Appendix H
Forestry, Agriculture, and Waste Management Policy Recommendations

Summary List of Alaska Climate Change Mitigation Policy Recommendations

Policy No.	Policy Recommendation	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 Forest Management Pre-Commercial Thinning	Included under FAW-2, along with all options using biomass in other sectors						Unanimous
	B. Boreal Forest Mechanical Fuels Treatment Projects							Unanimous
	C. Community Wildfire Risk Reduction Plans							Unanimous
	D. Boreal Forest Reforestation After Fire or Insect and Disease Mortality	0.09	0.12	0.15	1.6	$150	$92	Unanimous
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	$27	$90	Unanimous
	B. Biomass Feedstocks for Electricity Use	0.07	0.12	0.18	1.5	$59	$38	Unanimous
	C. Biomass Feedstocks to Offset Fossil Transportation Fuels	0.03	0.06	0.09	0.8	$41	$52	Unanimous
FAW-3	Advanced Waste Reduction and Recycling	0.27	0.45	0.65	5.3	–$43	–$8	Unanimous
	Sector Total Before Adjusting for Overlaps	0.47	0.78	1.11	9.5	$234	$25	
	Sector Total After Adjusting for Overlaps	0.47	0.78	1.11	9.5	$234	$25	
	Reductions From Recent Actions (CAFE standards)	N/A	N/A	N/A	N/A	N/A	N/A	
	Sector Total Plus Recent Actions	0.47	0.78	1.11	9.5	$234	$25	

CAFE = corporate average fuel economy; FAW = Forestry, Agriculture, and Waste Management (Technical Work Group); GHG = greenhouse gas; $MM = million dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Note that negative costs represent a monetary savings.

Also included in this appendix after FAW-3 is a policy that was considered by the Alaska Natural Systems Adaptation Group. This policy has been moved to this appendix because of the overlap between it and FAW-1 and FAW-2. This policy is mostly concerned with fostering the growth and management of healthy forests in Alaska, and getting the most possible benefits from Alaska's forestland. While the greenhouse gas (GHG) benefits of adaptation policies are not quantified, this policy nonetheless can provide additional insight into issues of forest health. It is being included to assist in the future implementation of forestry-related GHG mitigation approaches for the Alaska process.

FAW-1 elements A–C all have the potential to produce biomass that can be used for fuel feedstocks under FAW-2. Note that for FAW-1A, the Alaska Climate Change Advisory Group recognizes that the costs to collect, process, and transport most of the biomass generated from coastal forest thinning projects will be too costly to use as an energy source. The biomass feedstocks generated from the FAW-1 elements were added to the FAW biomass supply assessment (see the next section of this appendix). The GHG reductions for using the biomass from FAW-1 or other sources were quantified under FAW-2.

There are no overlaps between the FAW biomass policies and the policies in the Energy Supply and Demand (ESD) or Transportation and Land Use (TLU) appendices. Biomass demand from ESD-3 has been accounted for in the biomass availability analysis shown in the next section.

Biomass Resource Supply and Demand Assessment

This section provides a preliminary assessment of biomass availability in Alaska. These estimates were taken from readily available sources or updates from the Forestry, Agriculture, and Waste Management (FAW) Technical Work Group (TWG). 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 recommendation FAW-2, as well as any biomass-related recommendations considered in other TWGs (e.g., Energy Supply and Demand [ESD] and Transportation and Land Use [TLU]).

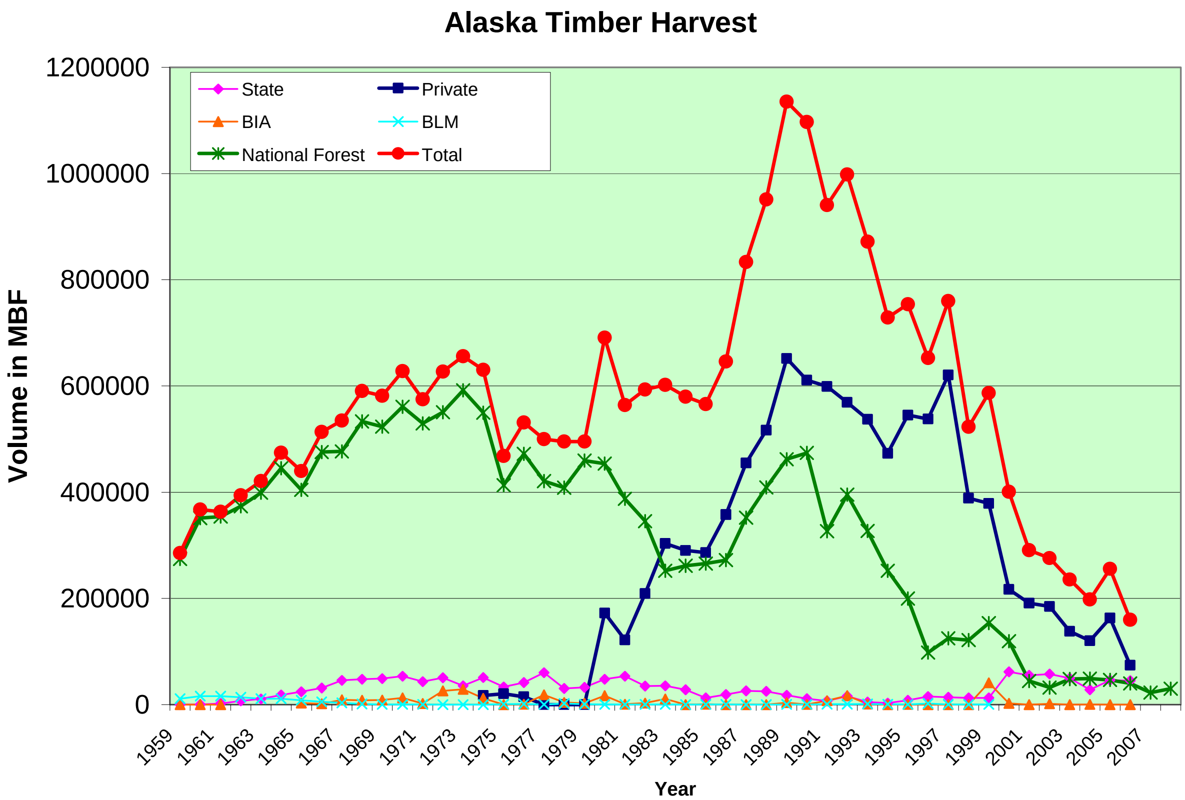
An assessment of biomass resources available to meet the feedstock requirements of the Alaska Climate Change Mitigation Advisory Group (MAG) policies is presented in Table H-1 on the following pages. Table H-2 presents the annual biomass demand that would result from MAG recommendations. Except for the final four entries, Table H-1 presents a total potential availability of biomass in dry tons based on business as usual (BAU) in Alaska 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 conditions 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. The Alaska Energy and Power Authority published locationally dependent costs. Although this information could not be used in this particular analysis, it is possible that it will be valuable for any future assessment of biomass costs.

After the analysis of recommendations from all TWGs is complete, the annual biomass demand for 2025 will be calculated in order to assess whether sufficient biomass supply exists to achieve the goals set forth in the policy recommendations made by the MAG.

The Alaska timber harvest is outlined in Figure H-1. As can be seen, the total timber harvest has declined significantly since the mid-1980s. It is possible that the supply estimates for the logging industry (logging residue, primary/secondary mill residue) are somewhat high, because most of the forest sector supply estimates for this analysis are from 2002. However, most of the declines in harvest volume had 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 near-term year to form a baseline.

Figure H-1. Alaska timber harvest: 1959–2007



MBF = thousand board-feet.

Table H-1. Potential annual biomass resource supply

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 SE AK (estimated range is $80–$100).[3] Cost estimate is likely only valid in SE AK. Converted from tonnes to short tons. Delivered costs are variable and may change significantly due to location and available transportation infrastructure.

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

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

Biomass Resource	Annual Biomass Supply (dry tons)	Delivered Cost[1] ($2005/dry ton)	Notes
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. Costs are 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 AK 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 wood 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.
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	$300	Assumes full implementation of FAW-1 Element A. Costs include thinning plus collection and delivery. $300 cost is based on personal communication between Jackson Schreiber and Chris Maisch, 4/29/09. As noted under FAW-1, removal of PCT biomass is unlikely to occur due to high delivery costs and potential damage to the stand from biomass removal equipment.
Boreal Forest: Mechanical Fuel Reduction	11,500	$75	Assumes full implementation of FAW-1 Element B. 40-mile distance to end user. $75 dollar cost is based on estimates from a personal communication between Jackson Schreiber and Chris Maisch, 4/29/09.
Boreal Forest Community Wildfire Reduction Plans	58,000	$75	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. $75 cost is based on Tok estimates from a personal communication between Jackson Schreiber and Chris Maisch, 4/29/09.

[4] R. Harris, Sealaska, FAW TWG, personal communication with S. Roe, Center for Climate Strategies (CCS), November 2008.

[5] CCS reviewed the methodology used in the 2005 National Renewable Energy Laboratory (NREL) report to estimate urban wood waste biomass availability. For the state of Alaska, NREL's data source for the municipal solid waste (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] U.S. Department of Energy, Energy Information Administration, *Biomass for Electricity Generation*. Accessed 2/18/2009 at http://www.eia.doe.gov/oiaf/analysispaper/biomass/.

Biomass Resource	Annual Biomass Supply (dry tons)	Delivered Cost[1] ($2005/dry ton)	Notes
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 tons. Same cost source/assumptions as above for urban wood waste.
Yard and Landscape Waste Debris	7,570	$36	Total biomass supply for the year 2025, assuming full implementation of FAW-3. Without implementation of FAW-3, the total biomass supply would be 119,217 dry tons. Same cost source/assumptions as above for urban wood waste.
Total Annual Biomass Supply	1,222,838		Excludes PCT biomass.
Total Annual Biomass Supply Available at <40$/ton	483,835		
Total Annual Biomass Supply Available at <100$/ton	1,153,337		Excludes PCT biomass.

AK = Alaska; BDT = bone dry ton; DOE = U.S. Department of Energy; EIA = Energy Information Administration; FAW = Forestry, Agriculture, and Waste Management (Technical Work Group); MSW = municipal solid waste; NREL= National Renewable Energy Laboratory; PCT = pre-commercial thinning; SE = southeast; TSS = TSS Consultants; USDA = U.S. Department of Agriculture.

Table H-2. 2025 annual biomass demand from MAG recommendations

Biomass Requirement	2025 Annual Biomass Demand (dry tons)	Notes
FAW-2. Element A. Biomass Heating	50,000	See FAW-2 quantification.
FAW-2. Element B: Biomass for Electricity Production	345,000	See FAW-2 quantification.
FAW-2. Element C: Biomass for Liquid Fuels Production	124,000	See FAW-2 quantification.
ESD TWG Biomass Needs	8,000	Based on personal communication with Jeremy Fischer, Energy Supply and Demand Technical Work Group. Represents demand for biomass from ESD-3. Assumed white spruce for heat content conversion of cordwood.
TLU Biomass Needs	0	No TLU options had biomass requirements.
Total	**527,000**	

MAG = Mitigation Advisory Work Group; ESD = Energy Supply and Demand; FAW = Forestry, Agriculture, and Waste Management; TLU = Transportation and Land Use; TWG = Technical Work Group.

FAW-1. Forest Management Strategies for Carbon Sequestration

Policy Description

Alaska forests can play a unique role in both preventing and reducing greenhouse gas (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 components of the soil. Permafrost soils add an additional dimension and complication to the role soils play in the boreal, subarctic, and arctic ecosystems, and the potential impacts of increased wildland fire in these regions have 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 this policy recommendation.

- Another concept to consider is the lower energy intensity of wood product manufacture when compared with other building products. Wood substitution prevents GHG emissions because it is typically less carbon intensive in production compared with wood substitutes.

Boreal Forest Options

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

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[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 and 25 years in southeast Alaska, 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.

Policy Design

Goals: Direct the maximum economically feasible biomass from the following policy elements to energy use. (The MAG 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 BAU 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 Risk Reduction 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 (DNR) Division of Forestry (DOF), Alaska Native Corporations (ANCs), University of Alaska (UA), Southeast Conference, Cooperative Extension Service (CES), Natural Resource Conservation Service (NRCS), Resource Development Council (RDC), Alaska Forest Association, U.S. Forest Service (USFS), state and private forestry, Alaska Board of Forestry, Soil and Water Conservation Districts, National Park Service, U.S. Bureau of Land Management.

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 (yr), and that thinning by Sealaska was around 4,000

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[9] The MAG 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] High-site-class lands are defined as high-severity burn areas in the quantification.

acres/yr.[11] No additional information was identified on thinning levels on other public lands or private lands in the coastal forest.

DNR indicates that about 535 acres/yr of boreal forest have been mechanically treated 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 the program to meet goals at various increments and establish a viable carbon-trading program to capture the revenue stream from the carbon dioxide (CO_2) sequestration perspective.

Mechanical Fuel Treatment Projects: Based on CWPP recommendations, utilize both mechanical methods and village Type II emergency fire-fighting crews and agency Type I fire crews to complete projects in their communities. Mechanical fuel treatments in Tok and Fairbanks have produced usable biomass for wood energy projects at a competitive rate per ton and will be cheaper than hand crew use in similar forest types. The transportation cost of the biomass is the most sensitive expense for these types of treatments and will greatly influence the freight-on-board cost per green ton to a wood biomass facility. 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 a 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—e.g., white spruce 75% and lodge pole pine 25% per unit area planted (an 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 CO_2 in harvested timber is stored in durable forest products that have over decades of service lives.

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

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

A strong timber industry in Alaska will serve to both stabilize and reduce the overall cost of delivered biomass in the state. If increased demand for biomass as a result of GHG policies can serve to strengthen the market for timber, then it is possible there could be cost benefits in the future.

Related Policies/Programs in Place

None identified.

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_2e):

Element A: Captured under FAW-2 and biomass utilization recommendations 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 H-5 under this recommendation. Capturing the benefits of this recommendation under FAW-2 may not be viable because of the implementation items listed, such as the economics and feasibility of removing the biomass without unacceptable residual damage to the stand.

Element B: Captured under FAW-2 and biomass utilization recommendations 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 recommendations 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, in 2015, 2020, and 2025.

Net Cost per tCO_2e (metric ton of CO_2 equivalent):

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

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

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

Element D: $92.

Data Sources: Data sources are specified or footnoted in the following 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 and Commercial Thinning

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-year rotation, as compared with 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 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 1950s and early 1960s. 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 (ANCs). 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 1990s, 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.

[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 which the rate of growth among a stand of trees peaks, and after which annual growth remains level or declines.

Pre-commercial Thinning. For PCT, the estimated theoretical biomass removed in 2025 through implementation of this policy was noted in Table H-1 at the front of this appendix. For use in policy recommendations 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 activity in the coastal forest. Table H-3 provides a summary of coastal forest inventory data from the USFS.[15]

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

Table H-3. Alaska 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**

AG = above ground.

Table H-4 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 H-3 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 factors 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 H-4 (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 H-4. Note that after this estimate of delivered costs was made, a revised estimate of $300/dry ton was provided by a TWG member as cited in the Biomass Supply and Demand Assessment at the beginning of this appendix. The overall

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

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 (PPI) estimates for the logging industry from 2002 to 2007 (about 1.2%/yr). 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.

Table H-4. 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
2025	6,000	9,737	150,000	84,737	$2,785,043	$7,558,263	$122
Total	**118,000**	**191,500**	**2,950,000**	**1,666,500**	**$50,951,588**	**$148,645,849**	**$120**

[a] TSS Consultants, *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan Final Report*, 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] TSS Consultants, *Southeast Alaska Biomass-to-Ethanol Project Feedstock Supply Plan Final Report,* June 20, 2000. Estimate of $80–$100 BDT logging residue collected and delivered to a proposed ethanol plant in southeast Alaska.

BDT = bone dry ton; PCT = pre-commercial thinning.

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-year rotation would yield 39,000 board-feet/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-ft, the estimates shown in Table H-5 were derived. As shown in this table, about 0.37 million metric tons (MMt) of CO_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, 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 H-5. Incremental timber production following pre-commercial thinning

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
Total	**118,000**	**1,445,400**	**2,649,900**	**$50,951,588**	**$34,546,695**

DWP = durable wood product; tCO_2e = metric tons of carbon dioxide equivalent.

[17] Southeast Alaska Wood Energy, presentation by R. Harris, Sealaska, provided to S. Roe, Center for Climate Strategies (CCS), November 2008.

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 H-5. 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. The cost of PCT does not address the cost of recovery of PCT material for biomass production, which is addressed in FAW-2.

It is possible that pre-commercial thinning can result in increased carbon sequestration over a long enough time period. Modeling has shown that managed forests produce higher levels of usable wood than unmanaged forests.[18] However, because this wood is measured in board-feet rather than overall biomass/carbon content, it is uncertain if carbon sequestration has increased in managed versus unmanaged forests. Given this uncertainty, PCT is not assumed to increase overall carbon sequestration.

Element B. Boreal Forest Mechanical Fuels Treatment Projects

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 H-6 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 DOF 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 H-1).

The delivered costs of biomass were also taken from the same 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 H-1 of the Biomass Supply and Demand Assessment.

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

[19] Douglas Hanson, *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. Available at http://www.forestry.alaska.gov/pdfs/07Biomass_Report.pdf.

Table H-6. 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
Total	**28,000**			**129,150**

[a] Douglas Hanson, *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 from implementation of these plans. The primary assumption was that the fuel treatments would be mechanical treatments, not prescribed fire.

Table H-7 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 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, the Center for Climate Strategies (CCS) assumed that the average

[20] D. Hanson, AK DOF, personal communication with S. Roe, CCS, January 2009.

community was one-third of 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 H-7, similar assumptions were made for biomass density and recovery as for the analysis under Element B above. The estimated removals for 2017–2025 (~58,000 dry tons/yr) were used as input to the Biomass Supply and Demand Assessment at the front of this appendix (see Table H-1). The same delivered cost as described under Element B is assumed for this option ($105/dry ton in 2005$).

Table H-7. Boreal forest treatments and biomass recovered

Year	Acres Treated	Biomass Density[a] (dry tons/acre)	Biomass Recovery Factor	Biomass Available (dry tons/year)
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
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] Douglas Hanson, *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 After Fire or Insect Damage and Disease

The GHG benefits for this element are the difference in carbon sequestration levels under BAU (no reforestation of lands damaged by fire/pests/disease) 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 Alaska GHG Inventory and Forecast (I&F) (Appendix D of this report), the average wildfire activity in the state during 1994–2004 was about 1.4 million acres/yr. Hence, on average, about 260,000 acres of high-severity-burn areas are created in the state annually.

Discussions between CCS and state foresters[22] have revealed a range of opinion regarding how reforestation projects should be carried out. This range of opinion is driven by several factors. First, 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). Second, from a carbon sequestration perspective, mixed hardwood forests may offer superior performance, especially during the early decades following replanting.

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. These areas could benefit the most from replanting efforts and could yield significant GHG reductions. Hence, the analysis below assumes that the reforestation projects will involve replanting 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 a DOF staff person for balsam poplar stands.[23] Using an assumed density of 26 pounds [lbs]/ft^3 (0% moisture) and a 50% carbon content for biomass, an annual carbon accumulation rate for balsam poplar stands would be 0.648 metric tons of carbon (tC)/acre-yr.

For the BAU scenario (grassland succession), an estimate of the 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

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[21] Monitoring Trends in Burn Severity Program, U.S. Geological Survey and USFS, available at http://mtbs.gov/index.html.

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

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

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

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 in 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 created 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 H-8 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 H-9. Boreal reforestation GHG benefits and costs

Year	Acres Replanted	Incremental Carbon Accumulated (tCO_2)	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	1$5,554,680	$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
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
Total	**697,072**	**1,630,147**	**$228,999,460**	**$149,828,971**

GHG = greenhouse gas; tCO_2 = tons of carbon dioxide.

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 is replaced during a 70-year rotation by growth release of crop trees. It is also assumed that biomass densities are otherwise

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

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 is based on 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 are used for 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 those for white spruce. The future value for the additional biomass sequestered is not included.

Key Uncertainties

Quantification of the cost per $MMtCO_2$ 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 (e.g., federal incentives would not be counted toward the societal costs for Alaska using the CCS costing methods). We do know most of these practices are being implemented irrespective of the sequestration or offset benefits. Private landowners, however, rely heavily on federal cost share or grant programs that face a questionable future in terms of congressional appropriations. For example, even though landowners are thinning without receiving any benefit from $MMtCO_2$ capture, they may not be able to continue without outside revenue or federal funds. While state and federal land managers may not be in a position to sell carbon credits, the existence of such a market will help demonstrate the benefits and justify funding requests.

Quantifying the reduced carbon emissions from catastrophic wildfires as a result of boreal forest mechanical fuel treatments is difficult.

Additional Benefits and Costs

Element A

- Through silviculture treatments, increases wood product output per acre and provides associated economic benefits (or conversely maintains forest product output on a smaller timberland footprint).
- Improves wildlife habitat (improves deer browse in silviculture-treated stands).
- Provides employment opportunities in rural communities in southeast Alaska.

- Maintains and enhances overall forest health to promote stand and ecosystem resilience to changing climate and resulting insect, disease, and other environmental stressors.

Element B

- Reduces catastrophic wildfire (difficult to quantify).
- Reduces loss of life and property due to catastrophic wildfire near settlements.
- Reduces carbon emissions from loss of property and from reconstruction of lost properties.
- Provides indirect wildlife benefits through management of stand structure and browse.

Element C

- Reduces catastrophic wildfire (difficult to quantify).
- Reduces loss of life and property due to catastrophic wildfire near settlements.
- Reduces carbon emissions from loss of property and from reconstruction of lost properties.
- Provides indirect wildlife benefits through management of stand structure and various habitat benefits.
- Engages communities in a proactive manner to empower residents to actively participate in and take responsibility for risk awareness and mitigation activities for wildland fire.

Element D

Results in social, economic, and biological benefits of reforestation, too numerous to list. State law recognizes these benefits by requiring reforestation after logging, with fires and salvage being exceptions to reforestation requirements.

Feasibility Issues

- Location, location, location. The lack of infrastructure and distance to end users limit the feasibility of any of the elements on the location, which affects costs of the treatments, transportation of the fuel if applicable, and additional benefits to justify the treatments.
- See prior comments regarding feasibility issues with respect the PCT residue from coastal forests. The same issues apply to other residue types if there is no infrastructure or if the location is distant to end users.

Status of Group Approval

Approved.

Level of Group Support

Unanimous

Barriers to Consensus

Not applicable.

FAW-2. Expanded Use of Biomass Feedstocks for Energy Production

Policy Description

This policy recommendation would increase the amount of biomass available from forestry and municipal solid waste (MSW) for generating heat/electricity and liquid/gaseous biofuels to displace the use of fossil energy sources. It would also 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 the goals.
- By 2025, achieve the full policy goals.

Parties Involved: Executive and legislative branches of state government, DNR, Alaska Department of Environmental Conservation (DEC), Alaska Energy Authority (AEA), ANCs, UA, Southeast Conference, Alaska Industrial Development Authority, CES and agencies, NRCS, Alaska State Chamber of Commerce, RDC, Alaska Forest Association, Alaska Public Service Commission, Alaska Department of Revenue, Alaska electric utilities and cooperatives, crop producers, and timberland owners.

Other: None.

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 produce wood biomass alternative fuel products or generate heat and electricity;

- 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 MSW (e.g., urban wood waste, waste vegetable oil);
- Large- and small-scale technologies that generate heat and electricity (combined heat and power [CHP] as well as cogeneration) and the production of synthetic fuels from biomass;
- Both conventional and emerging technologies (e.g., cellulosic ethanol/other liquid fuel, pyrolysis, 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 co-firing with other fuels.

A strong timber industry in Alaska will serve to both stabilize and reduce the overall cost of delivered biomass in the state. If increased demand for biomass as a result of GHG policies can strengthen the market for timber, then there could be cost benefits in the future.

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 recommendation. 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, Nitrous Oxide (N_2O), Methane (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: 0.01, 0.03, 0.04, respectively.

Element B: 0.07, 0.12, 0.18, respectively.

Element C: 0.03, 0.06, 0.09, respectively.

[26] Governor Palin, State of Alaska, State of the State address, 2009. Available at: http://www.gov.state.ak.us/news.php?id=1610.

Net Cost per tCO_2e:

Element A: $90.

Element B: $38.

Element C: $52.

Element A. Biomass Feedstocks to Offset Heating Oil Use

Small-scale biomass heat generators are already being installed in public facilities in Alaska, such as schools. 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 GHG emissions. Through 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 2015 and on a more limited scale than the biomass heating units. The electricity generated through CHP goes toward the 5% state electricity goal, discussed further in Element B. The heating requirements for FAW-2 can be seen in Table H-10.

Table H-10. Heating needs to meet 10% biomass for heating goal

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

Btu = British thermal unit.

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-kilowatt (kW) generators, which if used as directed, would consume 442 dry tons of biomass feedstock annually, providing a little over 3,900 million British thermal units (MMBtus) of usable heat. Heat-only generators would be used for 2010–-2015, after which 50% of generators will be assumed to be heat-only and 50% will be assumed to be combined heat and power (CHP) units. These units will produce 443 megawatt-hours (MWh) of electricity (all figures annual), as well as the previously stated 3,900 MMBtus of usable 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 include the cost of the infrastructure to deliver any heat generated. The estimate of biomass feedstocks required comes from the amount of biomass needed to keep the generators in operation. Table H-11 outlines the costs of the small-scale CHP units required in this policy, 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, to provide a comparison of the cost-effectiveness of this policy, given the potentially large range of biomass costs that can occur in Alaska.

Table H-11. 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 @ $65/Dry Ton ($MM)	Cost of Biomass Feedstocks @ $120/Dry Ton ($MM)
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 Community Power Corporation information provided by Art Lilley, 2/14/09.

[28] Based on the estimate that the heat distribution cost is typically $4,000 and the system costs are $10,000–$20,000. See http://www.toolbase.org/Technology-Inventory/Electrical-Electronics/combined-heat-power.

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 @ $65/Dry Ton ($MM)	Cost of Biomass Feedstocks @ $120/Dry Ton ($MM)
2024	106	75	31	$2.0	46,894	$3.0	$5.6
2025	112	78	34	$2.1	49,688	$3.2	$6.0

CHP = combined heat and power; $MM = million dollars.

The electricity emissions factor used comes from the Alaska I&F. 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 ($/kilowatt-hour [kWh]) comes from the ESD TWG,[29] who gave an estimate for the avoided cost of electricity produced in rural Alaska to be 21.4 cents/kWh, which is significantly higher than the estimate for the state as a whole. See Table H-12 for more details.

Table H-12. 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)	Rural Electricity Cost ($/kWh)	Electricity Savings ($MM)
2009	0	0	0	0.53	$0.214	$0
2010	0	97	0	0.54	$0.214	$0
2011	0	195	0	0.53	$0.214	$0
2012	0	292	0	0.53	$0.214	$0
2013	0	390	0	0.52	$0.214	$0
2014	0	488	0	0.51	$0.214	$0
2015	0	591	0	0.51	$0.214	$0
2016	1,672	696	834	0.50	$0.214	$0
2017	3,374	803	1,662	0.49	$0.214	$1
2018	5,107	912	2,482	0.49	$0.214	$1
2019	6,872	1,022	3,295	0.48	$0.214	$1
2020	8,281	1,111	3,919	0.47	$0.214	$2
2021	9,655	1,197	4,509	0.47	$0.214	$2
2022	10,994	1,281	5,068	0.46	$0.214	$2
2023	12,300	1,363	5,596	0.45	$0.214	$3
2024	13,574	1,442	6,096	0.45	$0.214	$3
2025	14,944	1,528	6,625	0.44	$0.214	$3

CHP = combined heat and power; GHG = greenhouse gas; kWh = kilowatt-hour; $MM = million dollars; MWh = megawatt-hour; tCO_2e = tons of carbon dioxide equivalent.

[29] The avoided cost of rural electricity includes arctic northwest and southwest Alaska estimates. The primary source for the ESD figures is from AEA (http://www.iser.uaa.alaska.edu/Publications/akelectricpowerfinal.pdf).

The heat produced from CHP is shown in Table H-13 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 come from the Alaska Quantifications and Assumptions memo (Appendix E of this report). A 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 H-13. Heat produced and GHG savings from small-scale heating and CHP

Year	Heat Generated (billion Btu)	Heat Delivered (billion Btu)	Diesel Fuel Costs ($/MMBtu)	Diesel Fuel Savings—Heat ($MM)	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

Btu = British thermal unit; CHP = combined heat and power; GHG = greenhouse gas; $MM = million dollars; MMBtu = million British thermal units; O&M = operation and maintenance; tCO_2e = tons of carbon dioxide equivalent.

The total costs and GHG benefits of small-scale CHP are outlined in Table H-14. The cost-effectiveness estimated at a delivered biomass cost of $65/ton is $90/$tCO_2e$, while at $120/ton, the cost-effectiveness would be $128/$tCO_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.

Table H-14. Net costs of 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 ($MMtCO_2e$)
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	$2.2	$3.0	0.01
2017	$2.1	$2.9	0.02
2018	$1.9	$2.8	0.02
2019	$1.8	$2.7	0.02
2020	$1.4	$2.3	0.03
2021	$1.2	$2.2	0.03
2022	$1.1	$2.1	0.03
2023	$1.0	$2.0	0.03
2024	$0.9	$1.9	0.03
2025	$0.9	$1.9	0.04
Total	**$27**	**$39**	**0.3**

CHP = combined heat and power; GHG = greenhouse gas; $MM = million dollars; $MMtCO_2e$ = million tons of carbon dioxide equivalent.

Element B. Biomass Feedstocks for Electricity Use

The goal was determined using baseline data from the Alaska I&F.[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 H-15. The additional biomass needed reflects the net amount of electricity needed after consideration of the power that would be produced by the CHP units quantified under Element A, above.

[31] The CCS Alaska Energy Supply I&F (Appendix D).

Table H-15. 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)*
2009	6,504	0.0%	—	
2010	6,617	0.3%	21	206,795
2011	6,733	0.6%	42	420,816
2012	6,851	0.9%	64	642,252
2013	6,970	1.3%	87	871,296
2014	7,092	1.6%	111	1,108,148
2015	7,216	1.9%	135	1,353,010
2016	7,342	2.2%	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

* The assumed heat rate for biomass plant is 10,000 Btu per kilowatt-hour.

BAU = business as usual; CHP = combined heat and power; GWh = gigawatt-hour; 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 CO_2e emissions by the Alaska-specific emissions factor for electricity generation. The CO_2e associated with this amount of electricity in each year is estimated by multiplying the MWh produced by the Alaska-specific emission factor for electricity production from the Alaska GHG I&F (these values in tCO_2e/MWh vary in each year of the forecast).[32] See Table H-16 for more details.

[32] Total electricity emissions per MWh were provided by the ESD TWG, and range from 0.53 tCO_2e/MWh in 2009 to 0.44 tCO_2e/MWh in 2025. It is recognized that biomass combustion is not truly zero CO_2e/MWh; however, the methane and nitrous oxide emissions from biomass combustion are relatively small.

Table H-16. 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**	

CHP = combined heat and power; GHG = greenhouse gas; GWh = gigawatt-hour; MMBtu = millions of British thermal units; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MWh = megawatt-hour; tCO_2e = metric tons of carbon dioxide equivalent.

Biomass to Electricity Costs

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 H-17, and the assumed fossil fuel costs are indicated in Table H-18. While 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 forego this payment through delivery as an energy feedstock.

The cost of implementing the policy 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 the U.S. Environmental Protection Agency's (EPA's) Emissions & Generation

Resource Integrated Database (eGRID)—i.e., 72% coal, 13% natural gas, and 15% oil (it is assumed that biomass would not replace hydropower), as indicated in Table H-7.[33]

The difference in costs of feedstock supply between biomass and coal, natural gas, and heating oil is calculated using the costs outlined in Tables H-17 and H-18. The difference in costs ($/MMBtu) is multiplied by the amount of energy (MMBtu) being replaced by biomass. Operation and maintenance (O&M) costs were taken from Table 38 of the U.S. Department of Energy (DOE) Energy Information Administration's (EIA) *Annual Energy Outlook 2008.*[34] 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 co-firing with biomass feedstocks replacing traditional electricity consumption. The costs for both $65/delivered ton and $120/delivered ton are included.

Table H-17. 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 H-1), these costs are near the mid-point of the range of likely low-cost biomass feedstocks in Alaska (~$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).[35] The above cost information is also consistent with the information produced for the Wolverine Clean Energy Venture study in Michigan[36] and summaries on Michigan pulpwood costs in a document titled: *Michigan Timber Market Analysis. Final Report.*

$/MMBtu = dollars per million British thermal units.

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[33] 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).

[34] See http://www.eia.doe.gov/oiaf/aeo/.

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

[36] 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.

Table H-18. Assumed costs of fossil fuel feedstocks[37]

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 = dollars per million British thermal units.

Table H-19 shows the costs of biomass co-firing. Note that the fuel costs shown to in the far right columns of Table H-19 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 policy, although this changes from year to year based on fossil fuel costs. This explains why the fuel costs in the high-cost scenario outlined in Table H-19 are more than double the costs of the mid-range fuel costs scenario. The total costs of biomass co-firing are outlined in Table H-20.

[37] Fossil fuel costs ($/MMBtu) for 2009–2020 come from the Methods of Quantification memo (Appendix E). Costs for 2021–2025 were held constant at 2020 levels.

Table H-19. Costs of generating electricity from biomass

Year	Estimated Electrical Output (MWh)	Estimated Cumulative Capacity (MW)	Variable O&M Costs (2005 $MM)	Fixed O&M Costs (2005 $MM)	Fuel Costs—Mid-Range[a] (2005 $MM)	Fuel Costs—High[b] (2005 $MM)
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	2	$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.

$MM = million dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MW = megawatt; MWh = megawatt-hour; O&M = operation and maintenance.

Table H-20. Net costs of biomass-to-electricity production

Year	Total Costs @ $65/Dry Ton (2005 $MM)	Total Costs @ $120/Dry Ton (2005 $MM)
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

Year	Total Costs @ $65/Dry Ton (2005 $MM)	Total Costs @ $120/Dry Ton (2005 $MM)
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**

$MM = million dollars.

Element C. Biomass Feedstocks to Offset Fossil Transportation Fuels

Biofuel GHG Reductions

The benefits for this policy are dependent on developing in-state production capacity that achieves GHG benefits beyond petroleum fuels. This policy 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 H-2.12 lists the quantity of biofuels required in each year to meet the goals of FAW-2.

Table H-21. 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

AK = Alaska; BAU = business as usual; MM = million.

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).[38] 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.[39] This increase was assumed based on the maturation of cellulosic ethanol technology, allowing increased yield per ton of biomass feedstock.

Table H-22 shows the number of 3 million (MM) 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 emission reductions from cellulosic ethanol

[38] Argonne National Laboratory GREET (Greenhouse gases, Regulated Emissions and Energy use in Transportation) model 1.8b emission factor for mixed feedstock cellulosic E100 (100% ethanol) for flex-fuel vehicle in grams per mile (g/mi) x GREET model average fuel economy (100 mi/4.3 gal).

[39] J. Ashworth, U.S. DOE, National Renewable Energy Laboratory, personal communication with S. Roe, CCS, April 2007.

will not occur in Alaska, and thus must be counted separately. Otherwise, comparing the forecast reductions against the Alaska I&F would no longer be possible.

Table H-22. 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 Emission Reductions ($MMtCO_2e$)	Total In-State Emission Reductions ($MMtCO_2e$)
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
Total				**1.0**	**0.8**

MM = million; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; yr = year.

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 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 page M-H-1 of this appendix.

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 DOE National Renewable Energy Laboratory (NREL) was used to estimate the O&M costs of a 70-MMgal/yr cellulosic ethanol plant.[40] 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

[40] 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). Accessed June 2008 at www.nrel.gov/docs/fy02osti/32438.pdf.

produce 3 MMgal ethanol/yr. The average capital cost of a new cellulosic ethanol plant is estimated to be $21.5 million, which is based on the average capital cost/MMgal of production for six different cellulosic ethanol plants. The costs estimated for these plants were quite variable, so rather than taking the estimated cost of a single plant, an average of $7.17/gal/yr was used. For a 3-MMgal/yr plant, this average results in a cost of $21.5 million. A new plant will need to be built for every 3 MMgal 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, the NREL estimate of feedstock costs ($30/ton) were replaced with more current estimates of the cost of delivered biomass: $65/ton for woody feedstocks.[41] 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 EIA *Annual Energy Outlook 2009*).[42] The costs of cellulosic ethanol production are shown in Table H-23. The value of the cellulosic ethanol produced and net costs of the program are outlined in Table H-24.

[41] 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 (http://michigansaf.org/Forestinfo/1-Maininfo.htm). Alaska biomass costs will be substituted once they are available.

[42] See http://www.eia.doe.gov/oiaf/aeo/.

Table H-23. Cost summary for cellulosic ethanol plants

Year	Cellulosic Ethanol Production (MM gal)	Cost of Feedstock @ $65/Ton Biomass (2005 $MM)	Cost of Feedstock @ $120/Ton Biomass (2005 $MM)	Other Annual Costs ($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; $MM = million dollars.

Table H-24. Cellulosic ethanol revenue and net costs

Year	Sale Price/Gallon 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**

$MM = million dollars.

To provide an overview of the entire policy, Table H-25 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 H-25. 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 ($MM)	Net Costs ($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

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 ($MM)	Net Costs ($MM)
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**

$MM = million dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Key Assumptions: The discount rate used in this analysis is 5%, as stated in the Methods of Quantification memo in Appendix E. 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 for Element C, or $66/t (as opposed to the current estimate of $41 million and $52/t).

Key Uncertainties

- *General*—Delivered fuel costs are highly dependent on project specifics, location, and infrastructure. A detailed biomass feedstock analysis that identifies the volume of biomass available and at what cost from mill waste, improved timber harvest utilization, pre-commercial thinning, and commercial thinning is essential to provide accurate estimates of the cost-effectiveness of biomass technologies.
    - Even in cases where biomass is currently available at a reasonable price, it can be difficult to find capital investment in biomass-intensive projects. Because the timber industry has declined significantly in the past two decades, uncertainty in long-term biomass supply factors into decision making regarding capital investments. Additional biomass sources that can be demonstrated to be reliable in the long term (such as MSW) would be helpful in securing additional investment in biomass technologies.
    - 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. If 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 geographic information system-based, localized approach to feedstock availability would significantly improve these analyses.
- *Economies of scale*—The rural Alaska setting presents challenges due to remoteness, size of communities, O&M capabilities, etc. Urban areas may have lower costs for coal, natural gas, and hydroelectric power, which makes renewable technologies less cost-competitive.

- *Net GHG reductions for biomass energy displacement of fossil fuels*—The total fuel-cycle emissions for collection, processing, delivery, and combustion of biomass have not been captured in the current analysis. However, the full fuel-cycle GHG emissions associated with fossil fuel extraction, processing, and transport have also not been factored into the estimates of net GHG reductions. Based on previous similar analyses, CCS does not believe that factoring the full fuel-cycle emissions would have a significant impact on the results.
- *Biomass supply*—The feasibility of any wood waste to be used in an alternate fuel project will be based in part on the cost of the biomass or "supply." The capital costs of adding a biomass wood waste facility to produce heat and/or heat and power at an existing mill are significant and should consider at a minimum the following points:
  - *Wood waste from the mill operation.* Logging and hauling costs have already been expended in getting the logs to the mill to manufacture lumber. This is the lowest-cost material for supply.
  - *Improved utilization from existing logging operations.* This wood is currently left in the woods or at the sort yard and is not recovered for any product. Fixed costs for roads, sort yards, equipment mobilization, etc., have been expended for the logs being sought for export or manufacture. Additional costs are the increased marginal costs to handle this material and to deliver it to the mill site. Material from conventional harvest systems will cost less than material that could be harvested from helicopter operations.
  - *Silviculture: commercial thin.* Costs for this biomass material are partly or wholly offset by revenue from the commercial log from which a product will be manufactured.
  - *Silviculture: pre-commercial thin.* This biomass is the most expensive material, as the trees being cut by definition are not commercial, so no revenue is being generated. Also, the size and nature of the material are the most costly to handle and transport to processing centers. No yarding equipment is mobilized for PCT and transportation infrastructure (such as roads, bridges, and sort yards), and log transfer facilities are often not in service when PCT takes place. The ratio of removed stems to crop trees can exceed ten to one, and damage to crop trees by removal of PCT residue is certain.
- *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*—There 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-MMgal/yr) ethanol plant. The analysis for Element C assumes four 3-MMgal/yr plants, although some of the costs are scaled down from cost estimates of larger plants. While the analysis attempts to avoid 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 a big economic benefit in communities, particularly rural areas where energy costs are a significant part of the economy. Dollars stay in the community versus being 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 the 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 affect important long-standing business in Alaska.
- Risks are associated with technologies that are unfamiliar, risks of system failure, or increases in life-cycle costs.
- Risks of fuel supply disruptions often require redundant multi-fuel systems for backup in addition to capital costs.

Feasibility Issues

Location, economies of scale, and limitations in infrastructure all make careful selection of biomass projects important. Early failures could 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

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

FAW-3. Advanced Waste Reduction and Recycling

Policy Description

This policy recommendation will 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, and management of organic wastes decreases downstream GHG emissions associated with the production of methane in landfills. This policy will also 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 policy's goals 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 the waste stream, via source reduction/re-use and waste diversion, by 10% by 2012, 15% by 2015, and 25% by 2025.

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

Parties Involved: Consumers, manufacturers, relevant trade associations, consumer associations, all state and local agencies, retail outlets, nonprofit 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 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.[43] 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.[44]

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[43] See http://touchngo.com/lglcntr/akstats/STATUTES/Title46/Chapter06/Section031.htm.

[44] See http://www.emergeknowledge.com/retrac.html.

- 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 of 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, began implementing a Pay As You Throw (PAYT) and curbside recycling program in October 2008. The residential waste hauler, Alaska Waste, is offering curbside recycling service to one-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 has statewide 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 its Web site 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 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 DEC, along with input informing the cost parameters.[45] Where Alaska-specific data were not available, CCS utilized national defaults derived from the EPA 2007 waste characterization report.[46] GHG emission reductions were modeled using EPA's WAste Reduction Model (WARM).[47]

Quantification Methods:

Business-as-Usual Waste Management Forecast

The BAU waste management profile in Alaska was developed using input from DEC.[48] However, 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 more than 20 tons/day, Class II accept 5–20 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).[49] (See Table H-26 for the total Alaska waste management projection.) The remainder of this section will describe the methods for developing the BAU waste management forecasts for distinct communities and community groups in Alaska.

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[45] 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.

[46] 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.

[47] U.S. EPA. "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.

[48] 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.

[49] 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 H-26. Alaska BAU waste management projection, 2005–2025

Total Alaska MSW	2005	2010	2012	2015	2020	2025
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)[a]	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%

[a] "MSW Diverted" includes waste recycled and waste composted.

BAU = business as usual; MSW = municipal solid waste.

According to data provided by DEC, 310 communities in Alaska deposit waste in 222 Class III landfills. The waste generation from these communities is assumed to be 5.9 lb/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. DEC reported that about 10 tons/yr of aluminum cans are shipped from Class III communities to be recycled. The quantity and growth rate of waste incinerated in Class III landfill communities are consistent with inputs used for the Alaska I&F. The amount of waste landfilled is the difference between the waste generated and the waste incinerated and diverted. Table H-27 presents the BAU waste management projections for the Class III landfill communities.

Table H-27. BAU waste management projections for Class III landfill communities, 2005–2025

Class III Landfill Communities	2005	2010	2012	2015	2020	2025
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)[a]	10	10	10	10	10	10

[a] "MSW Diverted" includes waste recycled and waste composted.

BAU = business as usual; MSW = municipal solid waste.

Similar to Class III landfill communities, Class II landfill communities are assumed to generate 5.9lb/person/day of waste. DEC estimates that Class II communities account for 7.3% of the total population of Alaska, and reported a small amount of waste recycled at these facilities (less than 300 tons/yr). The waste incinerated is based on the estimated amount incinerated by the North Slope Borough in Barrow. Therefore, the total waste landfilled is the difference between the waste generated and the waste incinerated. Table H-28 presents the BAU waste management projections for Class II landfill communities.

Table H-28. BAU waste management projections for Class II landfill communities, 2005–2025

Class II Landfill Communities	2005	2010	2012	2015	2020	2025
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)	3,609	3,753	3,841	3,975	4,167	4,341
MSW Diverted (tons)[a]	222	262	278	304	352	409

[a] "MSW Diverted" includes waste recycled and waste composted.

BAU = business as usual; MSW = municipal solid waste.

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 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 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%.[50] 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.[51] It was also assumed that no MSW combustion took place in Class I landfill communities. Table H-29 outlines the waste management projections for Class I landfill communities.

Table H-29. BAU waste management projection for Class I landfill communities, 2005–2025

Class I Landfills	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) [a]	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) [a]	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

[50] 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, 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.

[51] 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.

Class I Landfills	2005	2010	2012	2015	2020	2025
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) [a]	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) [a]	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) [a]	1,766	1,792	1,801	1,814	1,824	1,822

[a]"MSW Diverted" includes waste recycled and waste composted.

BAU = business as usual; MSW = municipal solid waste.

GHG Benefit Analysis

CCS applied the goals set forth by the MAG in the Policy Design section of this policy to the Alaska BAU waste management scenario in Table H-26. As the TWG did not prescribe a specific ratio of diversion that will be met through recycling/composting to what will be met through source reduction, CCS assumed the ratio of the two diversion strategies needed to meet the goal. Tables H-30, H-31, and H-32 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 2013, it is assumed that there is zero incremental diversion in these years.

Table H-30. Yearly waste management targets, 2010–2025

Types of Diversion	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 H-31. Alaska policy waste management scenario, 2010–2025

Total Alaska	2010	2012	2015	2020	2025
MSW Generated (including source reduction, 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

MSW = municipal solid waste.

Table H-32. Alaska incremental waste diversion, 2010–2025

Total Alaska	2010	2012	2013	2015	2020	2025
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**

MSW = municipal solid waste.

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 H-33 portrays the assumed incremental waste diversion for each of the major population centers in Alaska.

Table H-33. Metro Class I landfill incremental waste diversion, 2010–2025

Metro Class I Landfills	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

MSW = municipal solid waste.

GHG benefits were determined by using WARM,[52] which uses information for specific material inputs and disposal/diversion methods to estimate GHG emission reductions based on BAU and

[52] U.S. EPA. 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 U.S. EPA, *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.

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 toward the total emissions. CH_4 and N_2O emissions due to landfilling or combustion of organic waste, as well as avoided future CO_2 sequestration are counted toward 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. Tables H-34 and H-35 show the baseline waste generation, disposal, and diversion characterization. Table H-35 shows all potential waste types that may be entered into WARM, although data were 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 H-34. Assumed baseline Alaska waste characteristics—waste categories

Waste Categories	Baseline Generation Composition (BAU)	Baseline Anchorage, Juneau, Fairbanks Recycling Composition (BAU)	Baseline Mat-Su Valley Recycling Composition (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%

BAU = business as usual.

Table H-35. Assumed baseline Alaska waste characteristics—waste types

Waste Types	Baseline Generation Composition (% of waste generated)[53]	Baseline Anchorage, Juneau, Fairbanks Recycling Composition (% of waste recycled)[54]	Baseline Mat-Su Valley Recycling Composition (% of waste recycled)[55]	Baseline Non-Metro Recycling Composition (% of waste recycled)[56]	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%**

HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

[53] 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.

[54] 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.

[55] Ibid.

[56] Ibid.

The BAU and policy waste management projections (Tables H-26 and Table H-31, respectively) were multiplied by the percentages in Table H-35 to provide WARM inputs for 2015 and 2025. Again, it was assumed that the maximum diversion rate for any given waste type is 90%. It was also assumed that only biogenic waste (i.e., paper and organics) could be combusted. The amount of each biogenic waste type combusted is in proportion to that waste type's generation quantity. The amount of 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 H-36 and H-37 display the BAU and policy WARM modeling for 2025.

Table H-36. 2025 BAU WARM inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	5,730	281	5,449	—	N/A
Steel Cans	9,576	—	9,576	—	N/A
Copper Wire				—	N/A
Glass	53,294	1,194	52,100	—	N/A
HDPE	22,173	—	22,173	—	N/A
LDPE	25,116	—	25,116	—	N/A
PET	14,756	—	14,756	—	N/A
Corrugated Cardboard	122,561	21,867	93,449	7,245	N/A
Magazines/Third-Class Mail	33,201	1,988	29,250	1,963	N/A
Newspaper	43,090	7,625	32,918	2,547	N/A
Office Paper	23,547	161	21,994	1,392	N/A
Phonebooks	2,747	303	2,282	162	N/A
Textbooks	5,259	—	4,948	311	N/A
Dimensional Lumber					N/A
Medium-Density Fiberboard					N/A
Food Scraps	124,209	N/A	116,867	7,342	—
Yard Trimmings	128,055	N/A	119,217	7,570	1,268
Grass		N/A			
Leaves		N/A			

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Branches		N/A			
Mixed Paper (general)					N/A
Mixed Paper (primarily residential)	70,797	7,497	59,115	4,185	N/A
Mixed Paper (primarily from offices)	24,567	—	23,115	1,452	N/A
Mixed Metals	66,127	36,997	29,130	—	N/A
Mixed Plastics	58,553	629	57,923	—	N/A
Mixed Recyclables	164,003	3,080	160,923	—	N/A
Mixed Organics		N/A			
Mixed MSW		N/A			N/A
Carpet					N/A
Personal Computers					N/A
Clay Bricks		N/A		N/A	N/A
Concrete				N/A	N/A
Fly Ash				N/A	N/A
Tires					N/A
Total	**997,360**	**82,890**	**880,301**	**34,169**	

BAU = business as usual; HDPE = high-density polyethylene; LDPE = low-density polyethylene; MSW = municipal solid waste; N/A = not applicable; PET = polyethylene terephthalate; WARM = WAste Reduction Model.

Table H-37. 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	—	N/A
Steel Cans	9,576	1,323	—	8,253	—	N/A
Copper Wire						N/A
Glass	53,294	7,361	2,873	43,060	—	N/A
HDPE	22,173	3,063	—	19,111	—	N/A
LDPE	25,116	3,469	—	21,647	—	N/A
PET	14,756	2,038	—	12,718	—	N/A
Corrugated Cardboard	122,561	16,928	52,621	45,766	7,245	N/A
Magazines/Third-Class Mail	33,201	4,586	4,784	21,869	1,963	N/A
Newspaper	43,090	5,952	18,350	16,242	2,547	N/A
Office Paper	23,547	3,252	388	18,515	1,392	N/A
Phonebooks	2,747	379	729	1,477	162	N/A
Textbooks	5,259	726	—	4,222	311	N/A
Dimensional Lumber						N/A
Medium-Density Fiberboard						N/A
Food Scraps	124,209	N/A	N/A	116,867	7,342	—
Yard Trimmings	128,055	N/A	N/A	117,434	7,570	3,052
Grass		NA	NA			
Leaves		N/A	N/A			
Branches		N/A	N/A			
Mixed Paper, Broad		N/A				N/A
Mixed Paper, Residential	70,797	N/A	18,041	48,571	4,185	N/A
Mixed Paper, Office	24,567	N/A	—	23,115	1,452	N/A
Mixed Metals	66,127	N/A	59,514	6,613	—	N/A
Mixed Plastics	58,553	N/A	1,515	57,038	—	N/A
Mixed Recyclables	164,003	N/A	36,930	127,073	—	N/A

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Mixed Organics		N/A	N/A			
Mixed MSW		N/A	N/A			N/A
Carpet						N/A
Personal Computers						N/A
Clay Bricks			N/A		N/A	N/A
Concrete		N/A			N/A	N/A
Fly Ash		N/A			N/A	N/A
Tires						N/A
Total	**997,360**	**49,868**	**199,472**	**713,851**	**34,169**	

HDPE = high-density polyethylene; LDPE = low-density polyethylene; MSW = municipal solid waste; N/A = not applicable; PET = polyethylene terephthalate; WARM = WAste Reduction Model.

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 H-38 displays a summary of the waste diversion, reduction, and GHG benefits of this policy recommendation.

Table H-38. Overall policy results—GHG benefits

Year	Avoided Emissions ($MMtCO_2e$)	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
Total	**5.3**	**1,336,463**	**388,502**	**933,806**	**14,155**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Cost-Effectiveness

Source reduction—The amount of source-reduced waste shown in Table H-31 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 the cost of disposal.

The cost of program implementation is assumed to be $1 per capita per year.[57] This cost applies only to the regions served by the Metro Class I landfills. The cost figure uses a population projection from Alaska Department of Labor.[58] 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

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

[58] 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.

household per month (calculations based on total households in these areas yield a per-ton collection cost of $9.72).[59] The landfill tipping 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.[60]

The analysis assumes that costs begin to be incurred in 2012. The estimated cost savings result in a net present value (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 H-39.

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[59] 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.

[60] 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 H-39. Cost analysis for source reduction

Year	Anchorage Tons Reduced	Fairbanks Tons Reduced	Mat-Su Tons Reduced	Juneau Tons Reduced	Alaska 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
Total	**286,260**	**54,631**	**34,583**	**13,028**					**–$7.9**	**–$5.3**

$MM = million dollars; MSW = municipal solid waste.

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.[61] Annualized over the 10-year policy period at 5% interest, the capital cost is $0.4 million/yr. 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 H-40 provides the results of the cost analysis, which 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$.

[61] 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).

Table H-40. 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
Total	**848,854**	**52,243**	**11,241**	**21,468**					**–$51.0**	**–$16.2**

$MM = million dollars.

Composting—As WARM considers the sole form of diversion for yard trimmings and food waste to be composting, the tons of these items that are "recycled" are assumed to be composted. The net costs for increased composting in Alaska were estimated by adding the additional costs for collection (same calculation as recycling) and the net cost for composting operations. The net cost for composting operations is the sum of the annualized capital and operating costs of composting, increased collection fees, revenue generated through the sale of compost, and the avoided tipping fees for landfilling. Information on the capital and operating costs of composting facilities was received from Cassella Waste Management during the analysis of a similar option in Vermont.[62] These data are summarized in Table H-41.

Table H-41. Capital and operating costs of composting facilities

Annual Volume (tons)	Capital Cost ($1,000)	O&M Cost ($/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

O&M = operation and maintenance.

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 H-41. 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 $16.50/ton,[63] and a compost value of $16.50/ton.[64]

Table H-42 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 $13/$tCO_2e$.

[62] 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.

[63] 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.

[64] 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 H-42. 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
Total	**12,366**	**1,415**	**—**	**374**							**–$0.1**	**$0.03**

$MM = million dollars; O&M = operation and maintenance.

The overall cost analysis, as seen in Table H-43, 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 H-43. 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 $MM)	Cost-Effectiveness ($/$tCO_2e$)
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	
Total	**–$20.8**	**–$51.0**	**–$0.08**	**–$71.9**	**–$43.2**	**–$8**

$MM = million dollars; $/$tCO_2e$ = 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 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 waste disposed of is placed in landfills that actively recover methane at this assumed rate.

Key Uncertainties

According to 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 techniques used to treat this waste (e.g., recycling, landfilling) are not known, 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 WARM 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 industry, 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 (e.g., aluminum) subsidize lower-value materials (e.g., 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 MAG feels that the economic uncertainty present at the time of this analysis may justify a decrease in the discount rate. The cost-effectiveness analysis described above was repeated with a 3% discount rate, rather than a 5% discount rate. The lower discount rate increases the NPV of the savings from FAW-3 to –\$53 million, for a cost-effectiveness of –\$10/tCO_2e.

Additional Benefits and Costs

- Increased recycling will increase the anticipated life span of existing landfills due to the decreased amount of waste disposed of in those landfills.
- Increased recycling will decrease the revenue generated by landfills, but may not yield an equivalent decrease in operating costs.
- Small-scale composting of MSW could reduce costs for some rural communities by generating soil material that could be used as cover material for the local landfill.

Feasibility Issues

None identified.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

NS-6. Develop Capacity in New Forestry and Wood Biomass Opportunities

Following is a policy that was considered by the Alaska Natural Systems Adaptation Group. This policy has been moved to this appendix because of the overlap between it and FAW-1 and FAW-2B. This policy is mostly concerned with fostering the growth and management of healthy forests in Alaska, and getting the most possible benefits from Alaska's forestland. While the GHG benefits of adaptation policies are not quantified, this policy nonetheless can provide additional insight into issues of forest health. There is overlap with biomass supply in all of FAW-1 and FAW-2B.

Policy Description

Alaska should invest in economic development and infrastructure to attract and facilitate development of industrial capacity, at appropriate scales, to use insect- or fire-damaged timber and underutilized or new sources of wood biomass.

As the changing climate stresses the forests of Alaska, mortality of trees will increase due to insects, fire, and tree-decline agents. Finding economic and innovative uses for dead, small, and underutilized species will help managers confront this forest health crisis and provide for resilient forests more able to withstand rapid change.

This policy would invest in developing and deploying new harvesting technology and silvicultural techniques and demonstrating a variety of wood biomass systems to produce heat and power for rural and urban communities.

This policy would build on work initiated by the Alaska Wood Energy Development Task Group in 2002 and continue efforts to complete feasibility studies, engineering, financing, and construction of biomass space-heating facilities for public buildings. This can occur at several different scales—from individual wood-pellet stoves, solid-wood boilers, and wood-chip boiler systems. The policy would also explore the use of wood chips in co-firing applications with coal to produce electricity in large-scale utility settings.

Without investment in and demonstration of these types of projects and facilities, the technology will be slow to develop in Alaska. While there has been significant movement toward a variety of alternative energy options, wood biomass consistently ranks near the top in economics and ability to be implemented quickly. By demonstrating different technologies at a variety of scales, communities will be able to choose the best options for their situation. This would include fuel type, quantities available on a sustainable and economic basis, heat-load need, and a variety of other factors. In turn, this will permit forest managers to aggressively address forest health issues and utilize wood that would otherwise increase fire hazard and cause further declines in forest stand and community resilience.

Policy Design

This policy has several different facets that work together to achieve the overall result of using dead, small, or underutilized tree species to improve overall forest health and to form the basis of a wood bioenergy industry. This industry can function at several scales and can be as simple as an energy-efficient wood stove in a single-family dwelling, to a large, complex wood-energy plant in an urban community. The important aspect of this proposal is that it can be implemented at both the small and the large ends of the wood-energy spectrum, with numerous options in between. Communities can scale their options to the level they are comfortable with.

Currently in the state, there are several installations of Garn boilers, which use solid wood, much like a wood stove, but on a larger scale. The Garns are used to heat public buildings and other small-to-medium-sized buildings. There is a need to demonstrate a wood chip system that is more automated than the Garns and can handle large heat loads, such as an entire high school, hospital, or prison. Two communities, Delta and Tok, are considering a project like this, and both have applied to the AEA grant program to secure funds to move ahead with this work.

The next step up would be to look at a co-firing opportunity with an electric utility, where coal and wood chips would be burned together to produce the steam required to run turbines and generators to make electricity. UA is interested in this off-the-shelf technology for a proposed new generating unit at its Fairbanks campus.

All of these options are viable short-term solutions that have been in use in other parts of the nation and the world for many years. Alaska's cheap supplies of energy have prevented their evaluation and use in the state, and there is a need to demonstrate their reliability and economic feasibility.

In addition, air quality and related health issues have been raised by EPA concerning fine particulate matter (PM), called $PM_{2.5}$. Recently, the community of Fairbanks joined the City and Borough of Juneau in being a nonattainment area for the $PM_{2.5}$ standard. Wood-burning appliances, especially older wood stoves and some outdoor wood furnaces, will not meet this standard. Wood pellet stoves and boilers can meet this standard, and homeowners may need to switch to this type of fuel if they wish to continue using wood fuels. There is a need to manufacture wood pellets in Alaska, and at least one company has taken steps to do so, but there is much work to do on the harvesting and transportation sides to ensure that pellets can be produced economically.

This is important for mitigating the effects of climate change, because wood burning offsets fossil fuels, like oil, coal, or natural gas. Wood also produces CO_2 when combusted, but new trees are taking the place of harvested trees in the forest. These young trees sequester carbon and thus are considered carbon-neutral from a GHG perspective. Additionally, if the nation or Alaska adopts a cap-and-trade program for GHGs, the fuel offsets mentioned above can be sold as carbon credits in carbon exchange markets, such as CCX.

Goals:

There are several overarching goals for this policy:

- Replace fossil fuels with a renewable, locally produced fuel that is considered carbon-neutral with regard to GHG emissions.
- Create local employment in harvesting, silvicultural work, and operation of energy facilities, especially in rural communities.

- Actively manage forestlands for a variety of social, economic, and biological benefits.
- Demonstrate the feasibility and economics of different bioenergy technologies, from small- to large-scale technologies for space heating and electrical needs.

Specific goals include:

- Construct a wood chip boiler installation at a public school or similar facility, and have it operational by 2010.
- Complete feasibility studies for five communities interested in wood energy projects annually for each of the next 10 years.
- Develop and demonstrate harvesting and transportation systems using currently available equipment for wood energy facilities. Demonstrate one road-based system and one rural harvesting system.
- Establish a wood energy coordinator position in DOF to provide technical assistance to communities and AEA to determine the sustainability of wood supplies for wood energy projects.

Timing:

- Build on projects already initiated to enable rapid deployment of wood energy systems beginning in 2009. Additional projects can be brought on line as soon as feasibility studies, engineering, financing, and construction can be accomplished.
- Over the next 10 years, numerous projects can move forward in both urban and rural communities.
- Results will be both short and long term, and can be expected to continue through the design life of the facility.

Parties Involved: A number of entities can participate in this effort, ranging from public and private organizations with expertise in the areas discussed. A partial list would include AEA, Alaska Wood Energy Task Group, DOF, USFS, state and private forestry, DOE, USFS Forest Products Lab, Tanana Chiefs Conference, UA, Cold Climate Housing Research Center (CCHRC), and others.

Evaluation: The main type of monitoring would take place on the forest management side of this proposal. Managers would ensure that forest health and productivity were being maintained on sites and that best management practices (BMPs) were being applied. The state's Forest Resources and Practices Act could provide both effectiveness and implementation monitoring of BMPs.

Forest certification via a third-party organization, such as the Sustainable Forestry Initiative or the Forest Stewardship Council, could also ensure appropriate management standards are in place.

Research and Data Needs: The concept that wood fuels are carbon neutral should be thoroughly examined. This is a complex topic that involves carbon budgets and cycles in a dynamic environment. Protocols for certifying carbon storage and sequestration rates are needed for boreal and coastal forests.

Research in new harvesting equipment or application and adaptation of current equipment should be supported.

Air quality monitoring and testing of various wood-burning appliances should be completed in an arctic environment. CCHRC would be an ideal organization to conduct this needed work.

Implementation Mechanisms

This policy can best be implemented by building on efforts underway in a number of other organizations.[65] Coordination of these efforts is a key element for success and the efficient use of funding and talent. Currently, several projects are moving ahead as the result of funding via the AEA Alaska Renewable Energy Fund grant process. Fifteen wood biomass projects were funded under the Round 1 request for proposals, and the emphasis for this option should focus on providing support and technical assistance to ensure all these projects are successfully implemented.

Hiring a wood energy coordinator in DOF to provide technical assistance would facilitate accomplishing these projects. A key aspect will be developing harvest and biomass sourcing plans to ensure an economic and stable supply of biomass for these projects. This position would also assist with initial feasibility analysis for proposed projects and would focus on quantifying available fuel supplies and the cost per delivered ton of biomass feedstock to an energy facility. This will help ensure projects are viable from both economic and biological perspectives.

With regard to air quality concerns, work is also underway at CCHRC to test different types of wood-combustion appliances and fuel types to quantify emission profiles. This effort is instrumental in identifying the appropriate technologies for use in residential and light commercial applications, especially in urban and suburban locations. Support for this work should continue and should be expanded with additional funding as needed.

UA should be encouraged to continue its evaluation of the feasibility of including a co-firing bioenergy option for the proposed new power facility on campus. A facility that would co-fire wood chips or industrial pellets with coal should receive due consideration. A publication and resources from the USFS Sitka Forest Products Lab should be consulted in the process.[66]

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[65] Alaska Wood Energy Development Task Group Briefing Paper, Division of Forestry, May 2008. Available at: http://forestry.alaska.gov/pdfs/08DOF_AWEDTGBriefing.pdf.

[66] Nicholls, D.L., Patterson, S.E. and Uloth, Erin, *Wood and Coal Cofiring in Interior Alaska: Utilizing Woody Biomass From Wildland Defensible-Space Fire Treatments and Other Sources,* USFS Sitka Forest Products Lab, 2006. Available at: http://www.treeresearch.fs.fed.us/pubs/22566.

Related Policies/Programs in Place

Governor Palin's energy goal of 50% renewable by 2025 is directly related to the elements of this policy. Woody biomass for both heat and power production can play a role in achieving this goal, along with other types of renewable energy.

The Fuels for Schools program in the intermountain western states is a good example and source of information for woody biomass energy projects and should be emulated in Alaska.[67] Many other examples of successful wood energy projects around the country and overseas should be consulted as Alaska furthers the development of a state program.

Feasibility Issues

The suite of wood energy options for space heating is a well-understood technology that is very feasible to implement at the scales discussed. There is some need to ensure that air quality issues are addressed and the appropriate combustion appliances are recommended for situations unique to each application and community. Power generation options are also well understood, at least for larger-scale operations, such as in co-firing or in stand-alone biomass generation facilities. Problems could result if the scale of a facility is too large and is mismatched to the biomass resource. A thorough fuel analysis should be completed for proposed projects to ensure they are well matched to the sustainability, quantity, and type of biomass fuels in the area.

Projects that are considering a CHP approach (co-generation) are also fairly straightforward, but at smaller scales the technology is still developing. The same can be said for some of the harvesting equipment currently under development or just recently developed for small-stem biomass applications. While there are promising advancements in this field, caution and due diligence should be completed before investing capital in some of these prototype or first-generation harvesting or wood power systems.

Additional Benefits and Costs

In addition to the benefits of reducing CO_2 emissions via the offset of fossil fuels, this policy produces a number of direct and indirect benefits to the communities and individuals who adopt these principles.

Direct Benefits

- A huge asset to a community is a sustainable fuel supply that is locally produced and not subject to the wild fluctuations of fuel oil and natural gas.
- Forestlands surrounding the community will be actively managed, and a number of forest health benefits will accrue as a result. The treatment of hazard fuels will reduce future costs of suppressing fire in areas where the state cannot allow fire to burn, and will reduce overall emissions when treated areas do burn.

Indirect Benefits

[67] See http://www.fuelsforschools.info/.

- The importance of creating jobs and economic development, especially in rural areas of the state, cannot be overstated. Jobs will result from opportunities in both harvesting and other forest management activities, and in the operation of energy facilities.
- Habitat improvements will benefit a variety of species that depend on a mosaic of vegetation types and early-succession stages of forest development.
- Biomass facilities that replace previously used fossil fuels will be able to sell carbon credits for the fuel offsets generated.
- Providing a use for the low-quality, small-diameter trees in the forest will create opportunities for expansion of the forest product industry. Higher-quality trees can be sawn or processed into other products, because the whole stand will be managed, not just the best-quality trees.

Costs: The only specific cost generated by this policy is the creation of a wood energy forester position in DOF. Salary and operating costs would be approximately $100,000/yr. Key duties are discussed in the Implementation Mechanisms section, above.

Other direct costs would be the various projects, but other funding sources are currently available, such as AEA, USFS, DOE, and under some of the provisions of the American Recovery and Reinvestment Act (ARRA) of 2009. The Alaska Wood Energy Task Group via DOF and USFS has submitted a proposal for funding under the ARRA that would fund a number of wood energy projects around the state.