operation of a Community Recycling Center. The site is located adjacent to the Matanuska-Susitna Borough's Central Landfill.

The Municipality of Anchorage refuse collection utility has implemented a Pay As You Throw (PAYT) and curbside recycling program beginning in October 2008. The PAYT system promotes waste reduction through lower rates for smaller refuse containers. The utility is discontinuing flat-rate refuse collection service.

Alaskans for Litter Prevention and Recycling (ALPAR) has an in-store plastic bag recycling, reuse and conservation toolkit available on their website www.alparalaska.com.

Types(s) of GHG Reductions

CO_2: Upstream energy use reductions—The energy and GHG intensity of manufacturing a product is generally less when using recycled feedstocks than when 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 2015, 2025 ($MMtCO_2e$): 0.17 and 0.51, respectively.

Net Cost per tCO_2e: –$29.

Data Sources: Data on current waste disposal and recycling were provided by AK DEC.[17] Where AK-specific data was not available, CCS utilized national defaults derived from the U.S. EPA 2007 Waste Characterization Report.[18] GHG emission reductions were modeled using EPA's Waste Reduction Model (WARM).[19] Input informing the cost parameters was also provided by AK DEC.

[17] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009.

[18] U.S. EPA. (2008). "Municipal Solid Waste in the United States: 2007 Facts and Figures." Available at: http://www.epa.gov/osw/nonhaz/municipal/pubs/msw07-rpt.pdf.

[19] U.S. Environmental Protection Agency. "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 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

Quantification Methods:

Business-as-usual Waste Management Forecast

The business-as-usual (BAU) waste management profile in Alaska was developed using input from AK DEC.[20] MSW landfills are classified according to the average daily tonnage received. Class I landfills accept greater than 20 tons/day, Class II accept between 5 and 20 tons/day, and Class III landfills accept less than 5 tons/day. Population projections are from an Alaska Department of Labor report were used to develop the waste generation projections for the state, as well as the four key Alaska population centers (Anchorage, Fairbanks, Mat-su Borough, and Juneau).[21] See Table 3-1 for the total Alaska waste management projection. The remainder of this section will describe the methods for developing the BAU waste management forecast for distinct communities and community groups in Alaska.

Table 3-1. Total Alaska BAU Waste Management Projection, 2005-2025.

	2005	2010	2012	2015	2020	2025
Total Alaska						
MSW Generated (tons)	739,684	779,542	795,793	820,168	861,140	900,298
MSW Landfilled (tons)	634,848	669,620	683,863	705,208	740,777	774,414
MSW Incinerated (tons)	29,604	30,658	31,118	31,821	32,987	34,169
MSW Diverted (tons)[22]	75,232	79,264	80,812	83,140	87,376	91,716
Total Alaska Diversion %	10.2%	10.2%	10.2%	10.1%	10.1%	10.2%

According to data provided by AK DEC, there are 310 communities in Alaska that deposit waste in 222 Class III landfills. The waste generation from these communities is assumed to be 6.6 lbs/person/day, with waste collected 5 days per week (260 days per year). The population depositing waste in Class III landfills was assumed to be the remainder of the state's population after the populations of Class I and Class II communities were considered. AK DEC reported that there are about t10 tons per year of aluminum cans shipped from Class III communities to be recycled. The quantity and growth rate of waste incinerated in Class III landfill communities is consistent with inputs used for the AK Inventory and Forecast (I&F), less the waste that was reported to be incinerated in the North Slope Borough (within the Class II community

reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in tons of carbon equivalent (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, May 2002. Available at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

[20] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009.

[21] Alaska Department of Labor and Workforce Development. 2007. "Alaska Population Projections: 2007-2030." Available at: http://www.labor.state.ak.us/research/pop/projections/AlaskaPopProj.pdf.

[22] "Waste Diverted" includes waste recycled and waste composted.

classification). The amount of waste landfilled is the difference between the waste generated and the waste incinerated and diverted. Table 3-2 depicts the BAU waste management projections for the Class III landfill communities.

Table 3-2. Class III Landfill Communities BAU Waste Management Projection, 2005-2025.

	2005	2010	2012	2015	2020	2025
Class III Landfill Communities						
MSW Generated (tons)	63,406	63,619	63,401	63,073	62,153	60,930
MSW Landfilled (tons)	37,401	36,705	36,114	35,218	33,323	31,092
MSW Incinerated (tons)	25,995	26,904	27,277	27,845	28,819	29,827
MSW Diverted (tons)	10	10	10	10	10	10

Similar to Class III landfill communities, Class II landfill communities are assumed to deposit 6.6 lbs/person/day of waste for 260 days out of the year. AK DEC estimates that Class II communities account for 7.3% of the total population of Alaska. It is assumed that no waste is diverted in these communities. The waste incinerated is based on the estimated amount incinerated in the North Slope Borough. The total waste landfilled is therefore the difference between the waste generated and the waste incinerated. Table 3-3 shows the BAU waste management scenario for Class II landfill communities.

Table 3-3. Class II Landfill Communities BAU Waste Management Projection, 2005-2025.

	2005	2010	2012	2015	2020	2025
Class II Landfill Communities						
MSW Generated (tons)	41,522	43,754	44,667	46,036	48,320	50,490
MSW Landfilled (tons)	37,913	40,001	40,826	42,061	44,153	46,149
MSW Incinerated (tons)	3609	3753	3841	3975	4167	4341
MSW Diverted (tons)	0	0	0	0	0	0

Included in the consideration of the Class I landfill communities were the four large population centers of Anchorage, Fairbanks, Mat-su Borough, and Juneau. Additional communities served by Class I landfills are grouped into the "Non-Metro Class I Landfill Communities" category. The average per-capita waste generation rate for each community was based on input from AK DEC. The generation rate for the Non-Metro group was estimated by taking the weighted average of the generation rates from the communities in that group. Class I facilities are assumed to accept deposits for 312 days per year. Recycling rates for Anchorage, Mat-su Borough, and Juneau were provided by AK DEC. The baseline recycling rate for Anchorage is 19%, the baseline recycling rate for the Mat-su Borough is 1.2%, and the recycling rate for Juneau and Fairbanks is 5.7%.[23] It was assumed that Fairbanks had a recycling rate equal to that of Juneau.

[23] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009. Anchorage recycling information from a data sheet compiled by Alaskans for Litter Prevention and Recycling (ALPAR), provided by D. Buteyn of AK DEC.

Recycling attributed to the Non-Metro Class I Landfill Communities is based on reported recycling from the Kenai Peninsula Borough.[24] It was also assumed that no MSW combustion took place in Class I landfill communities. Table 3.4 outlines the waste management projections for Class I landfill communities.

Table 3-4. Class I Landfill Communities BAU Waste Management Projection, 2005-2025.

	2005	2010	2012	2015	2020	2025
Non-metro Class I Landfill Communities						
MSW Generated (tons)	90,636	94,822	95,932	97,597	99,717	101,074
MSW Landfilled (tons)	90,002	93,853	94,904	96,474	98,416	99,565
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	634	968	1027	1122	1301	1508
Anchorage						
MSW Generated (tons)	350,751	367,197	373,996	384,196	403,205	422,758
MSW Landfilled (tons)	284,108	297,430	302,937	311,199	326,596	342,434
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	66,643	69,767	71,059	72,997	76,609	80,324
Fairbanks						
MSW Generated (tons)	91,974	98,638	100,693	103,776	108,308	112,698
MSW Landfilled (tons)	86,456	92,719	94,652	97,550	101,810	105,936
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	5,518	5,918	6,042	6,227	6,499	6,762
Mat-su Borough						
MSW Generated (tons)	76,179	85,216	90,679	98,873	112,675	125,607
MSW Landfilled (tons)	75,265	84,193	89,590	97,686	111,323	124,100
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	914	1,023	1,088	1,186	1,352	1,507
Juneau						
MSW Generated (tons)	25,217	26,297	26,425	26,618	26,762	26,742
MSW Landfilled (tons)	23,704	24,719	24,840	25,021	25,157	25,137
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	1,513	1,578	1,586	1,597	1,606	1,604

GHG Benefit Analysis

CCS applied the goals set forth by the TWG in the "Policy Design" section to the Alaska BAU waste management scenario in Table 3-1. As the TWG did not prescribe a specific ratio of diversion that will be met through recycling/composting to that which will be met through source reduction, CCS assumed the ratio of the two diversion strategies needed to meet the goal. Tables

[24] Kenai Peninsula Borough Solid Waste Office. (2008). "Recycling and Solid Waste Programs." Data collected for the Homer Bailing Facility and Central Peninsula Landfill. Available at: http://www.borough.kenai.ak.us/SolidWaste/Informational%20Pages/recyclewaste.htm

3-5, 3-6, and 3-7 display the assumed annual diversion targets, the policy waste management scenario, and the incremental waste diversion, respectively. As the annual target for waste diversion does not exceed the BAU diversion level until the year 2013, it is assumed that there is zero incremental diversion in these years.

Table 3-5. Yearly Waste Management Targets, 2010-2025.

	2010	2012	2015	2020	2025
Diversion	5.0%	10.0%	15.0%	20.0%	25.0%
Recycling / Composting	5.0%	10.0%	13.0%	16.5%	20.0%
Source Reduction	0.0%	0.0%	2.0%	3.5%	5.0%

Table 3-6. Total Alaska Policy Waste Management Scenario, 2010-2025.

	2010	2012	2015	2020	2025
Total Alaska					
MSW Generated (including SR, tons)	779,542	795,793	820,168	861,140	900,298
MSW Landfilled (tons)	669,620	683,863	665,322	655,925	641,055
MSW Incinerated (tons)	30,658	31,118	31,821	32,987	34,169
MSW Diverted (tons)	79,264	80,812	123,025	172,228	225,075
MSW Recycled /Composted (tons)	79,264	80,812	106,622	142,088	180,060
MSW Source Reduced (tons)	-	-	16,403	30,140	45,015

Table 3-7. Total Alaska Incremental Waste Diversion, 2010-2025.

	2010	2012	*2013*	2015	2020	2025
Total Alaska						
MSW Diverted (tons)	-	-	12,204	39,886	84,852	133,359
MSW Recycled /Composted (tons)	-	-	6,844	23,482	54,712	88,344
MSW Source Reduced (tons)	-	-	5,359	16,403	30,140	45,015

The incremental waste diversion was allocated amongst the four large metro areas based on the proportion of waste diverted – and in the case of source reduction, waste generated – in each metro area under the BAU scenario. Any remaining incremental diversion needed to meet the goal was allocated to Anchorage. Table 3-8 portrays the assumed incremental waste diversion for each of the major population centers in Alaska.

Table 3-8. Class I Metro Landfill Communities Incremental Waste Diversion, 2010-2025.

	2010	2012	*2013*	2015	2020	2025
Anchorage						
MSW Diverted (tons)	-	-	10,100	33,158	71,236	112,200
MSW Recycled /Composted (tons)	-	-	6,218	21,340	49,767	80,437
MSW Source Reduced (tons)	-	-	3,882	11,818	21,469	31,763
Fairbanks						
MSW Diverted (tons)	-	-	1,089	3,484	7,073	10,936
MSW Recycled /Composted (tons)	-	-	411	1,409	3,283	5,301
MSW Source Reduced (tons)	-	-	678	2,076	3,791	5,635
Mat-su Borough						
MSW Diverted (tons)	-	-	705	2,259	4,600	7,340
MSW Recycled /Composted (tons)	-	-	82	282	657	1,060
MSW Source Reduced (tons)	-	-	623	1,977	3,944	6,280
Juneau						
MSW Diverted (tons)	-	-	310	983	1,942	2,883
MSW Recycled /Composted (tons)	-	-	133	451	1,005	1,545
MSW Source Reduced (tons)	-	-	177	532	937	1,337

GHG benefits were determined by using WARM,[25] which uses information for specific material inputs and disposal/diversion methods to estimate GHG emission reductions based on BAU and policy scenarios. Avoided emission of CO_2 and associated GHGs from the reduction of the amount virgin materials and energy consumption necessary for the production of products and packaging, as the total mass produced of these items would be reduced. WARM accounts for the origin of carbon sequestered in raw materials. Therefore, CO_2 emissions from the combustion or decomposition of biogenic waste are not counted towards the total emissions, CH_4 and N_2O emissions due to landfilling or combustion of biogenic waste, as well as avoided future CO_2

[25] U.S. Environmental Protection Agency. 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 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, May 2002. Available at: http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html

sequestration are counted towards the net life-cycle emissions of each waste management practice.

The key requirement for inputting data into WARM is that the amount of waste generated for each waste type must be the same under the policy and BAU scenarios. Therefore, although waste that is source reduced is not actually generated, it is considered as a part of the total generated under the policy scenario as that waste has the potential to be generated without incremental diversion efforts. A second requirement for an accurate result from WARM is that the MSW managed should be broken up by waste type. There are six categories and 34 distinct waste types accepted by WARM. Based on available Alaska data, 18 of those waste types were utilized. Table 3-9 and 3-10 show the baseline waste generation, disposal, and diversion characterization. In cases where, due to data selection from multiple sources, there was more waste projected to be diverted than generated for a given waste type, it was assumed that the maximum diversion percentage for any waste type is 90%.

Table 3-9. Assumed Baseline Alaska Waste Characteristics – Waste Categories

Category	Baseline Generation Composition (BAU)	Baseline Anchorage, Juneau, Fairbanks Recycling Composition (BAU)	Baseline Mat-Su Valley Recycling Compostition (BAU)	Baseline non-Metro Recycling Composition (BAU)
Paper	32.7%	45.9%	87.9%	9.7%
Organics	25.3%	1.6%	0.0%	0.0%
Mixed Plastic	12.1%	0.7%	7.3%	0.5%
Metals	8.2%	46.4%	4.8%	3.4%
Glass	5.3%	1.5%	0.0%	0.0%
Other	16.4%	3.8%	0.0%	0.0%

Table 3-10. Assumed Baseline Alaska Waste Characteristics – Waste Types

Waste Category Waste Type	Alaska Waste Generation Composition (% of waste Generated)[26]	Anchorage, Juneau, Fairbanks Baseline Recycling Composition (% of Waste Recycled)[27]	Mat-su Baseline Recycling Composition (% of Waste Recycled)[28]	ROS Baseline Recycling Composition (% of Waste Recycled)[29]	Total Baseline Recycling Composition (% of Waste Recycled)
Paper	**32.7%**	**45.9%**	**87.9%**	**96.1%**	**47.0%**
Corrugated Cardboard	12.3%	25.8%	27.7%	47.1%	26.1%
Magazines/Third-class Mail	3.3%	2.5%			2.4%

[26] U.S. EPA. (2008). "Municipal Solid Waste in the United States: 2007 Facts and Figures." Available at: http://www.epa.gov/osw/nonhaz/municipal/pubs/msw07-rpt.pdf.

[27] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009.

[28] *Ibid.*

[29] *Ibid.*

Waste Category Waste Type	**Alaska Waste Generation Composition (% of waste Generated)[26]**	**Anchorage, Juneau, Fairbanks Baseline Recycling Composition (% of Waste Recycled)[27]**	**Mat-su Baseline Recycling Composition (% of Waste Recycled)[28]**	**ROS Baseline Recycling Composition (% of Waste Recycled)[29]**	**Total Baseline Recycling Composition (% of Waste Recycled)**
Newspaper	4.3%	8.5%		39.4%	8.8%
Office Paper	2.4%	0.2%			0.2%
Phonebooks	0.3%	0.4%			0.4%
Textbooks	0.5%	0.0%			0.0%
Mixed - Residential	7.1%	8.5%	60.2%	9.7%	9.1%
Mixed - Office	2.5%	0.0%			0.0%
Glass	**5.3%**	**1.5%**		**0.0%**	**1.5%**
Metals	**8.2%**	**46.4%**	**4.8%**	**3.4%**	**45.4%**
Aluminum Cans	0.6%	0.2%	2.2%	3.4%	0.3%
Steel Cans	1.0%	0.0%			0.0%
Mixed Metals	6.6%	46.2%	2.6%		45.1%
Plastics	**12.1%**	**0.7%**	**7.3%**	**0.5%**	**0.8%**
HDPE	2.2%	0.0%			0.0%
LDPE	2.5%	0.0%			0.0%
PET	1.5%	0.0%			0.0%
Mixed Plastics	5.9%	0.7%	7.3%	0.5%	0.8%
Organics	**25.3%**	**1.6%**	**0.0%**	**0.0%**	**1.5%**
Food Scraps	12.5%	0.0%			0.0%
Yard Trimmings	12.8%	1.6%			1.5%
Other	**16.4%**	**3.8%**	**0.0%**	**0.0%**	**3.8%**

The BAU and Policy waste management projections were multiplied by the percentages in Table 3-9 to provide WARM inputs for the years 2015 and 2025. Again, it was assumed that the maximum diversion rate for any given waste type is 90%. It was also assumed that only biogenic waste (i.e. paper and organics) could be combusted. The amount of each biogenic waste type combusted is in proportion to that waste type's generation quantity. The amount of waste source reduced for each waste type for which this diversion method is an accepted WARM input was also proportional to each waste type's generation quantity. The amount of waste landfilled was estimated by subtracting the amount of waste diverted and combusted from the total waste generated. Tables 3-11 and 3-12 display the BAU and policy WARM modeling for 2025.

Table 3-11. 2025 BAU WARM Inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	5,172	278	4,894	-	NA
Steel cans	8,644	-	8,644	-	NA
Copper wire				-	NA
Glass	48,108	1,336	46,772	-	NA
HDPE	20,015	-	20,015	-	NA
LDPE	22,672	-	22,672	-	NA
PET	13,320	-	13,320	-	NA
Corrugated cardboard	110,633	23,951	79,437	7,245	NA
Magazines/third-class mail	29,970	2,224	25,783	1,963	NA
Newspaper	38,897	8,061	28,289	2,547	NA
Office paper	21,255	180	19,683	1,392	NA
Phonebooks	2,480	339	1,979	162	NA
Textbooks	4,747	-	4,436	311	NA
Dimensional lumber					NA
Medium-density fiberboard					NA
Food scraps	112,121	NA	104,779	7,342	-
Yard trimmings	115,593	NA	106,605	7,570	1,419
Grass		NA			
Leaves		NA			
Branches		NA			
Mixed paper (general)					NA
Mixed paper (primarily residential)	63,907	8,379	51,343	4,185	NA
Mixed paper (primarily from offices)	22,176	-	20,724	1,452	NA
Mixed metals	59,692	41,393	18,298	-	NA
Mixed plastics	52,855	711	52,144	-	NA
Mixed recyclables	148,042	3,446	144,597	-	NA
Mixed organics		NA			
Mixed MSW		NA			NA
Carpet					NA
Personal computers					NA
Clay bricks		NA		NA	NA
Concrete				NA	NA
Fly ash				NA	NA
Tires					NA
Totals	**900,298**	**91,716***	**774,414**	**34,169**	

N/A = not applicable; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; MSW = municipal solid waste. *Includes waste composted

Table 3-12. 2025 Policy WARM Inputs

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	5,172	714	546	3,911	-	NA
Steel cans	8,644	1,194	-	7,450	-	NA
Copper wire						NA
Glass	48,108	6,645	2,622	38,841	-	NA
HDPE	20,015	2,765	-	17,251	-	NA
LDPE	22,672	3,131	-	19,541	-	NA
PET	13,320	1,840	-	11,480	-	NA
Corrugated cardboard	110,633	15,281	47,021	41,086	7,245	NA
Magazines/third-class mail	29,970	4,139	4,366	19,502	1,963	NA
Newspaper	38,897	5,372	15,826	15,152	2,547	NA
Office paper	21,255	2,936	354	16,574	1,392	NA
Phonebooks	2,480	343	665	1,310	162	NA
Textbooks	4,747	656	-	3,780	311	NA
Dimensional lumber						NA
Medium–density fiberboard						NA
Food scraps	112,121	NA	NA	104,779	7,342	-
Yard trimmings	115,593	NA	NA	105,238	7,570	2,785
Grass		NA	NA			
Leaves		NA	NA			
Branches		NA	NA			
Mixed paper, broad		NA				NA
Mixed paper, residential	63,907	NA	16,450	43,272	4,185	NA
Mixed paper, office	22,176	NA	-	20,724	1,452	NA
Mixed metals	59,692	NA	53,722	5,969	-	NA
Mixed plastics	52,855	NA	1,396	51,459	-	NA
Mixed recyclables	148,042	NA	34,306	113,736	-	NA
Mixed organics		NA	NA			
Mixed MSW		NA	NA			NA
Carpet						NA
Personal computers						NA
Clay bricks			NA		NA	NA
Concrete		NA			NA	NA
Fly ash		NA			NA	NA
Tires						NA
Totals	**900,298**	**45,015**	**180,060***	**641,055**	**34,169**	

HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; MSW = municipal solid waste. *Includes waste composted

The resulting output for the 2015 and 2025 WARM runs predict the GHG reductions for these years to be 0.17 and 0.51 $MMtCO_2e$, respectively. The cumulative GHG reductions are calculated to be 3.96 $MMtCO_2e$. Table 3-13 displays a summary of the waste diversion, reduction, and GHG benefits of this recommendation.

Table 3-13. Overall Policy Results—GHG Benefits

Year	Avoided Emissions (MMtCO2e)	Incremental Waste Diversion (tons)	Source Reduction (tons)	Incremental Recycling (tons)	Incremental Composting (tons)
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	-	-	-	-	-
2013	0.06	12,204	5,359	6,723	121
2014	0.12	25,910	10,827	14,840	242
2015	0.17	39,886	16,403	23,119	363
2016	0.21	48,553	19,052	29,037	464
2017	0.24	57,383	21,750	35,069	564
2018	0.28	66,377	24,498	41,215	664
2019	0.31	75,533	27,294	47,474	765
2020	0.34	84,852	30,140	53,847	865
2021	0.38	94,242	33,021	60,256	965
2022	0.41	103,788	35,949	66,774	1,065
2023	0.45	113,490	38,924	73,400	1,166
2024	0.48	123,346	41,946	80,134	1,266
2025	0.51	133,359	45,015	86,977	1,366
Totals	**3.96**	**978,921**	**350,180**	**618,865**	**9,876**

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

Cost-Effectiveness

Source reduction—The amount of waste managed in Alaska under the policy scenario is reduced according to CCS's best judgment that 5% of the 25% goal would be feasible by 2025. The cost-effectiveness estimate for source reduction in Alaska comprises three elements: the cost of program implementation, the avoided costs of waste collection and disposal.

The cost of program implementation is assumed to be $1.00 per capita per year.[30] This cost applies only to the populations of the four largest metro areas. The cost figure uses a population projection from AK Department of Labor.[31] These funds are assumed to cover any education and marketing programs necessary to implement the source reduction goal.

[30] The source reduction program cost is a preliminary estimate consistent with costs assumed in similar options considered by CCS projects in Washington and Colorado.

[31] Alaska Department of Labor and Workforce Development. 2007. "Alaska Population Projections: 2007-2030." Available at: http://www.labor.state.ak.us/research/pop/projections/AlaskaPopProj.pdf.

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 assumed to be \$2.50 per household per month (calculations based on total households in these areas yields a per-ton collection cost of \$9.72).[32] The landfill tip fees that are offset vary by municipality. The landfill tipping fees used for this analysis are; \$60 for Anchorage, \$61 for Fairbanks, \$50 for Mat-su Borough, and \$140 for Juneau.[33]

The analysis assumes that costs begin to be incurred in 2012. The estimated cost savings result in an NPV of –\$4.1 million. Cumulative GHG reductions attributed to source reduction are 1.7 $MMtCO_2e$, and the estimated cost-effectiveness is –\$2/tCO_2e, as shown in Table 3-15.

Recycling—The net cost of increased recycling rates in Alaska 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 \$9.72 per ton. The capital cost of additional recycling facilities in Alaska is \$5.6 million.[34] Annualized over the 10-year policy period at 5% interest, the capital cost is \$0.4 million/year. The avoided cost for landfill tipping is the same as in the source reduction calculations. CCS assumed the value of recycled materials to be zero, based on recent volatility in recycling markets. Table 3-16 provides the results of the cost analysis. The analysis assumes that costs begin to be incurred in 2012. The estimated cost savings result in an NPV of –\$33.1 million. Cumulative GHG reductions attributed to recycling are 1.0 $MMtCO_2e$, and the estimated cost-effectiveness is –\$8/tCO_2e.

Composting—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 Alaska 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.[35] These data are summarized in Table 3-13.

[32] U.S. Census Bureau. "State & County QuickFacts. Accessed on January 9, 2009, at: http://quickfacts.census.gov/qfd/states/02/0203000.html, http://quickfacts.census.gov/qfd/states/02/0224230.html, http://quickfacts.census.gov/qfd/states/02/02170.html, and http://quickfacts.census.gov/qfd/states/02/0236400.html.

[33] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009.

[34] 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).

[35] 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.

Table 3-14. 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

CCS assumed that the composting facilities to be built within the policy period would tend to be from the first category (a capital cost of $75,000, and an O&M cost of $25/ton) shown in Table 3-13. It is assumed that three of these facilities are needed to meet the goal. To annualize the capital costs of these facilities, CCS assumed a 15-year operating life and a 5% interest rate. Other cost assumptions include the landfill tipping fees from the source reduction and recycling sections, an additional source-separated organics collection fee of $9.72/ton (as used above in the recycling element), a compost facility tipping fee of $16.5/ton,[36] and a compost value of $16.50/ton.[37]

Table 3-17 presents the results of the cost analysis for composting. GHG reductions were assumed not to begin until 2012, and the cumulative reductions estimated were 0.0014 $MMtCO_2e$. An NPV of $0.1 million was estimated, along with a cost-effectiveness of $47/t$CO_2$e.

[36] **NOT AN ALASKA-SPECIFIC PARAMETER.** Emerson, Dan. *Latest Trends in Yard Trimmings* Composting. 2005. Accessed on May 23, 2008, from: http://hs.environmental-expert.com/resultEachArticle.aspx?cid=6042&codi=5723&idproducttype=6.

[37] D. Buteyn (AK DEC), personal communication with H. Lindquist (CCS) December 11, 2008. D. Buteyn personal communication with B. Strode (CCS) December 2008 and January 2009.

Table 3-15. Cost Analysis for Source Reduction

Year	Ancorage Tons Reduced	Fairbanks Tons Reduced	Mat-su Tons Reduced	Juneau Tons Reduced	AK Metro Population	Avoided Landfill Tipping Fee (2006$MM)	Avoided MSW Collection Costs (2006$MM)	Program Costs (2006$MM)	Net Source Reduction Costs (2006$MM)	Discounted Costs (2006$MM)	GHG Reductions (MMtCO2e)	Cost Effectiveness
2010	-	-	-	-	502,210	$0.0	$0.0	$0.0	$0.0	$0.0	0.00	
2011	-	-	-	-	508,674	$0.0	$0.0	$0.0	$0.0	$0.0	0.00	
2012	-	-	-	-	515,138	$0.0	$0.0	$0.5	$0.5	$0.5	0.00	
2013	3,882	678	623	177	521,601	$0.3	$0.1	$0.5	$0.1	$0.1	0.03	
2014	7,821	1,370	1,282	354	528,065	$0.7	$0.1	$0.5	-$0.2	-$0.2	0.05	
2015	11,818	2,076	1,977	532	534,529	$1.0	$0.2	$0.5	-$0.6	-$0.5	0.08	
2016	13,694	2,408	2,338	613	541,186	$1.2	$0.2	$0.5	-$0.8	-$0.6	0.09	
2017	15,597	2,745	2,714	694	547,843	$1.3	$0.2	$0.5	-$1.0	-$0.7	0.10	
2018	17,528	3,088	3,107	774	554,499	$1.5	$0.2	$0.6	-$1.2	-$0.8	0.12	
2019	19,485	3,437	3,517	855	561,156	$1.7	$0.3	$0.6	-$1.4	-$0.9	0.13	
2020	21,469	3,791	3,944	937	567,813	$1.8	$0.3	$0.6	-$1.6	-$1.0	0.14	
2021	23,475	4,149	4,380	1,017	574,318	$2.0	$0.3	$0.6	-$1.8	-$1.0	0.16	
2022	25,508	4,513	4,832	1,097	580,823	$2.2	$0.3	$0.6	-$2.0	-$1.1	0.17	
2023	27,566	4,881	5,299	1,177	587,328	$2.4	$0.4	$0.6	-$2.2	-$1.2	0.18	
2024	29,651	5,256	5,782	1,257	593,833	$2.6	$0.4	$0.6	-$2.4	-$1.2	0.20	
2025	31,763	5,635	6,280	1,337	600,338	$2.8	$0.4	$0.6	-$2.6	-$1.2	0.21	
Totals	**249,257**	**44,026**	**46,075**	**10,821**					**-$6.2**	**-$4.1**	**1.7**	**-$2**

2006$MM = million 2006 dollars; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Table 3-16. Cost Analysis for Recycling

Year	Anchorage Tons Recycled	Fairbanks Tons Recycled	Mat-su Tons Recycled	Juneau Tons Recycled	Annual Collection Cost (2006$MM)	Annual Capital Cost (2006$MM)	Annual Recycled Material Revenue (2006$MM)	Landfill Tip Fees Avoided (2006$MM)	Net Policy Cost (Recycling) (2006$MM)	Discounted Costs (MM$)	GHG Reductions (MMt)	Cost Effectiveness ($/Mt)
2010	-	-	-	-	$0.0	$0	$0.0	$0.0	$0.0	$0.0	-	
2011	-	-	-	-	$0.0	$0	$0.0	$0.0	$0.0	$0.0	-	
2012	-	-	-	-	$0.0	$0.4	$0.0	$0.0	$0.4	$0.3	-	
2013	6,109	402	82	131	$0.1	$0.4	$0.0	$0.5	-$0.1	$0.0	0.0	
2014	13,486	887	181	287	$0.1	$0.4	$0.0	$1.1	-$0.6	-$0.5	0.1	
2015	21,012	1,382	282	444	$0.2	$0.4	$0.0	$1.7	-$1.1	-$0.8	0.1	
2016	26,396	1,735	354	552	$0.3	$0.4	$0.0	$2.1	-$1.4	-$1.1	0.1	
2017	31,885	2,096	428	661	$0.3	$0.4	$0.0	$2.5	-$1.8	-$1.3	0.1	
2018	37,480	2,463	503	770	$0.4	$0.4	$0.0	$2.9	-$2.2	-$1.5	0.2	
2019	43,180	2,837	579	879	$0.5	$0.4	$0.0	$3.4	-$2.6	-$1.7	0.2	
2020	48,985	3,218	657	988	$0.5	$0.4	$0.0	$3.8	-$3.0	-$1.8	0.2	
2021	54,827	3,601	735	1,094	$0.6	$0.4	$0.0	$4.3	-$3.4	-$2.0	0.2	
2022	60,769	3,990	814	1,200	$0.6	$0.4	$0.0	$4.8	-$3.8	-$2.1	0.2	
2023	66,813	4,386	895	1,306	$0.7	$0.4	$0.0	$5.2	-$4.2	-$2.2	0.3	
2024	72,957	4,789	977	1,412	$0.8	$0.4	$0.0	$5.7	-$4.6	-$2.3	0.3	
2025	79,202	5,198	1,060	1,517	$0.8	$0.4	$0.0	$6.2	-$5.0	-$2.4	0.3	
Totals	**563,099**	**36,981**	**7,545**	**11,240**					**-$33.1**	**-$8.3**	**1.0**	**-$8**

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

Table 3-17. Cost Analysis for Composting

Year	Anchorage Tons of Waste Composted	Fairbanks Tons of Waste Composted	Mat-su Tons of Waste Composted	Juneau Tons of Waste Composted	Annual Cost O&M ($MM)	Capital Cost ($MM)	Annualized Capital Cost ($MM)	Annual Collection Cost ($MM)	Avoided Landfill Tipping Fees ($MM)	Value of Composted Material ($MM)	Total Annual Composting Cost ($MM)	Discounted Costs ($MM)	GHG Reductions (MMtCO2e)	Cost Effective ness ($/Mt)
2010	-	-	-	-	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	-	
2011	-	-	-	-	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	-	
2012	-	-	-	-	$0.00	$0.23	$0.02	$0.00	$0.00	$0.00	$0.02	$0.02	-	
2013	109	9	-	2	$0.00	$0.00	$0.02	$0.00	$0.01	$0.00	$0.02	$0.02	4.3E-05	
2014	219	18	-	5	$0.01	$0.00	$0.02	$0.00	$0.01	$0.00	$0.01	$0.01	8.6E-05	
2015	328	27	-	7	$0.01	$0.00	$0.02	$0.00	$0.02	$0.01	$0.01	$0.01	1.3E-04	
2016	419	35	-	10	$0.01	$0.00	$0.02	$0.00	$0.02	$0.01	$0.01	$0.01	1.6E-04	
2017	510	42	-	12	$0.01	$0.00	$0.02	$0.01	$0.03	$0.01	$0.01	$0.00	2.0E-04	
2018	601	50	-	14	$0.02	$0.00	$0.02	$0.01	$0.03	$0.01	$0.00	$0.00	2.3E-04	
2019	691	58	-	16	$0.02	$0.00	$0.02	$0.01	$0.04	$0.01	$0.00	$0.00	2.7E-04	
2020	782	65	-	18	$0.02	$0.00	$0.02	$0.01	$0.04	$0.01	$0.00	$0.00	3.0E-04	
2021	873	73	-	20	$0.02	$0.00	$0.02	$0.01	$0.05	$0.02	-$0.01	$0.00	3.3E-04	
2022	963	80	-	22	$0.03	$0.00	$0.02	$0.01	$0.05	$0.02	-$0.01	$0.00	3.7E-04	
2023	1,054	88	-	24	$0.03	$0.00	$0.02	$0.01	$0.05	$0.02	-$0.01	-$0.01	4.0E-04	
2024	1,145	95	-	26	$0.03	$0.00	$0.02	$0.01	$0.06	$0.02	-$0.01	-$0.01	4.4E-04	
2025	1,236	103	-	28	$0.03	$0.00	$0.02	$0.01	$0.06	$0.02	-$0.02	-$0.01	4.7E-04	
Totals	**8,931**	**743**	**-**	**203**							**$0.0**	**$0.1**	**1.4E-03**	**$47**

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

The overall cost analysis, as seen in Table 3-18, yields an NPV of –$29.1 million and a cost-effectiveness of –$7, based on the cumulative emission reductions of 3.96 $MMtCO_2e$.

Table 3-18. 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 (2006$MM)	Cost Effectiveness ($/MtCO2e)
2010	$0.0	$0.0	$0.00	$0.0	$0.0	
2011	$0.0	$0.0	$0.00	$0.0	$0.0	
2012	$0.5	$0.4	$0.02	$0.9	$0.8	
2013	$0.1	-$0.1	$0.02	$0.1	$0.1	
2014	-$0.2	-$0.6	$0.01	-$0.8	-$0.6	
2015	-$0.6	-$1.1	$0.01	-$1.7	-$1.3	
2016	-$0.8	-$1.4	$0.01	-$2.2	-$1.7	
2017	-$1.0	-$1.8	$0.01	-$2.8	-$2.0	
2018	-$1.2	-$2.2	$0.00	-$3.4	-$2.3	
2019	-$1.4	-$2.6	$0.00	-$3.9	-$2.5	
2020	-$1.6	-$3.0	$0.00	-$4.5	-$2.8	
2021	-$1.8	-$3.4	-$0.01	-$5.1	-$3.0	
2022	-$2.0	-$3.8	-$0.01	-$5.7	-$3.2	
2023	-$2.2	-$4.2	-$0.01	-$6.3	-$3.4	
2024	-$2.4	-$4.6	-$0.01	-$7.0	-$3.5	
2025	-$2.6	-$5.0	-$0.02	-$7.6	-$3.7	
Totals	**-$17.1**	**-$33.1**	**$0.02**	**-$50.2**	**-$29.1**	**-$7**

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

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 Alaska 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 (2010-2025). 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 controlled and uncontrolled landfills).

Key Uncertainties

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

Additional Benefits and Costs

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

Feasibility Issues

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

Status of Group Approval

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

Level of Group Support

TBD **–** [blank until CCMAG meeting #5]

Barriers to Consensus

TBD **–** [blank until final vote by the CCMAG]