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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$)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2020	2025	Total 2010–2025			
FAW-1	Forest Management Strategies for Carbon Sequestration							
	A. Coastal Management Pre-Commercial Thinning	Included under FAW-2						Pending
	B. Boreal Forest Mechanical Fuels Treatment	Included under FAW-2						Pending
	C. Community Wildfire Protection Plans	Included under FAW-2						Pending
	D. Boreal Forest Reforestation	0.09	0.12	0.15	1.6	$150	$92	Pending
FAW-2	Expanded Use of Biomass Feedstocks for Energy Production							
	A. Biomass Feedstocks to Offset Heating Oil Use	0.01	0.03	0.04	0.3	$17	$55	Pending
	B. Biomass Feedstocks for Electricity Use	0.07	0.12	0.18	1.5	$59	$38	Pending
	C. Biomass Feedstocks to Offset Fossil Transportation Fuels	0.03	0.06	0.09	0.8	$41	$52	Pending
FAW-3	Advanced Waste Reduction and Recycling	0.27	0.45	0.65	5.3	-$43	-$8	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.

Biomass Resource Supply and Demand Assessment

This section provides a preliminary assessment of biomass availability in Alaska (AK). These estimates were taken from readily-available sources or updates from the technical work group. The source for each value indicated is provided in the notes section. Information on biomass availability is needed to assess the viability of the goals for policy option FAW-2, as well as any biomass related options considered in other TWGs (e.g., Energy Supply and Demand (ESD) and Transportation and Land Use (TLU)).

An assessment of biomass resources available to meet the feedstock requirements of the CCMAG policies is presented in Table 1 below. Except for the final four entries, the table presents a total potential availability of biomass in dry tons based on business as usual (BAU) in AK across the forestry, agriculture, and waste management sectors. The final four entries represent the values resulting from full implementation of FAW-1 and FAW-3, as mentioned in the notes column. 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).

Location and distance issues are paramount in assessing the feasibility of biomass as a resource. Because of this, it is impossible to accurately express all of the cost inputs involved in assessing delivered biomass cost/ton in a single number. The assumption was made that biomass could be delivered within a 180 mile radius. If this is not possible, delivery costs will be higher. A more detailed, community-based biomass assessment would be more effective at determining both biomass availability and biomass costs. This information would allow for location specific analysis to be possible, and provide an additional level of accuracy. This could be an effort to pursue in the future to expand Alaska's biomass utilization.

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

Biomass Resource	Annual Biomass Supply (dry tons)	Delivered Cost[1] ($2005/dry ton)	Notes

[1] Delivered cost expressed in units of $/dry ton. However, the FAW TWG reports that deliveries of biomass may sometime provide green tons, albeit at the price quoted for dry tons. Although this uncertainty exists, the delivered cost for dry tons is assumed to be correct, for the purpose of this analysis.

Biomass Resource	Annual Biomass Supply (dry tons)	Delivered Cost[1] ($2005/dry ton)	Notes
Logging Residue	669,502	$100	Biomass supply based on 2005 NREL Report.[2] Derived from the USDA Forest Service's Timber Product Output database for 2002. Delivered cost from a 2000 TSS study on ethanol feedstock production in southeast AK (estimated range is $80-$100).[3] Cost estimate likely only valid in SE Alaska. Converted from tonnes to short tons. Delivered costs are variable and may change significantly due to location and available transportation infrastructure.
Primary Mill Residue (Unused)	118,841	$13 (low) $30 (high)	2005 NREL Report. Derived from the USDA Forest Service's Timber Product Output database for 2002, includes mill residues burned as waste or landfilled. This value agrees well with an estimate of 100,000-150,000 BDT provided in the TSS ethanol feedstock report cited above. Cost based on TSS estimate assuming transport by barge to end user within a ~180 mile radius of Klawock. High estimate is based on end use at a distant end user adding another 200 miles to the radius (e.g. Juneau). R. Harris of the FAW TWG provided a 2008 estimate for 5 SE Alaska mills of ~53,000 BDT.[4] Converted from tonnes to short tons.
Secondary Mill Residue	1,814	$13 (low) $30 (high)	2005 NREL Report. Derived from data on the number of businesses 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. Same cost source and assumptions as above. Converted from tonnes to short tons.

[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.

[3] *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan*, Final Report, TSS Consultants, June 20, 2000, http://www.p2pays.org/ref/40/39064.pdf.

[4] R. Harris, Sealaska, FAW TWG, personal communication with S. Roe, CCS, November 2008.

Biomass Resource	Annual Biomass Supply (dry tons)	Delivered Cost[1] ($2005/dry ton)	Notes
Urban Wood Waste	58,967	$36	2005 NREL Report. Includes utility tree trimming and/or private tree companies and construction/demolition wood.[5] Based on information compiled by DOE EIA.[6] Assumes a cost of $12/wet ton for collection and processing (at 50% moisture) and $12/dry ton for transport to a local end user (50 mile radius). Converted from tonnes to short tons.
Coastal Forest: Pre-Commercial Thinning Residue	84,700	$117	Assumes full implementation of FAW-1 Element A. Costs include thinning plus collection and delivery.
Boreal Forest: Mechanical Fuel Reduction	11,500	$105	Assumes full implementation of FAW-1 Element B. 40-mile distance to end user.
Boreal Forest Community Wildfire Reduction Plans	58,000	$105	Assumes full implementation of FAW-1 Element C. 40-mile distance to end user. New community plans would need to begin after 2025 to maintain this level of biomass removal.
Municipal Solid Waste (MSW) Fiber	296,643	$36	Total biomass supply for the year 2025, assuming full implementation of FAW-3. Without implementation of FAW-3, the total biomass supply would be 383,938 dry tonsSame cost source/assumptions as above for urban wood waste.
Yard and Landscape Waste Debris	7,570	$36	Total biomass supply for the year 2025, assuming full implementation of FAW-3. Without implementation of FAW-3, the total biomass supply would be 119,217 dry tonsSame cost source/assumptions as above for urban wood waste.
Total Annual Biomass Supply	**1,307,538**		
Total Annual Biomass Supply Available at <40$/ton	**483,835**		
Total Annual Biomass Supply Available at <100$/ton	**1,153,337**		

BDT – bone dry ton

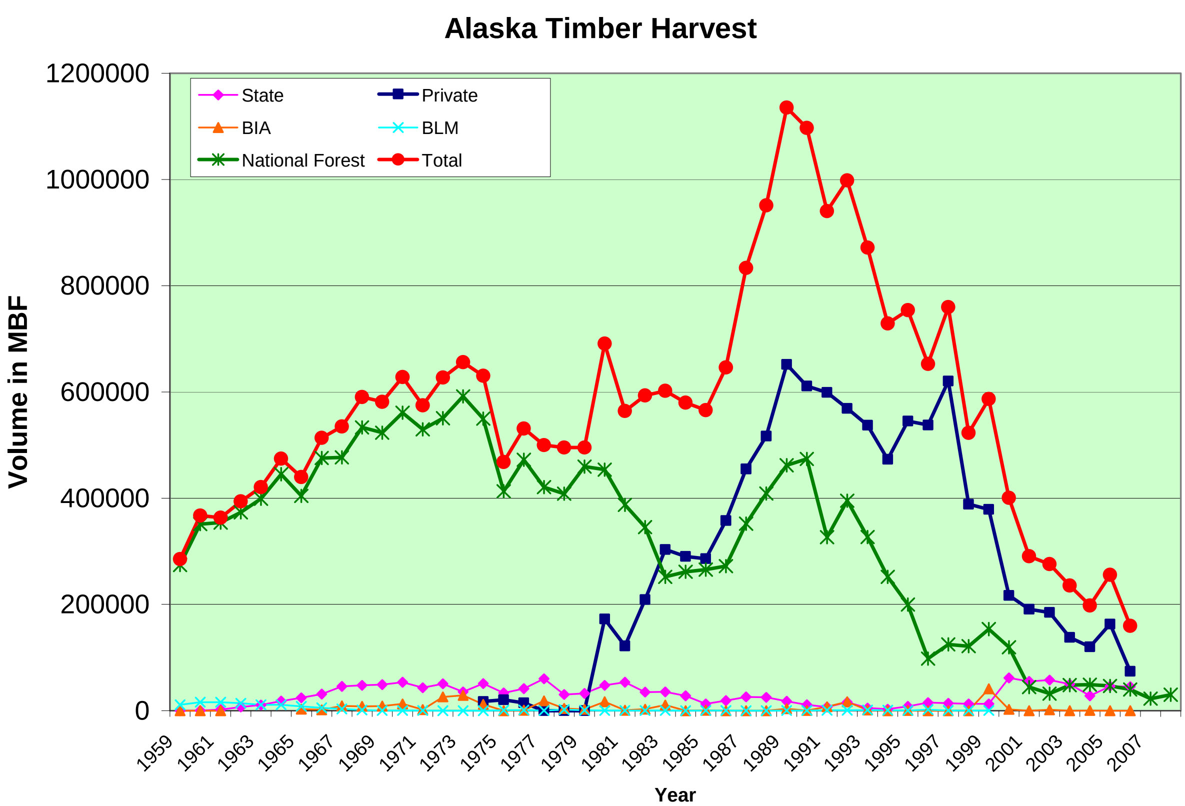
[5] CCS reviewed methodology used in the 2005 NREL Report to estimate urban wood waste biomass availability. For the state of Alaska, NREL's data source for the MSW wood component of urban wood waste did not provide the necessary source data to make the calculations used by NREL to estimate biomass availability from MSW wood waste. Therefore, CCS assumed that the urban wood waste component of NREL's biomass availability study does not include MSW wood waste for the state of Alaska.

[6] US Department of Energy, Energy Information Administration, *Biomass for Electricity Generation*, http://www.eia.doe.gov/oiaf/analysispaper/biomass/, accessed 2/18/2009.

Table 2. 2025 Annual Biomass Demand from CCMAG Recommendations

Biomass Requirement	2025 Annual Biomass Demand (dry tons)	Notes
FAW-2. Element A. Biomass Heating	192,000	See FAW-2 Quantification.
FAW-2. Element B: Biomass for Electricity Production	201,000	See FAW-2 Quantification.
FAW-2. Element C: Biomass for Liquid Fuels Production	125,000	See FAW-2 Quantification.
ESD TWG Biomass Needs	TBD	
TLU Biomass Needs	TBD	
Total	**TBD**	

The Alaska Timber Harvest is outlined in the table below. As can be seen, the total timber harvest has declined significantly since the mid-1980s. It is possible that our supply estimates for the logging industry (logging residue, primary/secondary mill residue) are unreasonably high, because most of the figures used in this analysis are mostly from 2002. However, the majority of the harvest reduction has already taken place by 2001. Thus, while choosing any single year to represent overall timber harvest is difficult, 2002 may be a reasonable choice for a representative year.



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 durable wood products produced from managed forests. Durable wood products produced as part of the timber harvest can serve to effectively sequester carbon for extended periods. Examples of management practices could be:
    - Extended rotations;
    - Pre-commercial thinning (PCT)[7] or commercial thinning (CT)[8] of young growth stands of timber;
    - Fertilization treatments; and
    - Other silvicultural treatments that would meet the intent of the policy option.
- Another concept to consider is the lower energy intensity of wood product manufacture when compared to other building products. Wood substitution prevents GHG emissions because it is typically less carbon intensive in production compared with wood substitutes.

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.

[7] PCT is the removal of trees not for immediate financial return but to reduce the stocking to concentrate growth on the more desirable trees. PCT is generally done between the ages of 15-25 years in southeast AK, with the ages being lower in the more productive southern half of the forest.

[8] CT is any type of thinning producing merchantable material at least equal to the value of the direct costs of harvesting. The age range for conducting CT on highly productive lands is considered 55-60 years.

- 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: Direct the maximum economically feasible biomass from the following policy elements to energy use (the TWG does not believe that a significant amount of biomass from these elements could be directed to durable wood products). The goal levels listed below include business as usual levels of action which are described under "Other" below.

Element A. 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

Element B. Boreal Forest Mechanical Fuels Treatment Projects[9]:
- By 2010, treat 1,000 acres annually across all ownerships
- By 2020, treat 2,000 acres annually
- By 2025, treat 2,500 acres annually

Element C. Community Wildfire Protection Plans:
- By 2010, complete 15 plans
- By 2015, complete 25 additional plans
- By 2025, complete 35 additional plans

Element D. Boreal Forest Reforestation after fire or insect and disease mortality:
- By 2010, reforest 5% of high site class lands[10]
- By 2015, reforest 15% of high site class lands
- By 2025, reforest 25% of high site class lands

Timing: As specified in the goals above.

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, National Park Service, US Bureau of Land Management.

[9] The FAW TWG notes that if fire use and prescribed fire treatments are included, the goals could be increased significantly; however, the overall carbon management benefits of these treatments are very difficult to quantify.

[10] White spruce 65 feet at a 100 year base and Birch and Aspen 45 feet at a 50 year base, D. Hanson, Division of Forestry personal communication".

Other: Forest thinning in the coastal Tongass National Forest by the USFS in the 1990-2000 time-frame was around 4,200 acres per year and that thinning by Sealaska was around 4,000 acres/yr.[11] No additional information was identified on thinning levels on other public lands or private lands in the coastal forest.

AK DNR indicates that about 535 acres per year of boreal forest have been mechanically on average since 2005.[12] Treatment typically consists of shear-blading flammable black spruce stands during winter and windrow burning of the biomass during the following fall.

Implementation Mechanisms

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 Emergency Fire Fighting (EFF)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 element.

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, when in practice much of the CO2 in harvested timber is stored in durable forest products that have service lives over decades.

Other needs: ?

Related Policies/Programs in Place

None identified.

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[11] *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan*, Final Report, TSS Consultants, June 20, 2000.

[12] D. Hanson, AK DNR, Division of Forestry, personal communication with S. Roe, CCS, 2/18/2009.

Types(s) of GHG Reductions

Enhanced forest management, including reforestation, has the potential to increase levels of carbon sequestration, thereby increasing the CO_2 removed annually by Alaska's forests. Forest management that includes wildfire hazard reduction lowers the potential for catastrophic wildfires, thereby protecting existing carbon stocks and sequestration levels. Biomass removed from the forest that is put to use as an energy source can offset GHG emissions from fossil fuel combustion. Biomass removed from the forest and used to produce durable wood products can sequester carbon over decades.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2020, 2025 (MMtCO$_2$e):

Element A: Captured under FAW-2 and biomass utilization options in other sectors (dry tons produced are provided in the Biomass Supply and Demand Assessment at the front of this appendix).

The suggestion was made to incorporate the reductions shown in Table 1-3 under FAW this option, and that the capture under FAW-2 that this may not be viable because of the implementation items listed. (Economics and feasibility of removing the biomass without unacceptable residual damage to the stand.

Element B: Captured under FAW-2 and biomass utilization options in other sectors (dry tons produced are provided in the Biomass Supply and Demand Assessment at the front of this appendix).

Element C: Captured under FAW-2 and biomass utilization options in other sectors (dry tons produced are provided in the Biomass Supply and Demand Assessment at the front of this appendix).

Element D: 0.09, 0.12, 0.15, respectively.

Net Cost per tCO$_2$e:

Element A: not applicable (delivered biomass cost per ton provided in Biomass Supply and Demand Assessment at the front of this appendix).

Element B: not applicable (delivered biomass cost per ton provided in Biomass Supply and Demand Assessment at the front of this appendix).

Element C: not applicable (delivered biomass cost per ton provided in Biomass Supply and Demand Assessment at the front of this appendix).

Element D: $92.

Data Sources: Data sources are specified or footnoted in the Quantification Methods section.

Quantification Methods: The GHG reductions and costs for each element of FAW-1 are provided below.

Element A. Coastal Forest Carbon Management – Silviculture Pre-Commercial Thinning (PCT) and Commercial Thinning (CT)

There are two GHG-related benefits for this element. The first comes from the beneficial re-use of silviculture removals as an energy source, which would offset fossil-based energy use. The second relates to the additional timber that would be available for use in durable wood products as a result of the PCT activity. Information from the TWG indicates that there would be additional timber suitable for carbon durable products available following a 70-yr rotation as compared to a BAU scenario where no silviculture is performed. Each of these benefits is addressed separately below. For the second benefit, the annual GHG benefit (additional CO_2 sequestered for future timber harvest) is not included in the summary of benefits above, since these reductions will only be realized at the time of harvest (70 years or more into the future).

Business As Usual (BAU). Business as usual (BAU) for the coastal temperate rainforest of Southeast Alaska was defined by the two 50 year long-term timber contracts between the Tongass National Forest (TNF) and the two pulp companies in the late 1950's and early 1960's. BAU evolved into a treatment of even aged regeneration harvest, i.e. clear cutting, with no subsequent silviculture treatments. This model is designed to produce fiber for pulp production in the most cost effective manner. Natural regeneration stocking following this harvest is typically thousands of trees per acre, and the TNF in accordance with national forest policy established rotation age[13] at approximately 90 years in accordance with the National Forest Management Act requirements that harvest not occur prior to the culmination of mean annual increment (CMAI)[14]. The Alaska Native Claims Settlement Act (ANCSA) was passed in 1971 and authorized formation of Alaska Native Corporations (ANC). Southeast Alaska ANC began receiving entitled ANCSA lands in the 1980s and soon thereafter commenced timber harvest operations. Even aged regeneration harvest was practiced exclusively on these lands until the 1990's and the BAU model did not prescribe any subsequent silviculture. But rotation age for these lands was not constrained by CMAI and was driven by the economic rotation. Under this circumstance rotation age is shorter, approximately age 50.

Re-Use of Silviculture Removals for Energy. Silviculture removals are divided between biomass from PCT and biomass from CT due to differential costs and practical and technical constraints associated with recovery of this material and different outcomes.

Precommercial Thinning. For PCT the estimated theoretical biomass removed in 2025 through implementation of this policy was noted on Table 1 at the front of this appendix. For use in policy options that require biomass, including FAW-2, the TWG assumes that the biomass would only be available at an extraordinarily high cost.. The policy design calls for 4,000 acres of PCT in 2010; 8,000-10,000 acres annually by 2015; and then maintaining 6,000 acres of PCT annually from 2025 onward. It is assumed that these goals are incremental to any BAU PCT

[13] Rotation Age is the time it takes to grow the next crop of trees in other words the time between the first harvest and the next harvest.

[14] Culmination of Mean Annual Increment is the age at whichs the rate of growth among a stand of trees peaks and after which annual growth remains level or declines.

activity in the coastal forest. Table 1-1 provides a summary of coastal forest inventory data from the US Forest Service.[15]

Removal of PCT biomass may not be prudent because of damage done to and the resultant condition stand after such removal due to the huge amount of PCT slash and further it may not be cost effective due to the extraordinarily high cost of removal.

Table 1-2 provides estimates of the amount of biomass removed as a result of the policy using two different estimates of biomass removal. The first uses the summary data from Table 1-1. The biomass density of PCT removals is assumed to include all above-ground (AG) biomass in live trees between 1 and 5 inch diameter plus all AG dead tree biomass. The sum of these is around 1.6 dry tons/acre. The second estimate comes from the TSS biomass feedstock report,[16] which referenced a removal rate of 25 dry tons/acre for PCT on second growth coastal forests. Given the order of magnitude difference in these two estimates, a mid-point estimate is also shown in Table 1-2 (roughly 85,000 dry tons/yr in 2025).

The delivered cost per dry ton was estimated to be $122 by 2025. The sources for cost information are cited at the bottom of Table 1-2. The overall estimate assumes a treatment cost of $417/acre and a collection/processing/delivery cost of $90/dry ton (it is unclear from the report what the delivery radius would be; however, it is probably safe to assume that it would be <100 miles to the end user). The thinning costs were escalated using growth in the annual Producer Price Index estimates for the logging industry from 2002 to 2007 (about 1.2%/year). For collection, processing, and delivery the estimates were not escalated for future years due to the uncertainties in future fuel costs, labor costs, and potential change due to technology advancement or economies of scale.

Incremental Timber Production. PCT offers the potential for GHG benefits by sequestering more carbon over a shorter period of time into more merchantable timber capable of producing carbon durable forest products. When that timber is turned into durable wood products (e.g., lumber, furniture), the carbon is sequestered for periods of decades or longer. Sealaska provided results from a modeling study of timber production on second growth lands,[17] which showed that a managed site using PCT following a 70-yr rotation would yield 39,000 board-ft/acre of harvestable timber while an unmanaged stand after a 90-year rotation would yield 27,000 board-ft/acre. Therefore, the incremental timber production for managed stands would be 257 board-ft/acre-yr. Using this incremental production estimate and an assumed density of 7 dry tons/thousand board feet, the estimates shown in Table 1-3 were derived. As shown in this table, about 0.37 $MMtCO_2$ would be sequestered in merchantable timber that would likely have been sequestered in non-merchantable timber in an unmanaged stand (and presumably lost to decomposition following future harvest).

Commercial Thinning. The practice of commercial thinning will produce carbon durable forest products and biomass capable of producing a wood waste alternate fuel product or energy. Revenue from the sale of commercial products is used to offset, or help offset, treatment costs,

[15] http://www.fs.fed.us/pnw/fia/local-resources/pdf/tables/AK_table1-9.pdf. Tables dated 08/10/2007, representing 2006 Forest Inventory & Analysis data.

[16] *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan*, Final Report, TSS Consultants, June 20, 2000.

[17] Southeast Alaska Wood Energy, presentation, R. Harris, Sealaska, provided to S. Roe, CCS, November 2008.

and there will be more merchantable timber capable of producing carbon durable forest products at rotation harvest. This treatment has the potential of lengthening rotation age as well.

Table 1-1. AK Coastal Forest Statistics

Forest Type Group	Ownership Class	Area (10^3 Acres)	Total AG Tree Biomass (dry tons)	Total AG Tree Density (dry ton/acre)	Total AG Live 1-5 Inch Trees (dry tons)	1-5 Inch Density (dry tons/acre)	Total AG Dead Trees (dry tons)	Dead Tree Density (dry tons/acre)
Softwood	All	13,557	700,932,159	51.70	19,641,041	0.66	2,913,848	0.21
Softwood	Public	12,402	620,421,874	50.03	15,661,532	0.57	2,565,780	0.21
Softwood	Private	1,155	80,510,285	69.71	3,979,509	1.56	348,068	0.30
Hardwood	All	1,207	16,796,604	13.92	1,352,303	0.51	53,029	0.04
Hardwood	Public	936	11,876,530	12.69	1,062,254	0.51	-	-
Hardwood	Private	271	4,920,074	18.16	290,049	0.49	53,029	0.20
All	**All**	**14,764**	**717,728,763**	**48.61**	**20,993,344**	**1.42**	**2,966,877**	**0.20**

Notes: AG = above ground.

Table 1-2. Theoretical Coastal PCT Removals and Delivered Costs

Year	Acres Thinned	Biomass: Low Estimate (dry tons)	Biomass: High Estimate[a] (dry tons)	Biomass: Mid-Point (dry tons)	Thinning Costs[b] ($2005)	Collection, Processing & Delivery Costs[c] ($2005)	Total Costs ($/ton delivered)
2010	4,000	6,492	100,000	56,492	1,571,196	5,038,842	117
2011	4,000	6,492	100,000	56,492	1,590,230	5,038,842	117
2012	5,000	8,114	125,000	70,614	2,011,579	6,298,553	118
2013	6,000	9,737	150,000	84,737	2,442,444	7,558,263	118
2014	7,000	11,360	175,000	98,860	2,882,827	8,817,974	118
2015	8,000	12,983	200,000	112,983	3,332,726	10,077,685	119
2016	8,000	12,983	200,000	112,983	3,370,792	10,077,685	119
2017	8,000	12,983	200,000	112,983	3,408,859	10,077,685	119
2018	9,000	14,606	225,000	127,106	3,877,791	11,337,395	120
2019	9,000	14,606	225,000	127,106	3,920,616	11,337,395	120
2020	10,000	16,229	250,000	141,229	4,403,823	12,597,106	120
2021	10,000	16,229	250,000	141,229	4,451,406	12,597,106	121
2022	9,000	14,606	225,000	127,106	4,049,090	11,337,395	121
2023	8,000	12,983	200,000	112,983	3,637,258	10,077,685	121
2024	7,000	11,360	175,000	98,860	3,215,909	8,817,974	122

Year	Acres Thinned	Biomass: Low Estimate (dry tons)	Biomass: High Estimate[a] (dry tons)	Biomass: Mid-Point (dry tons)	Thinning Costs[b] ($2005)	Collection, Processing & Delivery Costs[c] ($2005)	Total Costs ($/ton delivered)
2025	6,000	9,737	150,000	84,737	2,785,043	7,558,263	122
Totals	**118,000**	**191,500**	**2,950,000**	**1,666,500**	**50,951,588**	**148,645,849**	**120**

[a] *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan*, Final Report, TSS Consultants, June 20, 2000. Estimate of 25 BDT/acre for second growth forest thinning.
[b] AK DNR, State of Alaska Capital Project Summary, Governor's FY04 Capital Budget, Improve Forest Productivity in Southern Alaska, March 4, 2003.
[c] *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan*, Final Report, TSS Consultants, June 20, 2000. Estimate of $80-$100 BDT logging residue collected and delivered to a proposed ethanol plant in southeast Alaska.

Table 1-3. Coastal PCT Removals under Policy Goals and Delivered Biomass Costs

Year	Acres Thinned	Incremental Timber for DWP Accumulated (tons)	Incremental Carbon Accumulated (tCO_2)	Thinning Costs ($)	Discounted Thinning Costs ($2005)
2010	4,000	-	-	1,571,196	1,571,196
2011	4,000	7,200	13,200	1,590,230	1,514,504
2012	5,000	14,400	26,400	2,011,579	1,824,561
2013	6,000	23,400	42,900	2,442,444	2,109,875
2014	7,000	34,200	62,700	2,882,827	2,371,709
2015	8,000	46,800	85,800	3,332,726	2,611,278
2016	8,000	61,200	112,200	3,370,792	2,515,337
2017	8,000	75,600	138,600	3,408,859	2,422,612
2018	9,000	90,000	165,000	3,877,791	2,624,641
2019	9,000	106,200	194,700	3,920,616	2,527,264
2020	10,000	122,400	224,400	4,403,823	2,703,565
2021	10,000	140,400	257,400	4,451,406	2,602,645
2022	9,000	158,400	290,400	4,049,090	2,254,685
2023	8,000	174,600	320,100	3,637,258	1,928,916
2024	7,000	189,000	346,500	3,215,909	1,624,253
2025	6,000	201,600	369,600	2,785,043	1,339,653
Totals	**118,000**	**1,445,400**	**2,649,900**	**50,951,588**	**34,546,695**

Using the same assumed costs for PCT described above ($417/acre) escalated with historic PPI data for 2002-2007, the estimated annual thinning costs are shown in Table 1-3. Using the total accumulated carbon (2.65 $MMtCO_2$) and the total discounted costs (34 million $2005) yields a cost effectiveness estimate of $13/ton. Note that these cost estimates do not include the additional future value of the incremental timber yield. Cost of PCT does not address the cost of recovery of PCT material for biomass production which is addressed in FAW 2.

Two diagrams below illustrate the issues of increased carbon sequestration in managed and unmanaged forests in Alaska[18]. Figure 1-1 shows an area of land which had been clear-cut 90 years ago, and that has not been managed in the intervening years. Figure 1-2 shows land that was harvested 85 years ago, and that has been managed for the past 70 years. The managed stand has significantly higher usable wood (39 MBF/acre compared with 27) in spite of having 5 fewer years in which to grow.

Unfortunately, the correlation between usable board feet and carbon is not perfect, because a smaller number of large trees could possibly have a higher level of usable wood in spite of lower levels of carbon content.

[18] The two diagrams come from personal communication with Rick Rogers to Steve Roe, Nov. 2008.

Figure 1-1. Unmanaged stand, 90 years after harvest. 27 MBF/acre

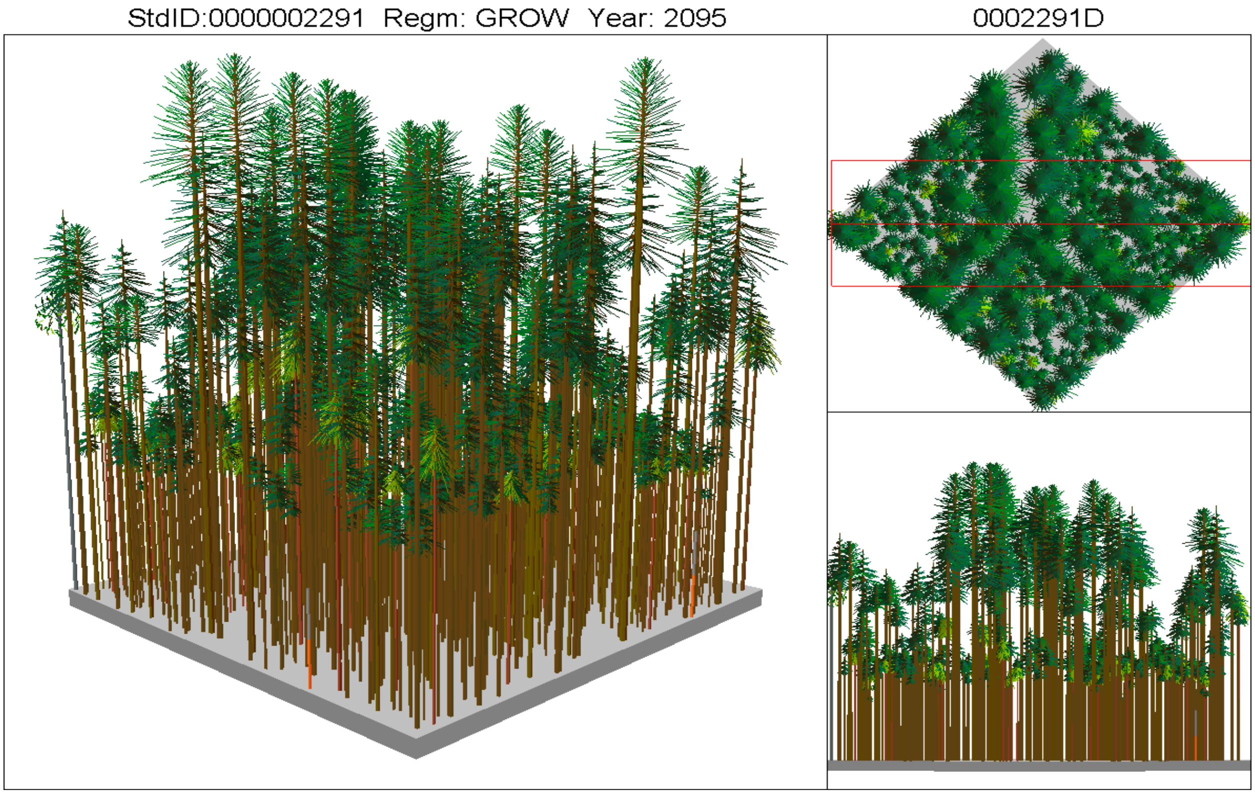
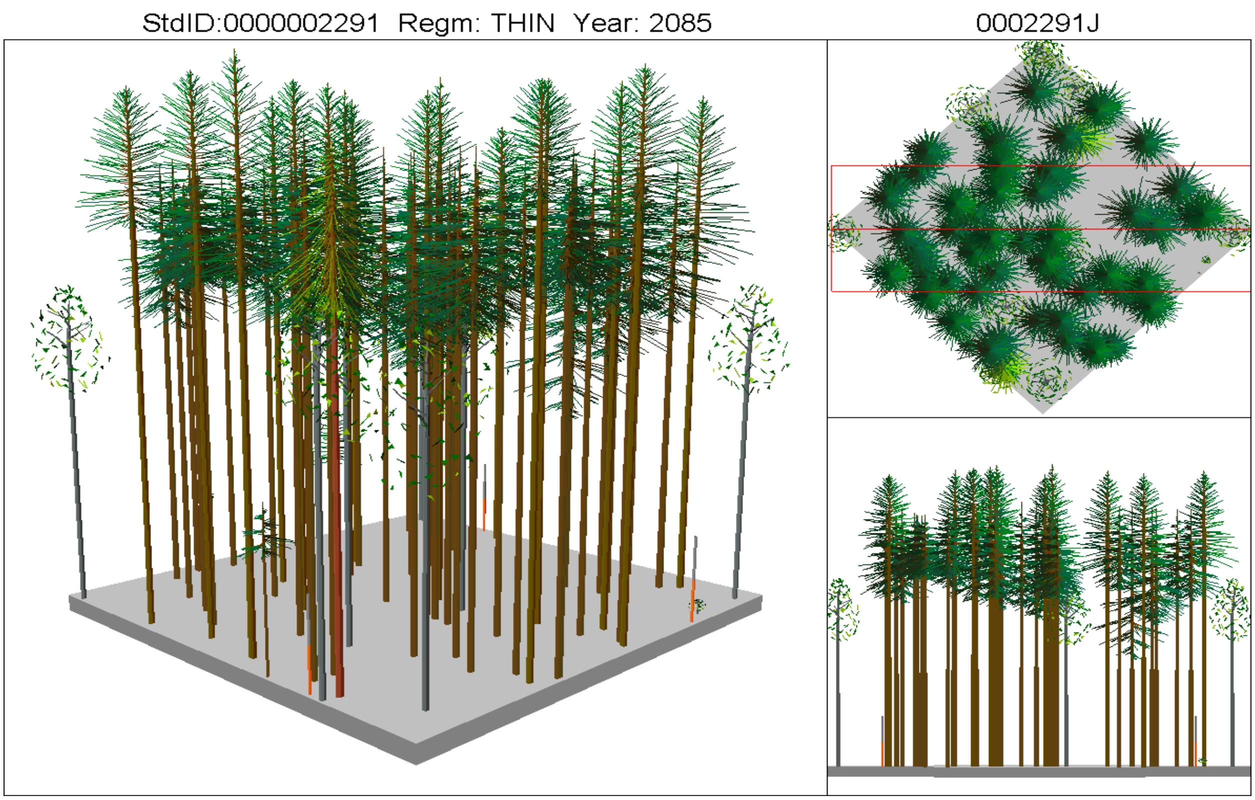


Figure 1-2. Managed stand, 85 years after harvest. 39 MBF/acre



Element B. Boreal Forest Mechanical Fuels Treatment

The quantifiable GHG benefits associated with this element are tied to the use of biomass removed during fuel treatments as an energy source, thereby reducing fossil fuel use and associated GHG emissions. Fuel treatments also lower the potential for catastrophic wildfires ("stand-replacement fires") and potentially structure fires, thereby lowering the potential for large losses in carbon stocks and future sequestration potential. This latter benefit is potentially much larger than the biomass energy benefit; however, information is not available to conduct a defensible quantification of the benefit.

Table 1-4 below provides the estimated dry tons of biomass removed from boreal forest treatments per the policy goals. Estimates of biomass density were taken from a recent Division of Forestry analysis of mechanical fuel treatments in the Fairbanks area.[19] A 75% biomass recovery factor is assumed. The estimated biomass removed in 2025 (~11,500 dry tons) was included in the Biomass Supply and Demand assessment at the front of this appendix (see Table 1).

The delivered costs of biomass were also taken from the same AK DOF study of the Fairbanks area. That study estimated a delivered cost of chipped green biomass of ~52/ton. This value assumes a transportation distance of 40 miles to the end user. Assuming a 50% moisture content and using the historic PPI data for the logging industry, a cost of $105/dry ton delivered (2005$) was estimated. This value was included in Table 1 of the Biomass Supply and Demand Assessment.

Table 1-4. Boreal Forest Treatments and Biomass Recovered

Year	Acres Treated	Biomass Density[a] (dry tons/acre)	Biomass Recovery Factor	Biomass Recovered (dry tons/yr)
2010	1,000	6.15	0.75	4,613
2011	1,100	6.15	0.75	5,074
2012	1,200	6.15	0.75	5,535
2013	1,300	6.15	0.75	5,996
2014	1,400	6.15	0.75	6,458
2015	1,500	6.15	0.75	6,919
2016	1,600	6.15	0.75	7,380
2017	1,700	6.15	0.75	7,841
2018	1,800	6.15	0.75	8,303
2019	1,900	6.15	0.75	8,764
2020	2,000	6.15	0.75	9,225
2021	2,100	6.15	0.75	9,686
2022	2,200	6.15	0.75	10,148
2023	2,300	6.15	0.75	10,609
2024	2,400	6.15	0.75	11,070
2025	2,500	6.15	0.75	11,531

[19] *Analysis of Wood Volume Available from Hazard Fuel Reduction Projects and Development of Wood Residue Markets in the Fairbanks Area, State of Alaska*, Department of Natural Resources, Division of Forestry, 2007.

Year	Acres Treated	Biomass Density[a] (dry tons/acre)	Biomass Recovery Factor	Biomass Recovered (dry tons/yr)
Total	**28,000**			**129,150**

[a] *Analysis of Wood Volume Available from Hazard Fuel Reduction Projects and Development of Wood Residue Markets in the Fairbanks Area, State of Alaska*, Department of Natural Resources, Division of Forestry, 2007. Assumes 50% moisture content to convert from green to dry tons.

Element C. Community Wildfire Risk Reduction Plans

The quantifiable GHG benefits associated with this element are similar to those of Element B: use of biomass removed during fuel treatments as an energy source; and lower potential for catastrophic wildfires ("stand-replacement fires") and structure fires. As with Element B, the latter benefit is potentially much larger than the biomass energy benefit; however, information is not available to conduct a defensible quantification of the benefit in terms of avoided CO_2 emissions and avoided loss of carbon sequestration potential. Therefore, a similar approach was taken to develop an estimate of the amount of biomass that would be available as a result of fuel treatments that would result from implementation of these plans. The primary assumption was that the fuel treatments would be mechanical treatments, not prescribed fire.

Table 1-5 provides a summary of biomass removed annually and available for energy use based on implementation of the policy goals. The number of acres to be treated annually was based on the levels of treatment conducted for the Fairbanks area from the report cited above and discussions with AK DOF.[20] In the Fairbanks area, wildfire risk reduction calls for about 1,500 acres/yr to be treated. To estimate the treatment area needed for the average size community addressed by this policy, CCS assumed that the average community was one-third the size of Fairbanks. This would mean that 500 acres should be treated annually in each of the plan areas. It was further assumed that treatments would be needed for 15 years before all of the areas requiring fuel reduction were treated.

As shown in Table 1-5, similar assumptions were made for biomass density and recovery as were used for the analysis under Element B above. The estimated removals for 2017 through 2025 (~58,000 dry tons/yr) were used as input to the Biomass Supply and Demand Assessment at the front of this appendix (see Table 1). The same delivered cost as described under Element B is assumed for this option ($105/dry ton in 2005$).

Table 1-5. Boreal Forest Treatments and Biomass Recovered

Year	Acres Treated	Biomass Density[a] (dry tons/acre)	Biomass Recovery Factor	Biomass Available (dry tons/yr)
2010	0	6.15	0.75	0
2011	7,500	6.15	0.75	34,594
2012	7,500	6.15	0.75	34,594
2013	7,500	6.15	0.75	34,594

[20] D. Hanson, AK Division of Forestry, personal communication, S. Roe, CCS, January 2009.

2014	7,500	6.15	0.75	34,594
2015	7,500	6.15	0.75	34,594
2016	7,500	6.15	0.75	34,594
2017	12,500	6.15	0.75	57,656
2018	12,500	6.15	0.75	57,656
2019	12,500	6.15	0.75	57,656
2020	12,500	6.15	0.75	57,656
2021	12,500	6.15	0.75	57,656
2022	12,500	6.15	0.75	57,656
2023	12,500	6.15	0.75	57,656
2024	12,500	6.15	0.75	57,656
2025	12,500	6.15	0.75	57,656
Total	**157,500**			**726,469**

[a] *Analysis of Wood Volume Available from Hazard Fuel Reduction Projects and Development of Wood Residue Markets in the Fairbanks Area*, State of Alaska, Department of Natural Resources, Division of Forestry, 2007. Assumes 50% moisture content to convert from green to dry tons.

Element D. Boreal Forest Reforestation

The GHG benefits for this element are the difference in carbon sequestration levels under BAU (no reforestation of lands damaged by fire/pests) and sequestration levels following reforestation. The policy goals call for reforestation of 5% of high site class lands by 2010; 15% by 2015; and 25% by 2025. No information is currently available on the number of boreal forest acres that would be considered high site class. As a surrogate, CCS obtained 2004-2006 data on Alaska wildfire acres and the number of acres considered to be high burn severity.[21] The available data cover only 2004-2006 and show that, on average, high burn severity areas comprise 19% of the total burn area. From the AK GHG I&F, the average wildfire activity in the state during the 1994-2004 period was about 1.4 MM acres/yr. Hence, on average, about 260,000 acres of high severity burn areas are created in the state.

Through discussions between CCS and state foresters[22], there is a range of opinion regarding the way in which reforestation projects should be carried out. This range of opinion is driven by several factors. Historically, reforestation projects have been carried out to promote future timber harvests, using the species thought to have the most future value as a timber resource (e.g., white spruce). Given the rise in the occurrence, affected area, and severity of wildfires, state foresters appear to be rethinking the desirability of reforestation projects using species susceptible to fire (including white spruce). Secondly, from a carbon sequestration perspective, mixed hardwood forests may offer superior performance, especially during the early decades following re-planting.

Based on discussions with state foresters, following a wildfire, through natural succession, some areas will come back into mixed hardwood stands fairly quickly. In other cases, grasses will take over and may dominate the area for years or potentially decades. It is these areas that could

[21] Monitoring Trends in Burn Severity (MTBS) Program, USGS and USFS, http://mtbs.gov/index.html.

[22] J. Hermanns, AK DOF, Tok Area Forest, and A. Egren, AK DOF Delta Area Forest, personal communications with S. Roe, CCS, March 2009.

benefit the most from re-planting efforts and yield significant GHG reductions. Hence, the analysis below assumes that the reforestation projects will involve re-planting areas taken over by grasses with hardwood species.

Information on biomass accumulation in boreal hardwood stands is limited. CCS received an estimate of 30 cords/acre over 35 years from an AK DOF staff person for balsam poplar stands.[23] Using an assumed density of 26 lb/ft^3 (0% moisture) and a 50% carbon content for biomass, an annual carbon accumulation rate for balsam poplar stands would be 0.648 tC/acre-yr.

For the BAU scenario (grassland succession), an estimate of the above ground (AG) carbon accumulation was taken from the 2006 inventory guidelines from the Intergovernmental Panel on Climate Change (IPCC) Volume IV, Chapter 6.[24] The default peak AG biomass for grasslands in boreal ecosystems is 1.7 metric tons of biomass per hectare (dry mass basis). So over the same 35-year period, the new grassland would have accumulated 0.010 tC/acre-yr (assuming 50% carbon content of the biomass). The incremental carbon accumulation for a replanted boreal hardwood stand over a grassland would be 0.638 tC/acre-yr (0.648 - 0.010 tC/acre-yr).

The schedule for reforestation projects is based on the average number of high-severity burn areas created every year described above and the policy goals. For example, the schedule assumes that 5% of high severity burn areas created in 2009 would be replanted in 2010 and that 25% of the areas create in 2024 are replanted in 2025. Replanting cost estimates for hardwood species were not available, so estimates for replanting costs of white spruce are used as a surrogate ($321/acre).[25] Table 1-6 below provides a summary of the acres to be replanted, the incremental accumulated carbon, and the costs. The total discounted costs are divided by the total GHG reductions (CO_2) through 2025 to yield a cost effectiveness of $92/t$CO_2$.

Table 1-6. Boreal Reforestation GHG Benefits and Costs

Year	Acres Replanted	Incremental C Accumulated (tCO2)	Replanting Costs ($)	Discounted Planting Costs ($2005)
2010	13,152	30,757	4,320,745	4,320,745
2011	18,413	43,060	6,049,042	5,760,993
2012	23,674	55,363	7,777,340	7,054,277
2013	28,935	67,666	9,505,638	8,211,327
2014	34,196	79,969	11,233,936	9,242,187
2015	39,457	92,272	12,962,234	10,156,249
2016	42,087	98,424	13,826,382	10,317,459
2017	44,718	104,575	14,690,531	10,440,286
2018	47,348	110,727	15,554,680	10,528,020
2019	49,979	116,878	16,418,829	10,583,724
2020	52,609	123,030	17,282,978	10,610,249
2021	55,240	129,181	18,147,127	10,610,249

[23] J. Graham, AK DOF, personal communication with J. Hermanns, AK DOF, 3/03/2009.

[24] IPCC 2006, section 6.3.1.2, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf.

[25] D. Hanson, AK DOF, personal communication with S. Roe, CCS, March 2009.

2022	57,870	135,333	19,011,276	10,586,190
2023	60,501	141,484	19,875,425	10,540,362
2024	63,131	147,636	20,739,574	10,474,894
2025	65,761	153,787	21,603,723	10,391,760
Totals	**697,072**	**1,630,147**	**228,999,460**	**149,828,971**

Key Assumptions:

Element A- For the incremental reductions associated with PCT and subsequent higher levels of merchantable timber, it is assumed that the carbon lost due to PCT are replaced during a 70-year rotation by growth release of crop trees. It is also assumed that biomass densities are otherwise similar between managed and unmanaged stands, and that there has only been a shift of biomass from non-merchantable to merchantable stock as a result of PCT. The higher future value of timber on managed stands has not been factored into the costs. Carbon benefits due to removal of biomass as a result of PCT for conversion into wood waste alternate fuel or energy production are questionable by the TWG.

Element B- A continuous supply of biomass for energy from this element will depend on maintaining annual treatment levels at the 2025 level (2,500 acres/yr) in the post-2025 period. The cost assumption assumes end use within a 40-mile radius. Future improvements in mechanical treatment and biomass collection and processing technologies have the potential to significantly reduce the estimated costs.

Element C- Similar assumptions as cited above for Element B on continuous supplies of biomass and delivered costs. To maintain biomass supply in the post-2025 time-frame, new community plans would need to be developed and implemented with mechanical treatment prescriptions.

Element D- Reforestation projects carried out as a result of this policy are designed to displace burn areas likely to be taken over by grasses with hardwood species. Costs for hardwood replantings are similar to white spruce. The future value for the additional biomass sequestered is not included.

Key Uncertainties

Quantification of the cost per MMtCO2 does not consider the other benefits of the stand treatments. It is uncertain what the incremental cost effectiveness per ton is for these practices if incentives are provided. We do know most of these practices are being implemented irrespective of the sequestration or offset benefits. Private land owners however rely heavily on federal cost share or grant programs that face questionable future in terms of congressional appropriations. For example, even though landowners are thinning without received any benefit from MMtCO2 capture landowners may not be able to continue without outside revenue or federal funds. If the full cost is estimated at $13/ton, something less than this may increase the level of PCT and resulting carbon capture. While State and Federal land managers may not be in position to sell carbon credits, the existence of such a market will help demonstrate benefits and justify funding requests.

Difficulty in quantifying the reduced carbon emissions from catastrophic wildfires as a result of boreal forest mechanical fuel treatments.

Additional Benefits and Costs

Element A:

- Silviculture treatments, increased wood product output per acre and associated economic benefits (or conversely maintain forest product output on a smaller timberland footprint)
- Improved wildlife habitat (improved deer browse in silviculture treated stands)
- Provide employment opportunities in rural communities in SE
- Maintain and enhance overall forest health to promote stand and ecosystem resilience to changing climate and resulting insect, disease and other environmental stressors.

Element B:

- Reduction in catastrophic wildfire (difficult to quantify)
- Reduction in loss of life and property due to catastrophic wildfire near settlements
- Reduction in carbon emissions from loss of property and carbon emissions resulting from reconstruction or lost properties.
- Indirect wildlife benefits through management of stand structure and browse.

Element C

- Reduction in catastrophic wildfire (difficult to quantify)
- Reduction in loss of life and property due to catastrophic wildfire near settlements
- Reduction in carbon emissions from loss of property and carbon emissions resulting from reconstruction or lost properties.
- Indirect wildlife benefits through management of stand structure and various habitat benefits.

- Engages communities in a proactive manner to empower residents to actively participate and take responsibility for risk awareness and mitigation activities for wildland fire.

Element D

Social, economic and biologic benefits of reforestation, too many to list. State law recognizes these benefits by requiring reforestation after logging, fires and salvage being exceptions to reforestation requirements.

Feasibility Issues

- Location, location, location. The lack of infrastructure and distance to end users limits the feasibility of any of the elements on the location which effects both costs of the treatments, transportation of the fuel if applicable and additional benefits to justify the treatments.

- See prior comments re. feasibility issues with respect the PCT residue from coastal forests. Same issues apply to other residue types if no infrastructure or if distant to end users.

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 and municipal solid waste for generating heat/electricity and liquid/gaseous biofuels to displace the use of fossil energy sources. Foster the development of biomass to energy projects where they are compliant with environmental requirements (see Implementation Mechanisms below for examples of projects and actions needed).

Policy Design

Goals:

Element A: By 2025, utilize biomass feedstocks to offset 10% of the state's heating oil use in the commercial and residential sectors.

Element B: By 2025, utilize biomass feedstocks to produce 5% of the state's electricity.

Element C: 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 policy goal.

By 2025, achieve the full policy goals.

Parties Involved:

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

Alaska should foster the following, where they are compliant with environmental requirements:

- wood biomass alternative fuel products for 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);
- large and small scale technologies that generate heat and electricity (combined heat and power as well as cogeneration) 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.

Related Policies/Programs in Place

The TWG and state agencies can work with CCS to identify existing or planned programs that address issues raised in this option. In Governor Palin's 2009 State of the State address she enumerated the following goal: "[generate] 50 percent of our electric power with renewable sources. That's an unprecedented policy across the U.S, but we're the state that can do it with our abundant renewables, and with Alaskan ingenuity."[26]

Types(s) of GHG Reductions

CO_2, N_2O, CH_4: Displaces emissions from fossil fuel combustion in electricity and heat production, as well as transportation.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2020, 2025 ($MMtCO_2e$):

Element A: 0.08, 0.14, 0.20, respectively.

Element B: 0.03, 0.07, 0.11, respectively.

Element C: 0.03, 0.06, 0.09, respectively.

Net Cost per tCO_2e:

Element A: -$32

[26] Governor Palin, State of Alaska, state of the state address, 2009.

Element B: $38

Element C: TBD

Element A. Biomass for Heating

Small scale biomass heat generators are already being installed in public facilities Alaska, such as schools, etc. There is also the opportunity to see wide scale use of pellet fuels in remote residential applications and other wood combustion appliances. This technology generates heat with very low associated greenhouse gas emissions. Through combined heat and power (CHP), small scale generators can provide both electricity and heat, although using this technology on a small scale is more difficult and very location specific. Therefore, installation of more cost effective CHP technology only occurs after the year 2015 and on a more limited scale than the biomass heating units. The electricity generated through CHP goes towards the 5% state electricity goal, discussed further in Element B. The heating requirements for FAW-2 can be seen in Table 2-1.

Table 2-1 Heating needs to meet 10% biomass for heating goal

Year	Goal	Billion BTU replaced with biomass (Petroleum)	Billion BTUs needed, Total
2009	0.0%	0	0
2010	0.6%	28	28
2011	1.3%	56	56
2012	1.9%	85	85
2013	2.5%	113	113
2014	3.1%	141	141
2015	3.8%	171	171
2016	4.4%	201	201
2017	5.0%	232	232
2018	5.6%	264	264
2019	6.3%	296	296
2020	6.9%	321	321
2021	7.5%	346	346
2022	8.1%	371	371
2023	8.8%	394	394
2024	9.4%	417	417
2025	10.0%	442	442

To meet the 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 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. Heat-only generators would be used for the years 2010-2015, after which 50% of generators will be assumed to be heat-only and 50% will be assumed to be CHP units. These units will produce 443 MWh of electricity (all figures annual) as well as the previously stated 3,900 MMBTUs of useable heat[27]. The number of heating units was determined based on the number that would be required to meet Alaska's 10% goal. Ideally, these units will be located in more remote settings, where fossil fuel generators are used to produce both electricity and heat. The 442 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 $264,000 per unit. In the case of the CHP generators, additional costs for heat distribution will vary according to the circumstances of each project, but they are estimated to add 27% to the capital costs on average[28]. Thus, the capital costs of installation includes the cost of the infrastructure to deliver any heat generated. The biomass feedstocks required comes from the amount of biomass needed to keep the generators in operation. Table 2-2 outlines the costs of the small scale CHP units required in this option, assuming a cost of woody biomass to be 65$/delivered dry ton. The costs are also displayed for a cost of 120$/delivered dry ton. This is meant to provide a comparison of the cost effectiveness of this option, given the potentially large range of biomass costs that can occur in Alaska.

Table 2-2: Number and costs of small scale heating and CHP units required

Year	Total Units Installed	Total Heating Units Installed	Total CHP Units Installed	Capital Cost of Installation	Annual Fuel Requirements (dry tons biomass)	Cost of biomass feedstocks @ 65$/ dry ton (million$)	Cost of biomass feedstocks @ 120$/ dry ton (million$)
2009	0	0	0	$0	0	$0.0	$0.0
2010	7	7	0	$2.4	3,165	$0.2	$0.4
2011	14	14	0	$2.4	6,334	$0.4	$0.8
2012	22	22	0	$2.4	9,509	$0.6	$1.1
2013	29	29	0	$2.4	12,689	$0.8	$1.5
2014	36	36	0	$2.4	15,874	$1.0	$1.9
2015	43	43	0	$2.5	19,222	$1.2	$2.3
2016	51	47	4	$2.6	22,630	$1.5	$2.7
2017	59	51	8	$2.6	26,101	$1.7	$3.1
2018	67	55	12	$2.7	29,634	$1.9	$3.6
2019	75	59	16	$2.7	33,231	$2.2	$4.0
2020	82	63	19	$2.2	36,104	$2.3	$4.3
2021	88	66	22	$2.1	38,904	$2.5	$4.7
2022	94	69	25	$2.1	41,635	$2.7	$5.0
2023	100	72	28	$2.0	44,297	$2.9	$5.3

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

[28] http://www.toolbase.org/Technology-Inventory/Electrical-Electronics/combined-heat-power Based on the estimate that the heat distribution is typically 4K and the system costs are between 10 and 20K.

Year	Total Units Installed	Total Heating Units Installed	Total CHP Units Installed	Capital Cost of Installation	Annual Fuel Requirements (dry tons biomass)	Cost of biomass feedstocks @ 65$/ dry ton (million$)	Cost of biomass feedstocks @ 120$/ dry ton (million$)
2024	106	75	31	$2.0	46,894	$3.0	$5.6
2025	112	78	34	$2.1	49,688	$3.2	$6.0

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 come from multiplying the BTUs of biomass going into the generator by the emissions factor for biomass (0.002 tCO_2e/MMBTU). The electricity cost ($/kWh) comes from the Alaska Quantification Memo. However, the electricity costs from the Quantification Memo mostly reflect the larger Alaskan municipalities such as Anchorage and Fairbanks. In order to more accurately reflect the higher costs of electricity in more rural areas, where this CHP technology is intended to be deployed, the AEA report was used.[29] This gave a cost of 44.3 cents/kWh, significantly higher than the estimate for the state as a whole. This estimate was then tied to the statewide estimate to reflect slightly increasing prices between 2010 and 2025. See Table 2-3 for more details.

Table 2-3. Electricity produced and GHG savings from small scale heating and CHP

Year	Electricity Generated (MWh)	GHG Emissions from Biomass (tCO_2e)	GHG Emissions Savings Electricity (tCO_2e)	Electricity Emissions Factor (tCO_2e/MWh)	Electricity Cost ($/kWh)	Rural Electricity Cost ($/kWh)	Electricity Savings (million $)
2009	0	0	0	0.53	0.10	0.443	0
2010	0	97	0	0.54	0.10	0.443	0
2011	0	195	0	0.53	0.10	0.443	0
2012	0	292	0	0.53	0.10	0.443	0
2013	0	390	0	0.52	0.09	0.492	0
2014	0	488	0	0.51	0.09	0.492	0
2015	0	591	0	0.51	0.09	0.492	0
2016	1,672	696	834	0.50	0.09	0.492	1
2017	3,374	803	1,662	0.49	0.09	0.492	2
2018	5,107	912	2,482	0.49	0.09	0.492	3
2019	6,872	1,022	3,295	0.48	0.09	0.492	3
2020	8,281	1,111	3,919	0.47	0.09	0.492	4
2021	9,655	1,197	4,509	0.47	0.09	0.492	5
2022	10,994	1,281	5,068	0.46	0.09	0.492	5
2023	12,300	1,363	5,596	0.45	0.09	0.492	6

[29] Located at: http://www.akenergyauthority.org/alaska_energy.html Accessed 3/25/09. The analysis looked at the average of eight cities of various sizes. These cities were meant to represent a cross section of Alaska's rural areas, to represent the true cost of electricity in these areas. The cities included were: Bethel, Coffman Cove, Cordova, Dillingham, Haines, Kake, Tok and Unalaska.

2024	13,574	1,442	6,096	0.45	0.09	0.492	7
2025	14,944	1,528	6,625	0.44	0.09	0.492	7

The heat produced from combined heat and power is shown in Table 2-4 below. The GHG savings were calculated based on the assumption that diesel generators would be replaced with biomass CHP plants. 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).[30] This accounts for the difference seen between heat generated and heat delivered.

Table 2-4. Heat produced and GHG savings from small scale heating and CHP

Year	Heat Generated (Billion BTU)	Heat Delivered (Billion BTU)	Diesel Fuel Costs ($/MMBTU)	Diesel Fuel Savings – Heat (Million $)	GHG emissions saved Heat (tCO_2e)	Additional O&M Costs ($MM)
2009	0	0	$13.25	$0.00	0	0.0
2010	28	26	$12.65	$0.33	2,021	0.3
2011	56	52	$12.11	$0.63	4,046	0.5
2012	85	78	$11.33	$0.88	6,073	0.8
2013	113	104	$10.68	$1.11	8,104	1.1
2014	141	130	$10.41	$1.35	10,139	1.3
2015	171	157	$9.83	$1.55	12,277	1.6
2016	201	185	$9.42	$1.75	14,454	1.9
2017	232	214	$9.43	$2.02	16,671	2.2
2018	264	243	$9.57	$2.32	18,927	2.5
2019	296	272	$9.71	$2.64	21,225	2.8
2020	321	296	$9.81	$2.90	23,060	3.0
2021	346	319	$9.81	$3.13	24,848	3.2
2022	371	341	$9.81	$3.34	26,592	3.5
2023	394	363	$9.81	$3.56	28,293	3.7
2024	417	384	$9.81	$3.77	29,951	3.9
2025	442	407	$9.81	$3.99	31,736	4.1

The total costs and GHG benefits of small scale CHP is outlined in Table 2-5 below.

Table 2-5. Net costs and GHG savings from small-scale heating and CHP

Year	Discounted Net Costs (Assuming 65$/ton biomass) ($MM)	Discounted Net Costs (Assuming 120$/ton biomass) ($MM)	Net GHG Emissions Avoided ($MMtCO_2e$)

[30] 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	Discounted Net Costs (Assuming 65$/ton biomass) ($MM)	Discounted Net Costs (Assuming 120$/ton biomass) ($MM)	Net GHG Emissions Avoided ($MMtCO_2e$)
2009	0.0	0.0	0.00
2010	2.0	2.1	0.00
2011	2.0	2.3	0.00
2012	2.1	2.5	0.01
2013	2.2	2.6	0.01
2014	2.2	2.8	0.01
2015	2.4	3.0	0.01
2016	2.0	2.7	0.01
2017	1.6	2.4	0.02
2018	1.2	2.1	0.02
2019	0.8	1.7	0.02
2020	0.3	1.2	0.03
2021	0.0	1.0	0.03
2022	-0.2	0.8	0.03
2023	-0.4	0.6	0.03
2024	-0.6	0.4	0.03
2025	-0.7	0.3	0.04
Total	17	28	**0.3**

Element B. Biomass to Electricity

The goal was determined using baseline data from the Center for Climate Strategies (CCS) Inventory and Forecast.[31] 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 2-6.

Table 2-6. 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 (After CHP) (GWh)	Estimated biomass required (MMBTU) The assumed heat rate for biomass plant is 10,000 BTU/kWh
2009	6,504	0.0%	-	

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

Year	Total BAU Projected generation (GWh)	Policy Goal proportion of total in-state electricity generation (%)	Additional Biomass generation to meet policy goals (After CHP) (GWh)	Estimated biomass required (MMBTU) The assumed heat rate for biomass plant is 10,000 BTU/kWh
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%	159	1,589,369
2017	7,470	2.5%	183	1,833,855
2018	7,601	2.8%	209	2,086,681
2019	7,734	3.1%	235	2,348,061
2020	7,869	3.4%	262	2,622,093
2021	8,006	3.8%	291	2,905,809
2022	8,146	4.1%	320	3,199,435
2023	8,288	4.4%	350	3,503,206
2024	8,433	4.7%	382	3,817,360
2025	8,581	5.0%	414	4,140,860

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).[32] See Table 2-7 for more details.

Table 2-7. 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 (After CHP) (GWh)	Electricity Emissions Factor (tCO_2e/MWh)	Avoided emissions from electricity Production ($MMtCO_2e$)	Approximate amount of biomass required to meet goal - assuming 12 MMbtu/ton (Dry Tons)
2009	0.0%	-	0.532		-
2010	0.3%	21	0.541	0.01	17,233
2011	0.6%	42	0.534	0.02	35,068
2012	0.9%	64	0.527	0.03	53,521
2013	1.3%	87	0.520	0.05	72,608
2014	1.6%	111	0.513	0.06	92,346
2015	1.9%	135	0.506	0.07	112,751
2016	2.2%	159	0.499	0.08	132,447
2017	2.5%	183	0.492	0.09	152,821
2018	2.8%	209	0.486	0.10	173,890
2019	3.1%	235	0.480	0.11	195,672
2020	3.4%	262	0.473	0.12	218,508
2021	3.8%	291	0.467	0.14	242,151
2022	4.1%	320	0.461	0.15	266,620
2023	4.4%	350	0.455	0.16	291,934
2024	4.7%	382	0.449	0.17	318,113
2025	5.0%	414	0.443	0.18	345,072
			Cumulative	**1.5**	

GWh = gigawatt-hours; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

[32] 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.

Biomass to Electricity Costs

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 2-8. The totals do not add up to 100% because not all available biomass is being used in FAW-2.

Table 2-8. Relative proportion of feedstocks available assumed to be used in FAW-2.

Biomass Fuel Type	Proportion
Biomass for Heat/CHP	4%
Biomass for Large Scale Electricity	26%
Biomass for Biofuels	9%

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 2-9, and the assumed fossil fuel costs are indicated in Table 2-10. 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.

Table 2-9. Assumed costs of biomass feedstocks

Biomass Fuel Type	Cost ($/dry ton delivered)	Heat Content (MMBtu/ton)	Cost ($/MMBtu delivered)	Source
Forest feedstocks	65.00	15.4	4.23	As shown in the Biomass Supply and Demand section of this appendix (Table 1), these costs are near the mid-point of the range of likely low cost biomass feedstocks in AK (~$35/dry ton) and moderately high cost feedstocks (~$100/dry ton). It is also within the range of estimated delivered biomass cost within the boreal forest (Tok Forest area).[33] The above cost information is also consistent with the information produced for the Wolverine Clean Energy Venture study in Michigan[34] and summaries on Michigan pulpwood costs in a document titled: *Michigan Timber Market Analysis. Final Report.*

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

[33] Hermanns, J., AK DOF, personal communication with S. Roe, CCS, March 2009.

[34] 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.

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.[35]

Table 2-10. Assumed costs of fossil fuel feedstocks[36]

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, natural gas and heating oil is calculated using the costs outlined in Table 2-9 and Table 2-10. The difference in costs ($/MMBtu) is multiplied by the amount of energy (MMBtu) being replaced by biomass. Operation and maintenance costs were taken from Table 38 of the U.S. Department of Energy (DOE) Energy Information Administration's (EIA) *Annual Energy Outlook 2008* (AEO 2008). While use of biomass may be pursued through other technology types (e.g., gasification) or end uses (e.g., heat or steam), this methodology was used to provide an estimate of the costs of cofiring with biomass feedstocks replacing traditional electricity consumption. The costs for both 65$/delivered ton and 120$/delivered ton are included. Table 2-11 shows the costs of biomass

[35] 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).

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

cofiring. Note that the fuel costs shown to the right of Table 2-11 indicate net costs of fuel, as compared with existing electricity generation. Therefore, this is the cost to use biomass minus the costs of coal/natural gas/oil, according to Alaska's fuel mix. There are positive costs of both the 65$/ton and the 120$/ton scenarios, when compared with the default fuel mix assumed for Alaska (72% coal, 13% natural gas, and 15% oil). The break even cost of replacing these fuels is somewhere in the range of 50$/ton for this option, although this changes from year to year based on fossil fuel costs. This explains why the High fuel costs outlined in Table 2-11 are more than double the costs of the mid-range fuel costs scenario. The total costs of biomass cofiring are outlined in Table 2-12.

Table 2-11. Costs of generating electricity from biomass

Year	Estimated Electrical Output (MWh)	Estimated cumulative Capacity (MW)	Variable O&M Costs (MM2005$)	Fixed O&M Costs (MM2005$)	Fuel Costs – Mid-Range[a] (MM 2005$)	Fuel Costs-High[b] (MM 2005$)
2009	-	-	$0.0	$0	$0.0	$0.0
2010	20,680	3	$0.0	$0.1	$0.1	$0.9
2011	42,082	6	$0.1	$0.2	$0.3	$1.8
2012	64,225	9	$0.1	$0.3	$0.5	$2.8
2013	87,130	12	$0.2	$0.4	$0.9	$4.0
2014	110,815	15	$0.2	$0.5	$1.2	$5.1
2015	135,301	18	$0.3	$0.6	$1.6	$6.4
2016	158,937	21	$0.4	$0.7	$2.0	$7.6
2017	183,386	25	$0.4	$0.8	$2.2	$8.8
2018	208,668	28	$0.5	$0.9	$2.4	$9.9
2019	234,806	32	$0.5	$1.1	$2.7	$11.1
2020	262,209	35	$0.6	$1.2	$3.0	$12.4
2021	290,581	39	$0.6	$1.3	$3.3	$13.7
2022	319,944	43	$0.7	$1.4	$3.6	$15.1
2023	350,321	47	$0.8	$1.6	$4.0	$16.5
2024	381,736	51	$0.9	$1.7	$4.4	$18.0
2025	414,086	56	$0.9	$1.9	$4.7	$19.5

[a] Delivered price of $65/dry ton in $2005.
[b] Delivered price of $120/dry ton in $2005.
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MW = megawatt; MWh =

megawatt-hour; O&M – operations and maintenance

Table 2-12. Net costs of biomass to electricity production

Year	Total Costs @ 65$/dry ton (MM 2005$)	Total Costs @ 120$/dry ton (MM 2005$)
2009	$0.0	$0.0
2010	$0.3	$1.0
2011	$0.6	$2.1
2012	$1.0	$3.3
2013	$1.5	$4.6
2014	$1.9	$5.9
2015	$2.5	$7.3
2016	$3.0	$8.7
2017	$3.5	$10.0
2018	$3.8	$11.3
2019	$4.3	$12.7
2020	$4.8	$14.1
2021	$5.3	$15.7
2022	$5.8	$17.3
2023	$6.4	$18.9
2024	$6.9	$20.6
2025	$7.5	$22.3
Total	**$59**	**$176**

Element C. 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 2-13, below, lists the quantity of biofuels required in each year to meet the goals of FAW-2.

Table 2-13. Quantity of biofuel required in FAW-2

Year	Implementation Path (% biofuels displaced)	BAU AK Gasoline Consumption (MM gallons)	Displacement Goal (MM gallons)
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).[37] The incremental benefit values will be used along with the production 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.[38] This increase was assumed based on the maturation of cellulosic ethanol technology, allowing increased yield per ton of biomass feedstock.

Table 2-14 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. Some of the emissions reductions from cellulosic ethanol will not occur in the state of Alaska, and thus must be counted separately. Otherwise, comparing the forecast reductions against the Alaska Inventory and Forecast would no longer be possible.

[37] 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).

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

Table 2-14. Projected biofuel production and emission reductions

Year	Cellulosic Ethanol Plants Required	Cellulosic Feedstock Used (MM dry tons/yr)	Cellulosic Ethanol Production (MM gallons/yr)	Total Life-Cycle Emissions Reduction ($MMtCO_2e$)	Total In-State Emissions Reduction ($MMtCO_2e$)
2009	0	0.00	0	0.00	0.00
2010	1	0.01	1	0.01	0.01
2011	1	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	2	0.04	4	0.04	0.03
2015	2	0.05	4	0.04	0.03
2016	2	0.06	5	0.05	0.04
2017	3	0.07	6	0.06	0.05
2018	3	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	4	0.09	9	0.09	0.07
2022	4	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	5	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 necessarily whole numbers in each year. 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.

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.[39] These costs were scaled down to accommodate the smaller cellulosic plants in Alaska, although O&M costs could not be scaled down in a linear fashion, because there are some efficiency losses from lost economies of scale. Cellulosic plants in this analysis are assumed to produce 3 million gallons ethanol/year. The average capital cost of a new cellulosic ethanol plant is estimated to be $21.5 million. This cost was based on the average capital cost/million gallons of production for six different cellulosic ethanol plants. The costs

[39] 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.

estimated for these plants was quite variable, so rather than taking the estimated cost of a single plant, and average in terms of cost/gallon annually was used. This average was $7.17/gallon/year and for a 3 million gallon/year plant results in a cost of $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: $65/ton for woody feedstocks.[40] 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 2-15. The value of the cellulosic ethanol produced and net costs of the program are outlined in Table 2-16.

Table 2-15. Cost summary for cellulosic ethanol plants

Year	Cellulosic Ethanol Production (million gallons)	Cost of Feedstock @ 65$/ton biomass (MM2005$)	Cost of Feedstock @ 120$/ton biomass (MM2005$)	Other Annual Costs (MM$)	Total Annual Costs @ 65$/ton biomass (MM$)	Total Annual Costs @ 120$/ton biomass (MM$)	Annualized Capital Costs (MM$)
2009	0	$0	$0	$0	$0	$0	$0
2010	1	$1	$1	$4	$4	$5	$2
2011	1	$1	$2	$4	$5	$6	$2
2012	2	$2	$3	$4	$5	$7	$2
2013	3	$2	$4	$4	$6	$8	$2
2014	4	$3	$5	$7	$10	$12	$3
2015	4	$3	$6	$7	$11	$13	$3
2016	5	$4	$7	$7	$11	$14	$3
2017	6	$4	$8	$11	$15	$19	$5
2018	7	$5	$9	$11	$16	$20	$5
2019	8	$5	$10	$11	$17	$21	$5
2020	8	$5	$10	$11	$16	$21	$5
2021	9	$6	$11	$15	$21	$26	$7
2022	10	$7	$12	$15	$21	$27	$7
2023	11	$7	$13	$15	$22	$28	$7
2024	12	$8	$14	$15	$22	$29	$7
2025	12	$8	$15	$18	$26	$33	$9

gal = gallon; $MM = million dollars.

40 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 2-16. Cellulosic ethanol revenue and net costs

Year	Sale Price/gal Ethanol (2005$)	Value of Cellulosic Ethanol Produced (MM$)	Discounted Net cellulosic ethanol costs @ 65$/ton biomass (MM$)	Total cellulosic ethanol costs @ 120$/ton biomass (MM$)
2009	$2.91	$0	$0	$0
2010	$1.92	$1	$4	$4
2011	$2.07	$3	$3	$4
2012	$2.19	$5	$2	$3
2013	$2.28	$7	$1	$2
2014	$2.00	$7	$4	$5
2015	$1.86	$8	$4	$5
2016	$1.94	$10	$3	$4
2017	$2.16	$13	$4	$6
2018	$2.20	$15	$3	$5
2019	$2.23	$17	$2	$5
2020	$2.23	$19	$1	$4
2021	$2.24	$21	$3	$6
2022	$2.25	$22	$2	$5
2023	$2.27	$25	$2	$4
2024	$2.28	$27	$1	$4
2025	$2.27	$28	$3	$5
Total			**$41**	**$70**

To provide an overview of the entire option, Table 2-16 summarizes the GHG savings and net costs of all three elements of FAW-2. The assumed delivered cost of biomass for these cost estimates is 65$/dry ton.

Table 2-16: Costs and GHG savings of FAW-2

Year	$MMtCO_2e$ Saved, Heating	$MMtCO_2e$ Saved, Electricity	$MMtCO_2e$ Saved, Biofuels	$MMtCO_2e$ Saved Total	Net Costs, Heating (MM$)	Net Costs, Electricity (MM$)	Net Costs, Biofuel (MM$)	Net Cost (MM$)
2009	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
2010	0.00	0.01	0.01	0.02	2.0	0.3	3.7	5.9
2011	0.00	0.02	0.01	0.04	2.0	0.6	2.8	5.4
2012	0.01	0.03	0.02	0.06	2.1	1.0	1.6	4.6
2013	0.01	0.05	0.02	0.08	2.2	1.5	0.6	4.2
2014	0.01	0.06	0.03	0.09	2.2	1.9	3.9	8.0
2015	0.01	0.07	0.03	0.11	2.4	2.5	3.5	8.3
2016	0.01	0.08	0.04	0.13	2.0	3.0	2.6	7.6
2017	0.02	0.09	0.05	0.15	1.6	3.5	4.2	9.3

2018	0.02	0.10	0.05	0.17	1.2	3.8	3.3	8.3
2019	0.02	0.11	0.06	0.19	0.8	4.3	2.4	7.5
2020	0.03	0.12	0.06	0.21	0.3	4.8	1.4	6.4
2021	0.03	0.14	0.07	0.23	0.0	5.3	3.2	8.5
2022	0.03	0.15	0.08	0.25	-0.2	5.8	2.5	8.1
2023	0.03	0.16	0.08	0.27	-0.4	6.4	1.7	7.6
2024	0.03	0.17	0.09	0.29	-0.6	6.9	1.1	7.4
2025	0.04	0.18	0.09	0.32	-0.7	7.5	2.6	9.4
Total				**2.6**				**117**

Key Assumptions:

The discount rate used in this analysis is 5%, as stated in the Quantification Memo. The discount rate used can have a significant impact on cost effectiveness. For example, if a 3% discount rate is used for the biofuels option, the cumulative cost would be $52 million dollars, or 66$/ton (as opposed to the current estimate of $41 million and 52$/ton).

Key Uncertainties

- **General -** Delivered fuel costs are highly dependent on project specifics, location and infrastructure. A detailed biomass feedstock analysis that identifies volume of biomass available and at what cost from: mill waste, improved timber harvest utilization, precommercial thinning and commercial thinning is essential to provide accurate estimates of the cost effectiveness of biomass technologies.
- In order to do these analyses, a single cost for delivered biomass must be used. However, this is heavily dependent on biomass feedstocks being available nearby in order to sell at this price. Is biomass cannot be delivered to a given location at the estimated price, then the economic analysis is going to be dramatically affected. This limitation pushes the limits of a state level analysis, and additional investigation of biomass availability is recommended. A GIS-based, localized approach to feedstock availability would significantly improve these analyses.
- Economies of scale. (In rural AK setting there are challenges due to remoteness, size of communities, O&M capabilities, etc. Urban areas may have lower cost coal, natural gas and hydroelectric power, which makes renewable technologies less cost competitive).
- **Element A -** The costs of constructing heat distribution systems associated with CHP plants are not known and have not been included, but will add to the overall cost of these systems.

  Element B – The could be potential location issues with population centers. Unless biomass feedstocks are located near both population centers and large scale power plants, implementing this option will not be possible.
- **Element C –** Cellulosic ethanol plants are more cost effective with larger plant sizes. It is unlikely that Alaska has sufficient biomass supplies to support a large scale (50 mgy) ethanol plant. The analysis for Element C assumes four 3 million gallon per year plants, although some of the costs are scaled down from cost estimates of larger plants. While

the analysis attempts to avoid an any unrealistic assumptions, it is possible that these smaller plants will be significantly more expensive in terms of annual O&M costs.

Additional Benefits and Costs

Additional Benefits:

- Biomass fuels can have big economic benefit in communities, particularly rural where energy costs are a significant part of the economy. Dollars stay in community vs. exported to import fuels from far away.
- Developing biomass fuel harvest and transport infrastructure can open the door to other forest management enterprises.
- It may be possible to sell fuel offset credits to a carbon exchange such as Chicago Climate Exchange (CCX) to produce an additional revenue stream.

Having markets for lower grade forest products discourages "high grading" and usually results in better forest management practices.Additional Costs:

- Fuel switching results in winners and losers. For example if biomass offsets coal it might negatively effect important long standing business in Alaska.
- Risks associated with technologies that are unfamiliar, risks of system failure or increase life cycle costs.
- Risks of fuel supply disruptions often require redundant multi-fuel systems for backup addition to capital costs.

Feasibility Issues

- Location, economies of scale, limitations in infrastructure all make careful selection of biomass projects important. Early failures could potentially frustrate the goals to broaden biomass use, so it will be important to vet projects thoroughly and to provide technical assistance and other support to the early "demonstration" projects to ensure successful startups.

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

Policy Description

Reduce overall waste generation and GHG emissions through increased recycling and active management of organic wastes. Recycling decreases upstream GHG emissions from material production and transportation; management of organic wastes decreases downstream GHG emissions associated with the production of methane in landfills. Increase economically-sustainable recycling and organic management efforts, including new and existing programs, by encouraging participation of both residential and commercial consumers, by identifying existing markets and technologies, and by supporting the development of necessary in-state infrastructure. Overall accomplishment of the goal will be documented via a reduction in the volume of waste deposited into landfills.

Policy Design

Goals: Quantify current waste generation rates (pounds per capita per day) for rural and urban areas. Reduce waste stream, via source reduction and waste diversion, by 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

Implementing the policy will require some combination of the following possible actions:

- Funding will need to be allocated to allow the State, via the Department of Environmental Conservation (DEC), to act upon its statutory authority to establish a "Solid Waste Reduction and Recycling Program" (AS 46.06.031) and to provide grants for building material recovery and waste-to-energy facilities (AS 46.06.120). This would likely require additional staff capacity.
- Tracking progress toward the stated goals will require legislation mandating the reporting of recycling and landfilling data (tons/year) to the DEC and adoption of a data gathering and reporting mechanism such as Re-TRAC.
- Achieving the stated goals may require the establishment of statewide or regional target per-capita waste disposal rates.

- Minimizing the cost of recycling will require creating needed infrastructure and coordinating material shipments to achieve an economy of scale. This could require subsidizing shipping from rural communities without road access. Authorizing the transport of recyclables via the Alaska Marine Highway System would benefit communities served by that system.
- Taxes or fees on products brought into the state and/or on wastes disposed in landfills may be options to pay necessary subsidies, programs, grants, and staffing.
- Promoting waste reduction and recycling incorporates elements from individuals to industry. Consistent outreach will be a vital component for individuals, and the support of local recycling industries will be a keystone to sustainable recycling efforts.

Related Policies/Programs in Place

Three of the 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 and has an optional PAYT service.

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.

Alaskans for Litter Prevention and Recycling (ALPAR) has state-wide programs including "Flying Cans" which provides backhaul of aluminum cans in communities as well as an in-store plastic bag recycling, reuse and conservation toolkit available on their website www.alparalaska.com.

There are also many recycling programs throughout the state that are not mentioned here.

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, 2020, 2025 ($MMtCO_2e$): 0.27, 0.45, and 0.65, respectively.

Net Cost per tCO_2e: –$8.

Data Sources: Data on current waste disposal and recycling were provided by AK DEC.[41] Where AK-specific data was not available, CCS utilized national defaults derived from the U.S. EPA 2007 Waste Characterization Report.[42] GHG emission reductions were modeled using EPA's Waste Reduction Model (WARM).[43] Input informing the cost parameters was also provided by AK DEC.

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.[44] However, it should be noted that because Alaska does not require the reporting of recycling data, the BAU profile represents an incomplete picture of current recycling efforts and rates. 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 and were used to develop the waste generation projections for the state, as well as the four key Alaska population centers (Anchorage, Fairbanks, Matanuska-Susitna Valley, and Juneau).[45] 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.

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[41] 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.

[42] 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.

[43] 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 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.

[44] 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.

[45] 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.

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

	2005	2010	2012	2015	2020	2025
Total Alaska						
MSW Generated (tons)	825,883	868,914	886,110	911,919	955,432	997,360
MSW Landfilled (tons)	729,402	767,035	782,326	805,250	843,640	880,301
MSW Incinerated (tons)	29,604	30,658	31,118	31,821	32,987	34,169
MSW Diverted (tons)[46]	66,877	71,222	72,666	74,848	78,805	82,890
Total Alaska Diversion %	8.1%	8.2%	8.2%	8.2%	8.2%	8.3%

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 5.9 lbs/person/day.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 10 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). 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)	71,553	71,562	71,736	71,997	72,068	71,809
MSW Landfilled (tons)	45,548	44,648	44,449	44,141	43,239	41,971
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 generate 5.9lbs/person/day of waste. AK DEC estimates that Class II communities account for 7.3% of the total population of Alaska. AK DEC reported a small amount of waste recycled at these facilities (less than 300 tons per year). The waste incinerated is based on the estimated amount incinerated by the North Slope Borough in Barrow. 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.

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

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)	42,579	44,897	45,876	47,344	49,803	52,150
MSW Landfilled (tons)	38,748	40,882	41,756	43,064	45,284	47,400
MSW Incinerated (tons)	3609	3753	3841	3975	4167	4341
MSW Diverted (tons)	222	262	278	304	352	409

The Class I landfills were divided into the "Metro Class I Landfills" (Anchorage, Fairbanks, Mat-Su Valley, and Juneau) and the "Non-Metro Class I Landfills" (Kenai Peninsula, Kodiak, and Unalaska). The average per-capita waste generation rate for each landfill 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 landfills in that group. Based on data compiled by the 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%.[47] It was assumed that Fairbanks had a recycling rate equal to that of Juneau. Recycling attributed to the Non-Metro Class I Landfill Communities is based on reported recycling from the Kenai Peninsula Borough.[48] 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.

[47] 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. Additional input provided by D. Mears of Anchorage Solid Waste Services via e-mail on March 2, 2009.
[48] 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

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

	2005	2010	2012	2015	2020	2025
Non-metro Class I Landfill Communities						
MSW Generated (tons)	100,213	103,820	105,084	106,995	109,528	111,309
MSW Landfilled (tons)	98,895	101,744	102,882	104,589	106,739	108,076
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	1,318	2,075	2,201	2,406	2,789	3,233
Anchorage						
MSW Generated (tons)	408,555	430,619	438,593	450,554	472,846	495,776
MSW Landfilled (tons)	352,203	371,223	378,097	388,408	407,626	427,393
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	56,352	59,396	60,496	62,145	65,220	68,383
Fairbanks						
MSW Generated (tons)	115,591	122,397	124,947	128,773	134,397	139,844
MSW Landfilled (tons)	109,048	115,469	117,875	121,484	126,789	131,928
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	6,543	6,928	7,072	7,289	7,607	7,916
Mat-Su Borough						
MSW Generated (tons)	56,199	63,960	68,060	74,211	84,570	94,277
MSW Landfilled (tons)	55,532	63,202	67,253	73,331	83,567	93,159
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	666	758	807	880	1,003	1,118
Juneau						
MSW Generated (tons)	31,194	31,659	31,814	32,046	32,220	32,195
MSW Landfilled (tons)	29,428	29,867	30,013	30,232	30,396	30,372
MSW Incinerated (tons)	0	0	0	0	0	0
MSW Diverted (tons)	1,766	1,792	1,801	1,814	1,824	1,822

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 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
Recycling / Composting	5.0%	10.0%	13.0%	16.5%	20.0%
Source Reduction	0.0%	0.0%	2.0%	3.5%	5.0%
Total Waste Diversion	5.0%	10.0%	15.0%	20.0%	25.0%

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

	2010	2012	2015	2020	2025
Total Alaska					
MSW Generated (including SR, tons)	868,914	886,110	911,919	955,432	997,360
MSW Incinerated (tons)	30,658	31,118	31,821	32,987	34,169
MSW Recycled /Composted (tons)	71,222	88,611	118,549	157,646	199,472
MSW Source Reduced (tons)	-	-	18,238	33,440	49,868
Total MSW Diverted (tons)	71,222	88,611	136,788	191,086	249,340
MSW Landfilled (tons)	767,035	766,381	743,310	731,359	713,851

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

	2010	2012	*2013*	2015	2020	2025
Total Alaska						
MSW Recycled /Composted (tons)	-	15,945	25,027	43,702	78,841	116,582
MSW Source Reduced (tons)	-	-	5,965	18,238	33,440	49,868
Total MSW Diverted (tons)	-	15,945	30,992	61,940	112,281	166,450

The incremental waste diversion was allocated among the Metro Class I Landfills based on the proportion of waste diverted – and in the case of source reduction, the proportion of 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. Metro Class I Landfill Incremental Waste Diversion, 2010-2025.

	2010	2012	*2013*	2015	2020	2025
Anchorage						
MSW Recycled /Composted (tons)	-	14,459	22,698	39,651	71,619	106,037
MSW Source Reduced (tons)	-	-	4,443	13,538	24,649	36,552
MSW Diverted (tons)	-	14,459	27,142	53,188	96,267	142,589
Fairbanks						
MSW Recycled /Composted (tons)	-	903	1,417	2,474	4,463	6,599
MSW Source Reduced (tons)	-	-	841	2,575	4,704	6,992
MSW Diverted (tons)	-	903	2,258	5,049	9,167	13,591
Mat-su Valley						
MSW Recycled /Composted (tons)	-	189	297	518	935	1,382
MSW Source Reduced (tons)	-	-	467	1,484	2,960	4,714
MSW Diverted (tons)	-	189	764	2,002	3,895	6,096
Juneau						
MSW Recycled /Composted (tons)	-	395	616	1,059	1,825	2,563
MSW Source Reduced (tons)	-	-	213	641	1,128	1,610
MSW Diverted (tons)	-	395	828	1,700	2,952	4,173

GHG benefits were determined by using WARM,[49] 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 derives from the reduction of the total mass of products and packaging produced from virgin materials, including the energy consumption necessary for the production of the products and packaging. WARM accounts for the origin of carbon sequestered in raw materials. Therefore, CO_2 emissions from the combustion or decomposition of organic waste are not counted towards the total emissions. CH_4 and N_2O emissions due to landfilling or combustion of organic waste, as well as avoided future CO_2

[49] 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. Table 3-10 shows all potential waste types that may be entered into the WARM model, although data was not sufficient to develop a characterization that included estimates for all waste types. 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%	96.1%
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	**Baseline Generation Composition (% of waste Generated)[50]**	**Baseline Anchorage, Juneau, Fairbanks Recycling Composition (% of Waste Recycled)[51]**	**Baseline Mat-Su Valley Recycling Composition (% of Waste Recycled)[52]**	**Baseline non-Metro Recycling Composition (% of Waste Recycled)[53]**	**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%
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 (Table 3-1) were multiplied by the percentages in Table 3-10 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

[50] 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.

[51] 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.

[52] *Ibid.*

[53] *Ibid.*

amount of source reduction 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	5,730	281	5,449	-	NA
Steel cans	9,576	-	9,576	-	NA
Copper wire				-	NA
Glass	53,294	1,194	52,100	-	NA
HDPE	22,173	-	22,173	-	NA
LDPE	25,116	-	25,116	-	NA
PET	14,756	-	14,756	-	NA
Corrugated cardboard	122,561	21,867	93,449	7,245	NA
Magazines/third-class mail	33,201	1,988	29,250	1,963	NA
Newspaper	43,090	7,625	32,918	2,547	NA
Office paper	23,547	161	21,994	1,392	NA
Phonebooks	2,747	303	2,282	162	NA
Textbooks	5,259	-	4,948	311	NA
Dimensional lumber					NA
Medium-density fiberboard					NA
Food scraps	124,209	NA	116,867	7,342	-
Yard trimmings	128,055	NA	119,217	7,570	1,268
Grass		NA			
Leaves		NA			
Branches		NA			
Mixed paper (general)					NA
Mixed paper (primarily residential)	70,797	7,497	59,115	4,185	NA
Mixed paper (primarily from offices)	24,567	-	23,115	1,452	NA
Mixed metals	66,127	36,997	29,130	-	NA
Mixed plastics	58,553	629	57,923	-	NA
Mixed recyclables	164,003	3,080	160,923	-	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	997,360	82,890	880,301	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	5,730	791	676	4,262	-	NA
Steel cans	9,576	1,323	-	8,253	-	NA
Copper wire						NA
Glass	53,294	7,361	2,873	43,060	-	NA
HDPE	22,173	3,063	-	19,111	-	NA
LDPE	25,116	3,469	-	21,647	-	NA
PET	14,756	2,038	-	12,718	-	NA
Corrugated cardboard	122,561	16,928	52,621	45,766	7,245	NA
Magazines/third-class mail	33,201	4,586	4,784	21,869	1,963	NA
Newspaper	43,090	5,952	18,350	16,242	2,547	NA
Office paper	23,547	3,252	388	18,515	1,392	NA
Phonebooks	2,747	379	729	1,477	162	NA
Textbooks	5,259	726	-	4,222	311	NA
Dimensional lumber						NA
Medium–density fiberboard						NA
Food scraps	124,209	NA	NA	116,867	7,342	-
Yard trimmings	128,055	NA	NA	117,434	7,570	3,052
Grass		NA	NA			
Leaves		NA	NA			
Branches		NA	NA			
Mixed paper, broad		NA				NA
Mixed paper, residential	70,797	NA	18,041	48,571	4,185	NA
Mixed paper, office	24,567	NA	-	23,115	1,452	NA
Mixed metals	66,127	NA	59,514	6,613	-	NA
Mixed plastics	58,553	NA	1,515	57,038	-	NA
Mixed recyclables	164,003	NA	36,930	127,073	-	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	997,360	49,868	199,472	713,851	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, 2020, and 2025 WARM runs predict the GHG reductions for these years to be 0.27, 0.45 and 0.65 $MMtCO_2e$, respectively. The cumulative GHG reductions are calculated to be 5.3 $MMtCO_2e$. 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	-	15,945	-	15,945	-
2013	0.09	30,992	5,965	24,805	223
2014	0.18	46,324	12,044	33,834	446
2015	0.27	61,940	18,238	43,033	669
2016	0.30	71,664	21,174	49,710	780
2017	0.34	81,561	24,162	56,507	892
2018	0.38	91,629	27,203	63,423	1,003
2019	0.42	101,869	30,295	70,459	1,115
2020	0.46	112,281	33,440	77,615	1,226
2021	0.49	122,784	36,625	84,822	1,338
2022	0.53	133,452	39,860	92,143	1,449
2023	0.57	144,286	43,146	99,580	1,561
2024	0.61	155,285	46,482	107,132	1,672
2025	0.65	166,450	49,868	114,798	1,784
Totals	**5.3**	**1,336,463**	**388,502**	**933,806**	**14,155**

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

Cost-Effectiveness

Source reduction—The amount of source reduced waste shown in Table 3-6 is based on CCS's best judgment that source reduction will feasibly account for one-fifth of the 25% diversion goal 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.[54] This cost applies only to the regions served by the Metro Class I Landfills. The cost figure uses a population

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

projection from AK Department of Labor.[55] These funds are assumed to cover any outreach 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 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).[56] 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.[57]

The analysis assumes that costs begin to be incurred in 2012. The estimated cost savings result in an NPV of –$5.3 million. Cumulative GHG reductions attributed to source reduction are 1.8 $MMtCO_2e$, and the estimated cost-effectiveness is –$3/$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 single-stream recycling, revenue obtained for the value of recycled materials, and avoided landfill tipping fees. There is also a significant amount of material collected as source separated material at drop-off sites. The additional cost for separate curbside collection of recyclables is $9.72 per ton. The capital cost of additional recycling facilities in Alaska is estimated to be $5.6 million.[58] 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 –$51.0 million. Cumulative GHG reductions attributed to recycling are 1.6 $MMtCO_2e$, and the estimated cost-effectiveness is –$10/$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

[55] 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.

[56] 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.

[57] 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.

[58] 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).

facilities was received from Cassella Waste Management during the analysis of a similar option in Vermont.[59] These data are summarized in Table 3-14.

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 3-14. 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,[60] and a compost value of $16.50/ton.[61]

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 0.0020 MMtCO_2e. An NPV of $0.03 million was estimated, along with a cost-effectiveness of $13/t$CO_2$e.

[59] 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.

[60] **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.

[61] 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	Anchorage 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)
2010	-	-	-	-	502,210	$0.0	$0.0	$0.0	$0.0	$0.0
2011	-	-	-	-	508,674	$0.0	$0.0	$0.0	$0.0	$0.0
2012	-	-	-	-	515,138	$0.0	$0.0	$0.5	$0.5	$0.5
2013	4,443	841	467	213	521,601	$0.4	$0.1	$0.5	$0.1	$0.1
2014	8,956	1,700	962	426	528,065	$0.7	$0.1	$0.5	-$0.4	-$0.3
2015	13,538	2,575	1,484	641	534,529	$1.1	$0.2	$0.5	-$0.8	-$0.6
2016	15,694	2,988	1,755	738	541,186	$1.3	$0.2	$0.5	-$1.0	-$0.8
2017	17,883	3,407	2,037	835	547,843	$1.5	$0.3	$0.5	-$1.2	-$0.9
2018	20,106	3,832	2,332	932	554,499	$1.7	$0.3	$0.6	-$1.5	-$1.0
2019	22,361	4,265	2,640	1,030	561,156	$1.9	$0.4	$0.6	-$1.7	-$1.1
2020	24,649	4,704	2,960	1,128	567,813	$2.1	$0.4	$0.6	-$1.9	-$1.2
2021	26,965	5,148	3,287	1,224	574,318	$2.3	$0.4	$0.6	-$2.1	-$1.2
2022	29,313	5,600	3,627	1,321	580,823	$2.5	$0.5	$0.6	-$2.4	-$1.3
2023	31,694	6,057	3,977	1,417	587,328	$2.7	$0.5	$0.6	-$2.6	-$1.4
2024	34,107	6,521	4,340	1,513	593,833	$2.9	$0.5	$0.6	-$2.8	-$1.4
2025	36,552	6,992	4,714	1,610	600,338	$3.1	$0.6	$0.6	-$3.1	-$1.5
Totals	**286,260**	**54,631**	**34,583**	**13,028**					**-$7.9**	**-$5.3**

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$MM)	Discounted Costs (MM$)
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	14,459	903	189	395	$0.2	$0.4	$0.0	$1.1	-$0.6	-$0.5
2013	22,504	1,394	297	610	$0.3	$0.4	$0.0	$1.8	-$1.1	-$1.0
2014	30,706	1,896	406	825	$0.4	$0.4	$0.0	$2.4	-$1.7	-$1.4
2015	39,067	2,407	518	1,041	$0.5	$0.4	$0.0	$3.1	-$2.2	-$1.7
2016	45,140	2,780	599	1,192	$0.6	$0.4	$0.0	$3.6	-$2.6	-$2.0
2017	51,325	3,160	681	1,342	$0.7	$0.4	$0.0	$4.1	-$3.0	-$2.2
2018	57,621	3,546	764	1,492	$0.7	$0.4	$0.0	$4.6	-$3.5	-$2.3
2019	64,029	3,940	849	1,642	$0.8	$0.4	$0.0	$5.1	-$3.9	-$2.5
2020	70,548	4,340	935	1,792	$0.9	$0.4	$0.0	$5.6	-$4.3	-$2.6
2021	77,119	4,743	1,022	1,938	$1.0	$0.4	$0.0	$6.1	-$4.7	-$2.8
2022	83,798	5,153	1,110	2,083	$1.1	$0.4	$0.0	$6.6	-$5.2	-$2.9
2023	90,584	5,569	1,199	2,228	$1.2	$0.4	$0.0	$7.1	-$5.6	-$3.0
2024	97,478	5,992	1,290	2,372	$1.3	$0.4	$0.0	$7.7	-$6.1	-$3.1
2025	104,479	6,421	1,382	2,516	$1.3	$0.4	$0.0	$8.2	-$6.5	-$3.1
Totals	**848,854**	**52,243**	**11,241**	**21,468**					**-$51.0**	**-$16.2**

$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)
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	195	22	-	6	$0.01	$0.00	$0.02	$0.00	$0.01	$0.00	$0.02	$0.01
2014	389	45	-	12	$0.01	$0.00	$0.02	$0.01	$0.02	$0.01	$0.01	$0.01
2015	584	67	-	18	$0.02	$0.00	$0.02	$0.01	$0.03	$0.01	$0.00	$0.00
2016	681	78	-	21	$0.02	$0.00	$0.02	$0.01	$0.04	$0.01	$0.00	$0.00
2017	779	89	-	24	$0.02	$0.00	$0.02	$0.01	$0.04	$0.01	$0.00	$0.00
2018	876	100	-	27	$0.03	$0.00	$0.02	$0.01	$0.05	$0.02	-$0.01	$0.00
2019	974	111	-	29	$0.03	$0.00	$0.02	$0.01	$0.05	$0.02	-$0.01	-$0.01
2020	1,071	123	-	32	$0.03	$0.00	$0.02	$0.01	$0.06	$0.02	-$0.01	-$0.01
2021	1,168	134	-	35	$0.03	$0.00	$0.02	$0.02	$0.06	$0.02	-$0.01	-$0.01
2022	1,266	145	-	38	$0.04	$0.00	$0.02	$0.02	$0.07	$0.02	-$0.02	-$0.01
2023	1,363	156	-	41	$0.04	$0.00	$0.02	$0.02	$0.07	$0.03	-$0.02	-$0.01
2024	1,461	167	-	44	$0.04	$0.00	$0.02	$0.02	$0.08	$0.03	-$0.02	-$0.01
2025	1,558	178	-	47	$0.04	$0.00	$0.02	$0.02	$0.08	$0.03	-$0.03	-$0.01
Totals	**12,366**	**1,415**	**-**	**374**							**-$0.1**	**$0.03**

$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 –$43.2 million and a cost-effectiveness of –$8, based on the cumulative emission reductions of 5.3 $MMtCO_2e$.

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	-$0.6	$0.02	-$0.1	-$0.1	
2013	$0.1	-$1.1	$0.02	-$1.0	-$0.9	
2014	-$0.4	-$1.7	$0.01	-$2.0	-$1.7	
2015	-$0.8	-$2.2	$0.00	-$3.0	-$2.4	
2016	-$1.0	-$2.6	$0.00	-$3.7	-$2.7	
2017	-$1.2	-$3.0	$0.00	-$4.3	-$3.0	
2018	-$1.5	-$3.5	-$0.01	-$4.9	-$3.3	
2019	-$1.7	-$3.9	-$0.01	-$5.6	-$3.6	
2020	-$1.9	-$4.3	-$0.01	-$6.2	-$3.8	
2021	-$2.1	-$4.7	-$0.01	-$6.9	-$4.0	
2022	-$2.4	-$5.2	-$0.02	-$7.5	-$4.2	
2023	-$2.6	-$5.6	-$0.02	-$8.2	-$4.4	
2024	-$2.8	-$6.1	-$0.02	-$8.9	-$4.5	
2025	-$3.1	-$6.5	-$0.03	-$9.6	-$4.6	
Totals	**-$20.8**	**-$51.0**	**-$0.08**	**-$71.9**	**-$43.2**	**-$8**

$MM = million dollars; $/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent.

Key Assumptions:

In entering MSW management data into WARM, a key assumption is that no portion of the policy goals will be achieved via existing programs. Accordingly, the BAU projections extend current practices into the future and do not include any additional gains in the recycling or composting rates of existing programs. Therefore, to the extent that growth in existing programs does contribute toward achieving the policy goals, there will be a corresponding decrease (from the WARM estimates) in the GHG reductions that new programs must achieve. To that same extent, the benefits and costs calculated by WARM are overstated.

Other key assumptions include those that are built into WARM and which are used to calculate life-cycle GHG benefits, and the assumptions stated above regarding the costs associated with meeting the policy goals for increased source reduction, recycling, and composting.

Finally, the BAU projections assume that all landfills recover and utilize methane at a 75% recovery rate. This is based on a built-in assumption in WARM that all disposed waste is placed into landfills that actively recover methane at this assumed rate.

Key Uncertainties

According to AK DEC, 23,700 tons of MSW were shipped out of Alaska in 2006. Most of this waste originates in Southeast Alaska and is managed in Washington and Oregon. Since the ultimate management technique used to treat this waste (i.e. recycling, landfilling), CCS did not consider the waste exported as a part of Alaska's waste stream.

Due to insufficient data on the characterization of waste landfilled in Alaska, CCS was required to project the BAU and policy scenarios using a default national waste characterization from EPA. The adjustments and aggregation of material types required to fit the data to the WARM model reduce the certainty of the GHG benefit estimates.

The economic sustainability of recycling programs in Alaska depends on the market value of the recycled materials being greater than the cost to transport those materials to recyclers. Until and unless Alaska develops an in-state recycling industries, the viability of recycling programs will fluctuate with changes in the price of fuel and the market value of recyclables. There will be some buffering of commodity prices as a whole as higher value materials (i.e. aluminum) subsidize lower value materials (i.e. plastics). There are some existing and developing in-state recycling industries; however, there may not be sufficient feedstock to support in-state recycling industries for all materials. Due to geographic constraints, Alaskan recycling industries are likely to be local or regional efforts, further reducing potential economies of scale. It is important to note that currently, local recycling efforts do not remanufacture the recycled products. For instance newspaper is made into insulation and other cellulose replacements rather than being remade into newsprint. Similarly, recycled glass is not remanufactured into bottles.

The FAW TWG feels that the economic uncertainty present at the time of this analysis may justify a decrease in the discount rate. CCS re-ran the cost-effectiveness analysis described above with a 3% discount rate, rather than a 5% discount rate. The lower discount rate increases the net present value of savings from FAW-3 to -$53 million, for a cost-effectiveness of -$10/tCO$_2$e.

Additional Benefits and Costs

Increased recycling will increase the anticipated life span of existing landfills due to the decreased amount of waste disposed in those landfills.

Increased recycling will decrease the revenue generated by landfill but may not yield an equivalent decrease in operating costs.

Small-scale composting of municipal solid waste could reduce costs for some rural communities by generating soil material that could be used as cover material for the local landfill.

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]