Alaska Climate Change Strategy's Mitigation Advisory Group

Final Report

Greenhouse Gas Inventory and Forecast

and

Policy Recommendations

Addressing

Greenhouse Gas Reduction in Alaska

Submitted to the

Alaska Climate Change Sub-Cabinet

August, 2009

Table of Contents

Acknowledgments

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Members of the Alaska Climate Change Mitigation Advisory Group

The Alaska Climate Change Mitigation Advisory Council (MAG) was comprised of 26 representatives from Alaska's business community, utilities, petroleum producers and other key industries, environmental organizations, public interest groups, universities and research institutions, military installations, and state, local, and tribal government. The Governor's Office selected the following individuals to serve on the Alaska Climate Change Mitigation Advisory Group:

Larry Hartig, Chair, Executive Sub-Cabinet on Climate Change; Commissioner, Department of Environmental Conservation

Steve Colt, Economist, Institute for Social & Economic Research, UAA (Anchorage)

Jeff Cook, Government Affairs, Flint Hills Resources (Fairbanks)

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Randy Virgin, Director, Sustainability, Economic and Community Development, Municipality (Anchorage)

Kathie Wasserman, Director, Alaska Municipal League (Juneau)

Dan White, Director, Institute of Northern Engineering, UAF, Fairbanks

The following individuals were also selected by the Governor's Office and served on the MAG for a portion of its tenure:

Scott Anaya, Director, Alaska Building Science Network (Anchorage)
Robert Batch, V.P., Health, Safety, Environment, BP Exploration (Alaska) Inc. (Anchorage)
Joe Everhart, Senior Vice President, Wells Fargo (Anchorage)
Stan Stephens, Owner, Stan Stephens Charters (Valdez)

Acronyms and Abbreviations

Acronym	Definition
$/tCO$_2$e	dollars per metric ton of carbon dioxide equivalent
$MM	Million dollars
A/V	audio
AAG	Adaptation Advisory Group
AARA	American Recovery and Reinvestment Act of 2009
ADOL	Alaska Department of Law
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEA	Alaska Energy Authority
AEO2006	*(EIA) Annual Energy Outlook 2006*
AEO2008	*(EIA) Annual Energy Outlook 2008*
AFOLU	Agriculture, Forestry, and Other Land Uses
AFV	alternative-fuel vehicle
AG	Above ground
AHFC	Alaska Housing Finance Corporation
AIDEA	Alaska Industrial Development and Export Authority
AK	Alaska
AMATS	Anchorage Metropolitan Area Transportation Solutions
ANC	Alaska Native Corporation
ANCSA	Alaska Native Claims Settlement Act
AOGCC	Alaska Oil and Gas Conservation Commission
API	American Petroleum Institute
APTA	American Public Transportation Association
APU	auxiliary power unit
BAU	business as usual
BBLS	barrels
BC	black carbon
BDT	bone dry ton
BIA	Business & Industry Association of New Hampshire
BMP	Best management practices
BOD	biochemical oxygen demand
BOF	(Alaska) Board of Fisheries
Btu	British thermal unit
C	carbon
CAA	(US) Clean Air Act

Acronym	Definition
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CBM	coal bed methane
CC	Cross-Cutting Issues
CCHRC	Alaska Cold Climate Housing Research Center
CCS	Center for Climate Strategies
CCSC	Alaska Climate Change Sub-Cabinet
CCSR	carbon capture and storage, sequestration and/or reuse
CCX	Chicago Climate Exchange
CEC	Commission for Environmental Cooperation
CES	Cooperative Extension Service
CFC	chlorofluorocarbon
CFL	Compact fluorescent lights
CGF	central gas facility
CH_4	Methane
CHP	combined heat and power
CMAI	culmination of mean annual increment
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COE	U.S. Army Corps of Engineers (Alaska District)
COPs	Conferences of the Parties
CPC	Community Power Corporation
CSE	cost of saved energy
CT	Commercial thinning
CWPP	Community Wildfire Protection Plan
DCCED	(Alaska) Department of Commerce, Community, and Economic
DEC	(Alaska) Department of Environmental Conservation
DMV	Department of Motor Vehicles
DNR	(Alaska) Department of Natural Resources
DOE	(United States) Department of Energy
DOF	(Alaska DNR) Division of Forestry
DOR	(Alaska) Department of Revenue
DSM	demand-side management
EC	elemental carbon
EE	energy efficiency

Acronym	Definition
EEZ	exclusive economic zone
eGRID	(US EPA) Emissions & Generation Resource Integrated Database
EGU	electric generating unit
EIA	(US DOE) Energy Information Administration
EIIP	Emission Inventory Improvement Program
EISA	Energy Independence and Security Act of 2007
EOR	enhanced oil recovery
EPA	(United States) Environmental Protection Agency
EPAct	federal Energy Policy Act (2005)
EPRI	Electric Power Research Institute
EPS	Environmental Program Specialist
ESD	Energy Supply and Demand
EUR	estimated ultimate recovery
FAA	Federal Aviation Administration
FAW	Forestry, Agriculture and Waste
FF	fossil fuels
FHWA	Federal Highway Administration
FIA	(USFS) Forest Inventory and Analysis
FMATS	Fairbanks Metropolitan Area Transportation Study
g	gram
gal	gallon
GHG	greenhouse gas
GWh	gigawatt-hour [one million kilowatt-hours]
GWP	global warming potential
HB	House Bill
HDPE	high-density polyethylene
HFC	hydrofluorocarbon
HPS	high-pressure sodium
HVAC	heating, ventilation, and air conditioning
I&F	Inventory and Forecast
IAWG	Immediate Actions Work Group
Ind.	Industrial
IPCC	(United Nations) Intergovernmental Panel on Climate Change
ISER	Institute for Social and Economic Research
ITS	intelligent transportation system
JPO	Joint Pipeline Office

Acronym	Definition
kg	kilogram
kW	kilowatt
kWh	kilowatt-hour
lb	pound
LDPE	low-density polyethylene
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design [Green Building
LF	landfill
LFGTE	landfill gas-to-energy
LMOP	(EPA) Landfill Methane Outreach Program
LPG	liquefied petroleum gas
MAG	Mitigation Advisory Group
MM	million
MMBtu	million British thermal units
MMS	(Alaska) Minerals Management Service
MMt	million metric tons
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MPH	miles per hour
MPO	metropolitan planning organization
Mscf	thousand standard cubic feet
MSW	municipal solid waste
Mt	metric ton (1,000 kilograms or 22,051 pounds
MW	megawatt [one thousand kilowatts]
MWh	megawatt-hour [one thousand kilowatt-hours]
N	nitrogen
N/A	not applicable
N_2O	nitrous oxide
NASS	(USDA) National Agricultural Statistics Service
NEI	(EPA) National Emissions Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NextGen	Next Generation Air Transportation System
NGO	nongovernmental organization
NHDES	New Hampshire Department of Environmental Services
NIMBY	Not In My Back Yard
NO_x	oxides of nitrogen
NPV	net present value

Acronym	Definition
NQ	not quantified
NRCS	(USDA) Natural Resources Conservation Service
NREL	(US DOE) National Renewable Energy Laboratory
NSB	Alaska North Slope Borough
NSR	New Source Review
O&G	Oil and Gas
O&M	operation and maintenance
ODS	ozone-depleting substance
OG	Oil and Gas
OM	organic material
OMB	(Alaska) Office of Management and Budget
PAYT	Pay As You Throw
PBF	public benefit fund
PCE	Power Cost Equalization
PCT	Pre-commercial thinning
PET	polyethylene terephthalate
PFC	perfluororocarbon
PHEV	plug-in hybrid electric vehicles
PM	particulate matter
$PM_{2.5}$	particulate matter of less than 2.5 micrometers
PMT	passenger miles traveled
PPI	Producer Price Index
PTC	production tax credit
R&D	research and development
RCA	Regulatory Commission of Alaska
RCI	Residential, Commercial, and Industrial
RDC	Resource Development Council
RE	Renewable energy
Res/Con	residential and commercial sectors
RNWG	Research Needs Working Group
SAR	(IPCC) Second Assessment Report
SB	Senate Bill
SCAG	Southern California Association of Governments
SE	southeast
SED	(DOE EIA) State Energy Data
SEDS	State Energy Data System

Acronym	Definition
SF_6	sulfur hexaflouride
SGIT	(EPA) State Greenhouse Gas Inventory Tool
SOV	single-occupant-vehicle
Strategy	Alaska Climate Change Strategy
Sub-Cabinet	Alaska Climate Change Sub-Cabinet
t	metric ton
T&D	transmission and distribution
TAF	(FAA) Terminal Area Forecast System
TAR	(IPCC) Third Assessment Report
TBD	to be determined
tC	metric ton of carbon
TCF	Trillion cubic feet
tCO_2	metric tons of carbon dioxide
tCO_2e	metric tons of carbon dioxide equivalent
TCR	The Climate Registry
TEM	(UAF) Terrestrial Ecosystem Model
Tg	teragram
TJ	terajoule
TLU	Transportation and Land Use
TNF	Tongass National Forest
TSS	TSS Consultants
TWG	Technical Work Group
TWh	terawatt-hours
UA	University of Alaska
UAA	University of Alaska - Anchorage
UAF	University of Alaska - Fairbanks
UIC	underground injection control
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VIUS	Vehicle Inventory and Use Survey
VMT	vehicle miles traveled

Acronym	Definition
W	watt
W/m^2	watts per square meter
WARM	(US EPA) WAste Reduction Model
WCI	Western Climate Initiative
WRAP	Western Regional Air Partnership
WW	wastewater
yr	year

Alaska Climate Change Strategy
Mitigation Advisory Group
Executive Summary

Important Introductory Note

The Mitigation Advisory Group (MAG) was tasked by the Alaska Climate Change Sub-cabinet with preparing recommendations on measures that might be included in a strategy to mitigate (i.e. reduce) greenhouse gas emissions in Alaska. It was not within the scope of the MAG's charge to evaluate what affect any recommended measure, if developed and implemented in Alaska, might have on climate in Alaska. The MAG was not asked to, and did not, take any position on the extent or causes of climate change in Alaska.

This report contains a range of potential mitigation measures identified by the MAG. These include measures the MAG believes need more analysis and development before they should be considered for implementation. If ultimately included in the Alaska Climate Change Strategy recommended by the Governor's Climate Change Sub-Cabinet, these measures should be identified as options for further study only.

This report also describes measures where the benefits and feasibility of implementation are more certain. These may require much less analysis or development before they could be considered for implementation. A similar short boxed statement appears at the beginning of the "Oil and Gas" and "Energy, Supply and Demand" sections of the report identifying those measures – or "recommendations" as they are called in the report – that clearly fall in the "options for further study" side of this continuum.

Regardless, the MAG believes no "recommendation" discussed in this report should be included in the set of recommendations provided by the Sub-Cabinet to the Governor for his consideration without first evaluating the economic impacts that adoption of the recommendation would have in Alaska. It was not within the scope of the MAG's charge to fully quantify the macro-economic costs or benefits of any recommendations that might be developed and eventually implemented to reduce greenhouse gas emissions from sources within Alaska.

On September 14, 2007, Governor Sarah Palin signed Administrative Order 238[1], which established the Alaska Climate Change Sub-Cabinet and tasked it with preparing Alaska's Climate Change Strategy. A warming climate is having serious and broad-scale impacts in Alaska, including flooding of villages; increasingly strong coastal storms, eroding the beaches of

[1] This report, Appendix A. Administrative Order 238 Establishing the Alaska Climate Change Sub-Cabinet,

coastal villages; subsidence from thawing of permafrost; and a record number of forest fires threatening communities, property, and air quality. The comprehensive Alaska Climate Change Strategy describes the actual and foreseeable effects of climate warming in Alaska[2,3], recommends appropriate measures and policies to prepare communities for responding to them, and provides guidance regarding Alaska's participation in regional and national responses to climate change.

The Sub-Cabinet formed two Work Groups to address Alaska's immediate and research needs, and two Advisory Groups to focus on reducing GHG emissions (mitigation) and preparing for a changing climate (adaptation) in the state. This report details the processes, analyses, and recommendations of the diverse group of 26 members of the MAG to reduce Alaska's GHG emissions, such as the expanded use of energy conservation and efficiency, renewable energy and fuels, land-use management, and transportation planning. The MAG was not tasked with a review of the underlying science of GHG emissions and did not address this in its deliberations. The MAG recognizes that the Sub-Cabinet will undertake further review, input, and analysis of these options before making its final recommendations to the Governor's Office.

Sector-specific Technical Work Groups (TWGs), comprised of subject-matter experts, advised the MAG in each of the following areas: Cross-Cutting Issues; Energy Supply and Demand; Forestry, Agriculture, and Waste Management; Oil and Gas; and Transportation and Land Use.

Alaska's Department of Environmental Conservation (DEC) provided the overall leadership of the effort and substantive support. The Center for Climate Strategies (CCS), a nonpartisan, nonprofit organization guided the process, facilitating the MAG and most TWG meetings and conference calls with the capable assistance of two local Alaskan facilitators and provided technical expertise for quantification of the costs and benefits of the policy recommendations.

The MAG recommends 32 policies for the Sub-Cabinet's consideration and further analysis. Specifically, the MAG is recommending these options as potentially the best methods to reduce GHG emissions in Alaska. The MAG is not recommending implementation of these actions without further study, input and analysis.

On a strict cost basis, some recommendations currently are too expensive to implement, however, others argue that the societal costs from climate change and the cost of inaction is estimated to be quite high if climate change continues its current trajectory unabated.[4] Without attributing the cause of climate change, a University of Alaska Anchorage study estimated that climate change could add $3.6–$6.1 billion (+10% to +20% above normal wear and tear) to

[2] Immediate Action Workgroup: Recommendations to the Governor's Sub-Cabinet on Climate Change, March 2009. 168 pages. http://www.climatechange.alaska.gov/docs/iaw_finalrpt_12mar09.pdf

[3] Adaptation Advisory Group: Recommendations to the Governor's Sub-Cabinet on Climate Change, in publication, 2009. http://www.climatechange.alaska.gov

[4] Stern, Sir Nicholas, et.al, *Stern Review: The Economics of Climate Change*, for the Prime Minister of the United Kingdom, 2007. http://webarchive.nationalarchives.gov.uk/

future costs for public infrastructure from now to 2030 and $5.6–$7.6 billion (+10% to +12%) from now to 2080.[5] Alaska's GHG emissions constitute about 0.7% of U.S. GHG emissions.

Many of these policies are quantified in terms of potential GHG emissions reduced and direct costs or savings. An overview of the MAG's work, by sector, can be found in the report's chapters, and detailed analyses of the recommended policy options are presented in the appendices. The MAG approved 30 of the 32 options unanimously; objections are noted. The estimated efficacy of these policies can be compared against the Alaska GHG Inventory and Forecast[6] (I&F) that was prepared prior to, and updated throughout, the MAG process.

One action is recommended to be placed on hold awaiting outcome of federal action. One action (not included in the total above) is not currently recommended because cost-effective technology essential to implementation does not exist.

Inventory of Alaska's Greenhouse Gas Emissions

CCS initially prepared a comprehensive draft I&F of emissions in 2007 for the Alaska DEC. The report presented an assessment of the state's GHG emissions and sinks (carbon storage) from 1990 to 2020. In 2009, the forecast was updated and extended to 2025. The draft I&F provided an initial comprehensive understanding of Alaska's actual and potential GHG emissions, and thereby informed the identification and analysis of policy options for mitigating GHG emissions. The MAG and the TWGs were asked to review, discuss, evaluate and revise specific portions of the draft inventory and forecast pertaining to their sectors, as well as alternative data and approaches. Those revisions have been incorporated in this report. No review of methodology or forecasting was performed by the MAG or TWGs.

Emissions and Reference Case Projections (Business as Usual)

Alaska's anthropogenic (human-caused) GHG emissions and sinks were estimated for the period 1990–2025. Historical GHG emission estimates (1990–2005) were developed from the best data available. The reference case emission projections (2006–2025) are based on a compilation of various existing projections of fuel use, electricity generation, and other GHG-emitting activities for Alaska, along with a set of transparent assumptions described in the appendices of this report.

The I&F covers the six types of gases included in the U.S. Greenhouse Gas Inventory[7]: carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Emissions of these GHGs are presented using a common metric, CO_2 equivalence, which indicates the relative contribution of each gas to atmospheric change as compared to CO_2.

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[5] Larsen,P.,S. Goldsmith, O.Smith, M. Wilson, K Stzepek, P. Chinowski, and B. Saylor, *Estimating the Future Costs of Alaska Public Infrastructure at Risk from Climate Change.* Univeristy of Alaska Anchorage. 2007 http://www.sciencedirect.com

[6] Center for Climate Strategies. *Final Alaska Greenhouse Gas Inventory and Reference Case Projections: 1990–2025*. Prepared for the Alaska Climate Change Mitigation Advisory Group, July 2009, available at http://www.akclimatechange.us/Inventory_Forecast_Report.cfm and attached as Appendix D of this report.

[7] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, EPA 430-R-08-005, April 15, 2008. Available at: http://epa.gov/climatechange/emissions/usinventoryreport.html.

Activities in Alaska accounted for approximately 50.6 million metric tons[8] of carbon dioxide equivalent (MMtCO_2e) emissions in 2005, an amount equal to about 0.7% of total U.S. gross GHG emissions.[9] Estimates of carbon sinks, i.e., CO_2 sequestered in Alaska's managed forests[10], are -1.4 MMtCO_2/year. This leads to net emissions of 49.2 MMtCO_2e in Alaska in 2005. Table EX-1 summarizes these figures.

Table EX-1. Summary of Alaska historical and projected gross and GHG net emissions, 1990–2025 (MMtCO_2e)

Types of Emissions	1990	2000	2005	2010	2020	2025
Total Gross Emissions	**39.0**	**46.1**	**50.6**	**53.5**	**60.3**	**62.8**
Increase over 1990		*18%*	*30%*	*37%*	*55%*	*61%*
Forest Carbon Sinks	–0.3	–1.4	–1.4	–1.4	–1.4	–1.4
Total Net Emissions	**38.7**	**44.7**	**49.2**	**52.1**	**58.9**	**61.4**
Increase over 1990		*15%*	*27%*	*35%*	*52%*	*59%*

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

Alaska's gross GHG emissions grew at a faster rate than those of the nation as a whole. From 1990 to 2005, Alaska's gross GHG emissions increased by 30%, while national emissions rose by 16%.

Gross emissions by sector, both historical and projected under a business-as-usual (BAU) scenario, are illustrated in Figures EX-1 and EX-2. A consumption-based model is used, as opposed to a production-based model. This means that only emissions related to products purchased or obtained within Alaska are included, with the exception of oil and gas, as opposed to emissions from producing a product that is consumed outside the state. One particularly challenging aspect has been to segregate aviation fuel purchased for aircraft that are using Alaska's airports for refueling stops en route to out-of-state destinations.[11] Approximately 31% of the aviation GHG emissions associated with jet fuel sold in Alaska is for refueling aircraft unrelated to the Alaskan transport or freight.

The principal source of Alaska's GHG emissions is the industrial sector, accounting for 49% of total state gross GHG emissions in 2005. The industrial sector includes direct fossil fuel combustion at industrial sites as well as fossil fuel industry emissions associated with oil and natural gas production, processing, transmission and distribution, flaring, fugitive methane from leaks and venting, and pipeline fuel use, as well as with oil production and refining and coal mining emission releases. The next-largest contributor to total gross GHG emissions is the

[8] One metric ton is equivalent to 2,200 pounds.

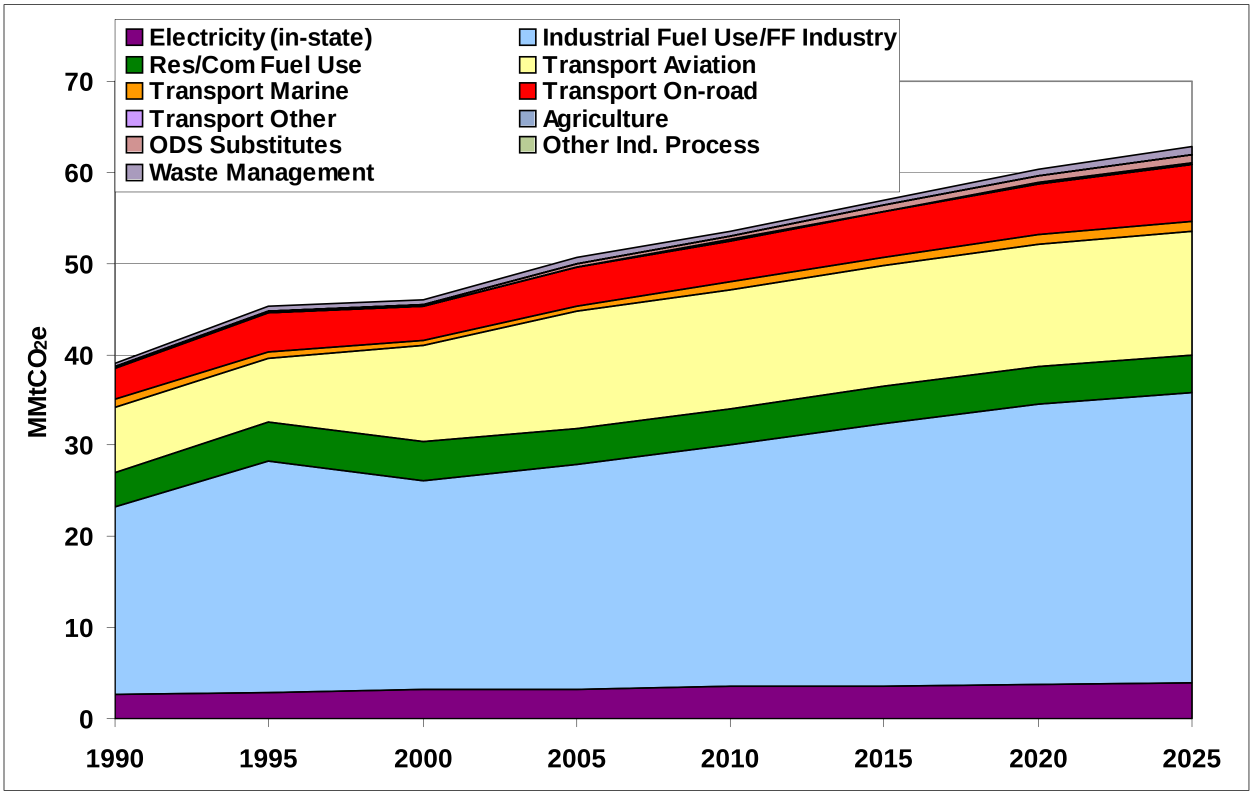
[9] Gross emissions exclude carbon sinks, such as forests, which absorb carbon dioxide and result in lower net GHG emissions.

[10] Managed forests reference coastal maritime forests in Alaska. See Appendix H: Forestry, Agriculture, and Waste Management Sectors. As described in the appendix, Alaska's boreal forests are not considered managed forests; hence, they are not included in this table (as they are considered a natural source). If the boreal forest was to be included as an anthropogenic source (a managed forest), the overall impacts to the state's I&F would be tremendous: the net sink of 1.4 MMtCO_2 would convert to a net source of over 40 MMtCO_2 annually due in large part to carbon losses from wildfires.

[11] See Chapter 7: Transportation and Land Use Sectors and Appendix J: Transportation and Land Use Policy Recommendations.

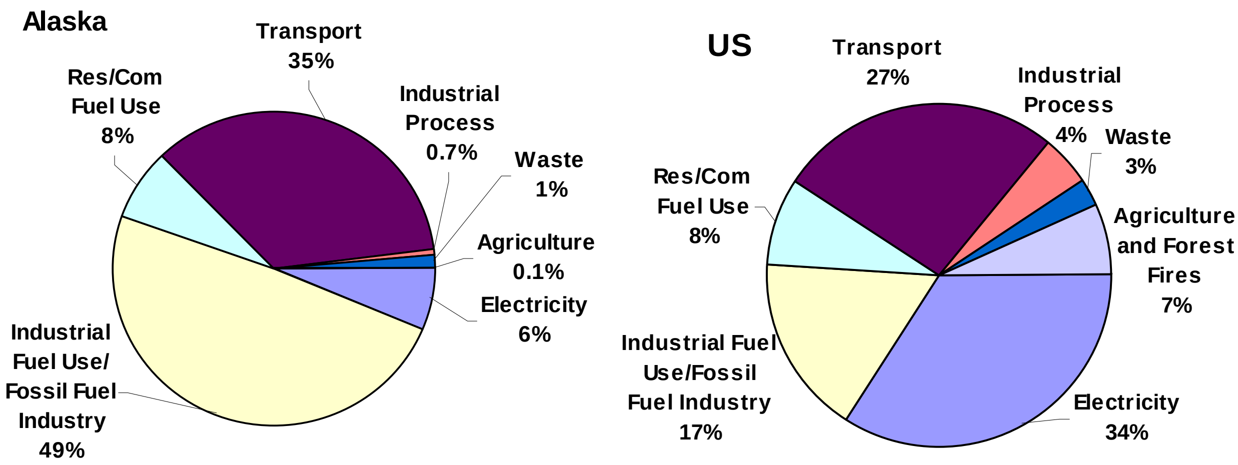
transportation sector, which accounted for 35% of the total Alaska gross GHG emissions in 2005.

Figure EX-1. Gross Alaska GHG emissions by sector, 1990–2025: historical and projected



GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; FF=fossil fuel; Res/Com = direct fuel use in the residential and commercial sectors; ODS = ozone-depleting substance. Gross emissions exclude forest carbon sinks and natural sources (forest carbon losses in the boreal forest).

Figure EX-2. 2005 Alaska emissions by sector



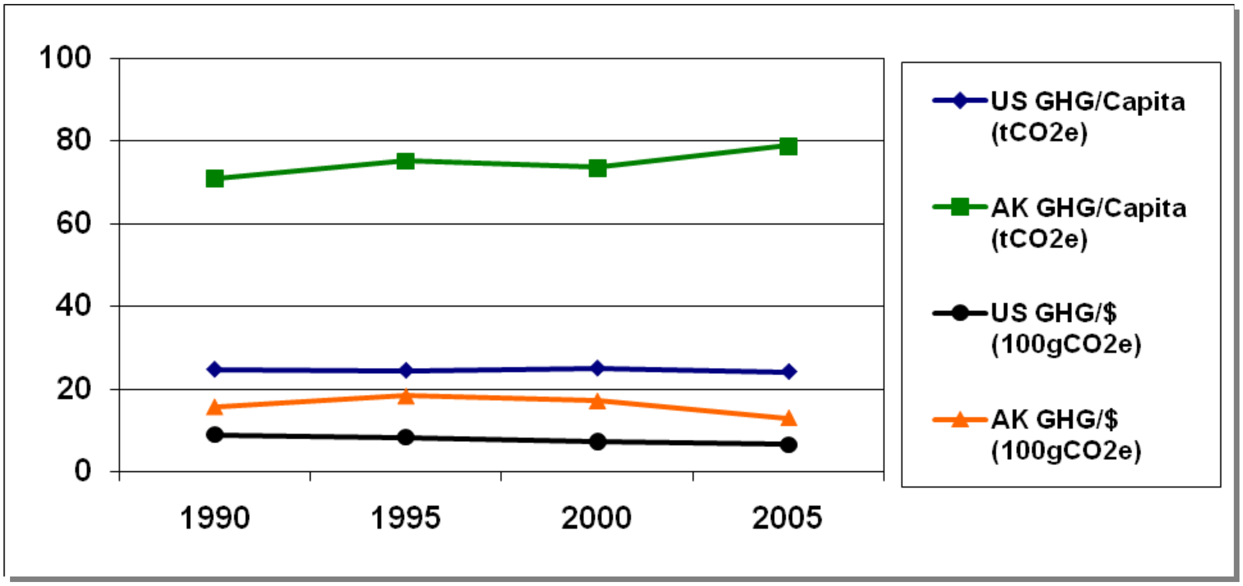
Notes: Res/Com = Residential and commercial fuel use sectors.

Emissions from the residential and commercial fuel use sectors are associated with the direct use of fuels (natural gas, petroleum, coal, and wood) to provide space heating, water heating, process heating, cooking, and other energy end uses. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county, and state), and other commercial establishments. The industrial fuel use/fossil fuel industry sector accounts for direct fuel combustion in the industrial sector as well as fugitive methane that occurs from leaks and venting during the production, processing, transmission, and distribution of fossil fuels. The industrial processes sector accounts for emissions associated with manufacturing and excludes emissions included in the industrial fuel use/fossil fuel industry sector. The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, railway locomotives, boats, and ships. Emissions from non-highway agricultural and construction equipment are included in the industrial sector. Electricity = Electricity generation sector emissions on a consumption basis. In Alaska, the electricity consumed is assumed to be the same as the electricity produced in the state.

On a per capita basis, Alaskans emitted about 79 metric tons (t) of CO_2e in 2005, higher than the national average of 24 tCO_2e in 2005 and higher than any other state (Figure EX-3). The higher per-capita emission rates in Alaska are driven by emissions from the industrial fuel combustion and transportation sectors, which are much higher than the national average. Major contributing factors to a higher per capita emissions include: Alaska is a major exporter of energy, requiring significant emissions to produce; greater distances for travel and transport; high levels of air traffic, including refueling stops for pass-through flights; long periods of low light and extremely cold temperatures; and overall low population.

During 1990–2005, per-capita emissions in Alaska increased slightly; economic growth exceeded emissions growth, leading to declining estimates of GHG emissions per unit of state product. Emissions per unit of gross product dropped by 26% nationally and by 17% in Alaska. (See bottom two lines of Figure EX-3)

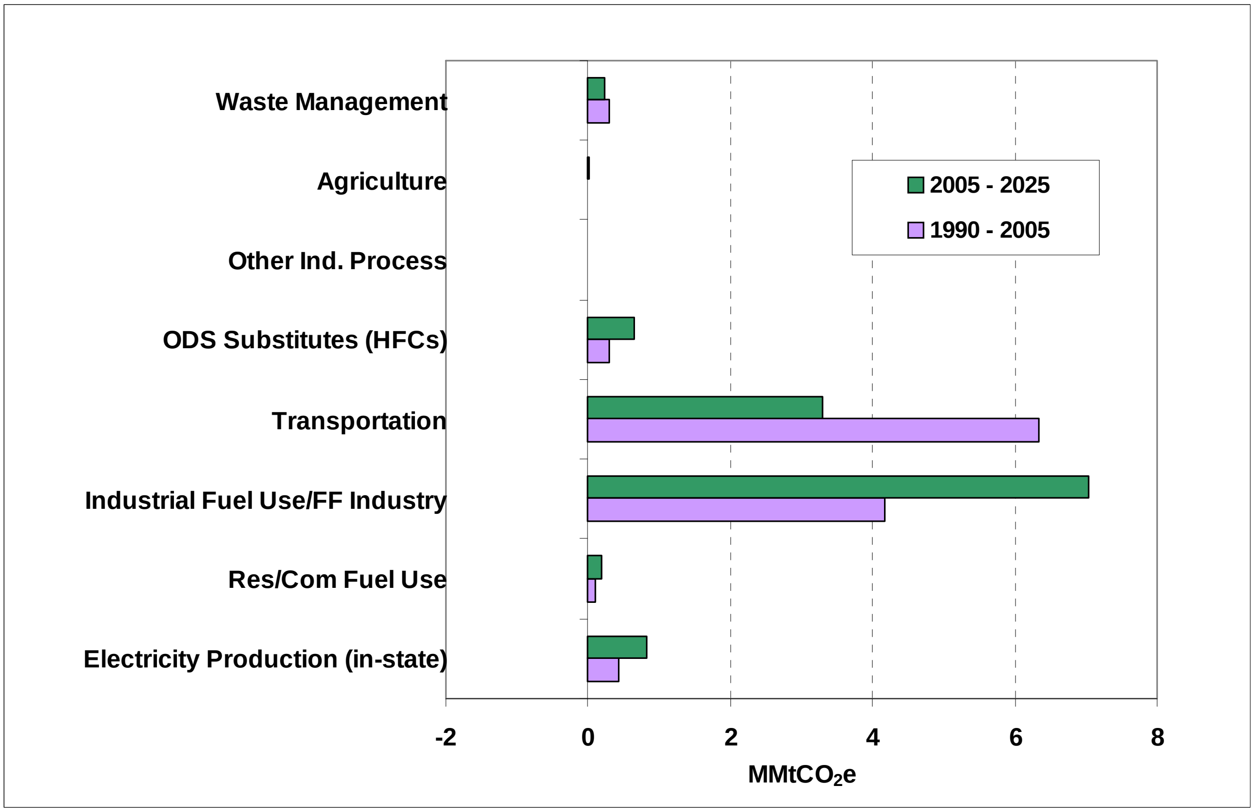
Figure EX-3. Comparison of U.S. and Alaska GHG emissions, per capita and per-unit gross product



AK = Alaska; CO_2e = carbon dioxide equivalent; g = gram; GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent.

Alaska's gross GHG emissions are projected to climb to 62.8 $MMtCO_2e$ per year by 2025—61% above 1990 levels. Historical and projected GHG emissions by sector are displayed in Figure EX-4. As shown in Figure EX-4, emissions associated with industrial fuel use are projected to be the largest contributor to future emissions growth. Emissions from the transportation sector, despite an overall reduction in transportation emissions from 2005 to 2025, are projected to continue to be the next largest contributor to gross GHG emissions.

Figure EX-4. Historical and projected emissions by sector



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; Ind. = industrial; ODS = ozone-depleting substance; HFCs = hydrofluorocarbons; FF= fossil fuel; Res/Com = residential and commercial sectors.

Some data gaps exist in this analysis, particularly for the reference case projections. Emissions of aerosols, which include volcanic dust and particulate matter from forest fires and fossil fuel combustion, could have significant climate impacts through their effects on radiative forcing.[12] The degree to which any of these aerosol sources play a net positive or negative effect on radiative forcing depends on their chemical make-up. A key determinant is the ratio of organic carbon to black carbon. Aerosols with a lower ratio will have a net positive effect (i.e. a global warming effect). The primary sources of these aerosols are fossil fuel combustion (diesel fuel, coal, residual oil). Aerosols from forest fires have a very high organic carbon to black carbon ratio, which produce a net negative climate forcing effect. On a CO_2-equivalent basis, the total estimated black carbon emissions for 2002 in Alaska were 3.0 $MMtCO_2e$. It is estimated that black carbon emissions will decrease by 2018 after new engine and fuel standards take effect. These estimates are not incorporated into the Alaska reference case projections because a global warming potential for black carbon has not yet been assigned by the Intergovernmental Panel on Climate Change.

[12] Change in the radiation balance between the energy absorbed by the Earth and that, which is radiated back into space. Particulate matter in the atmosphere can absorb or reflect energy. Radiative forcing estimates for the different types aerosol species are available from the Intergovernmental Panel on Climate Change; however, global warming potentials have not been set. See Appendix H of the AK Inventory & Forecast Report for a discussion of the black carbon inventory and forecast and Appendix I of that report for more discussion on the climate forcing of aerosols.

Primary tasks for future GHG inventory work in Alaska include review and revision of key emissions drivers. These are most notably electricity, fossil fuel production, transportation fuel use growth rates, and future electricity generation source mix, which will be major determinants of Alaska's future GHG emissions.

Appendix D, Alaska Greenhouse Gas Inventory and Reference Case Projections, provides detailed background information on GHGs and climate-forcing aerosols.

Recent Climate Change Mitigation Actions

The federal Energy Independence and Security Act of 2007 was signed into law in December 2007, requiring actions that will reduce GHG emissions over the next few years. GHG emission reductions associated with implementing the Corporate Average Fuel Economy (CAFE) requirements in Alaska were quantified. The MAG also identified recent actions that Alaska has undertaken to control GHG emissions and conserve energy. A weatherization bonding program reduces emissions relative to the overall BAU reference case projections slightly. This program is only funded from 2010 to 2014, and would account for a reduction of about 0.07 $MMtCO_2e$ in 2010. Future reductions were not quantified, as it cannot be assumed that the program will continue beyond 2014.

Table EX-2 summarizes the GHG emission reductions projected to be achieved by these recent actions. This table shows a total reduction of about 0.7 $MMtCO_2e$ in 2025 from the BAU reference case emissions, or a 1.2% reduction from the BAU emissions in 2025 for all sectors combined.

Table EX-2. Emission reduction estimates associated with the effect of recent actions in Alaska (consumption-based, gross emissions)

Sector/Recent Action	GHG Reductions ($MMtCO_2e$)		GHG Emissions ($MMtCO_2e$)	
			Business as Usual	With Recent Actions
	2015	2025	2025	2025
Residential/Commercial/Industrial (RCI) Fuel Use				
Weatherization Bonding	0	0	33.9	33.9
Transportation and Land Use (TLU)				
Federal Corporate Average Fuel Economy (CAFE) Requirements	0.22	0.73	21.1	20.4
Total (RCI + TLU Sectors)			**55**	**54.3**
Alaska Total (All Sectors)			**62.8**	**62.1**

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

Alaska Climate Change Strategy Mitigation Advisory Group Recommendations

Along with the data from the I&F, individual members of the MAG contributed insights, observation, experience, and data from their particular field of expertise. These, combined with presentations from scientists, agency personnel, and practitioners in the fields of climate change and energy policy, fortified the MAG and TWGs while they deliberated over actions most likely to effectively reduce GHG emissions in Alaska.

The MAG and TWGs began with a catalog of over 350 potential actions and policies that could be adopted to mitigate climate change. This catalog was compiled by CCS based on its extensive experience in over 25 other states and regions. Alaskans involved in the MAG and TWG processes carefully weighed, combined, customized, and prioritized the actions that seemed most viable for the state. Through iterative processes and joint deliberation, 32 options, somewhat evenly distributed in number by sector, were identified for further study.

Participants developed comprehensive descriptions and designs of the policy options. They then identified potential goals and implementation measures for each, noting any related programs or policies in place or pending implementation. Parties whose involvement would be necessary were also identified. Policies that were quantifiable were carefully evaluated by CCS's technical experts[13] for reductions in GHG emissions and associated direct costs. These quantifications were reviewed, revised where necessary, and approved by the MAG. The results for each sector are displayed later in this Executive Summary and are discussed in detail in the report's chapters and appendices.

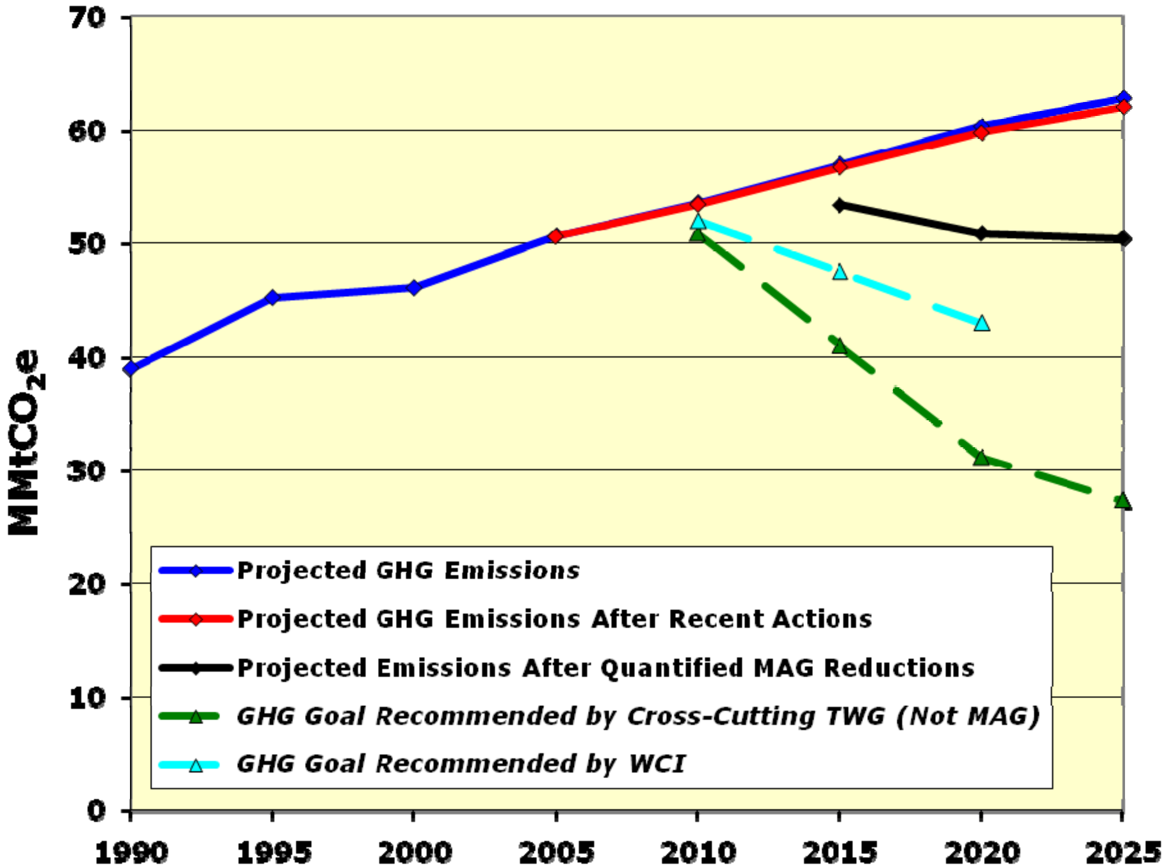
Cumulatively, if all quantified actions were implemented, there would be a reduction in GHGs from 62.1 to 50.4 MMtCO_2e by 2025. This is 11.7 MMtCO_2e below the BAU projection if no actions other than federal CAFE standards were implemented. Figure EX-5 illustrates the projected results from different reduction strategies. Figure EX-5b illustrates the projected results after removing emissions from aviation refueling unrelated to Alaska activities and beyond the state's control from the baseline BAU. If all quantified actions were implemented, the BAU GHG emissions without transient aviation refueling would be reduced from 58.5 to 46.8 MMtCO_2e by 2025.

The lowest line on these graphs illustrates the reduction target that the Cross-Cutting Issues (CC) TWG recommended that the Sub-Cabinet consider as a statewide goal.[14] This represents reductions of 20% below 1990 GHG emissions levels by 2020, and 80% below 1990 levels by 2050. For comparison purposes, the recommended emission reduction goal from the Western Climate Initiative (WCI) is also shown on each. WCI is comprised of seven western states and four Canadian provinces as members; seven other U.S. states and six Mexican states are observers. Alaska is an observer state.

[13] Technical experts were from E. H. Pechan & Associates, ICF International, Ross & Associates and Synapse Energy Economics.

[14] See Chapter 3: Cross-Cutting Issues and Appendix F: Cross-Cutting Issues Policy Recommendations.

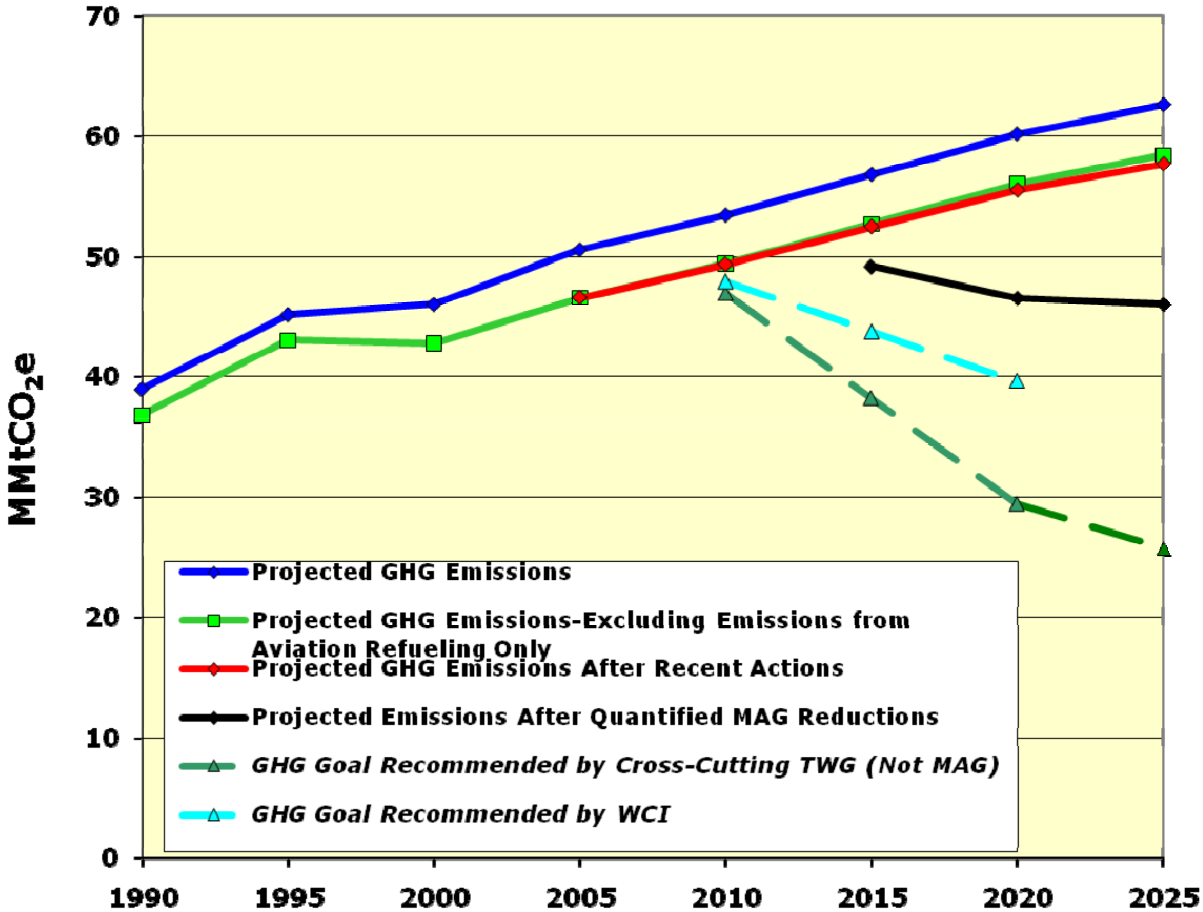
Figure EX-5a. Projected Alaska GHG emission scenarios: historical to 2025 (consumption-based, gross emissions)



GHG = greenhouse gas; MAG = Mitigation Advisory Group. $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; TWG = Technical Work Group; WCI = Western Climate Initiative.

As is evident on both EX-5a and EX-5b, the quantified options recommended in this report are not sufficient to reach tentative goals. Unquantified options, such as conservation and state government leading-by-example, will reduce emissions further. Other emission-reducing actions beyond the scope of this report are anticipated. In particular, actions that save money and energy will be very advantageous for a broad range of individuals and businesses to implement independent of recommendations from the Sub-Cabinet. For example, a MAG member from an aviation-dependent delivery corporation outlined the aggressive sustainability measures implemented by the company that not only save money and fuel but also reduce GHG emissions.

Figure EX-5b. Projected Alaska GHG emission scenarios: historical to 2025 (consumption-based, gross emissions excluding refueling transient aircraft)



GHG = greenhouse gas; MAG = Mitigation Advisory Group. $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; TWG = Technical Work Group; WCI = Western Climate Initiative.

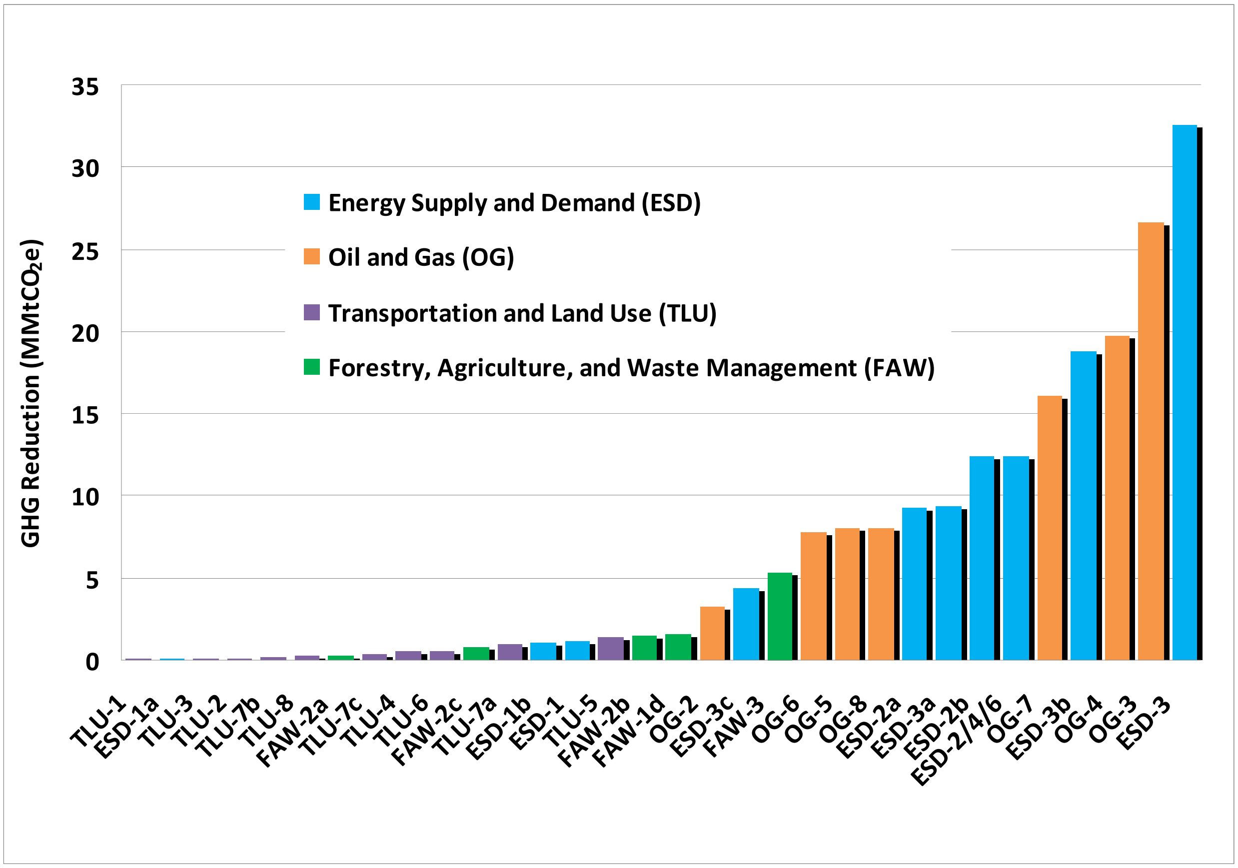
Not shown on the graphs but of interest to the MAG is the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report goal of stabilizing the global atmosphere at 450 parts per million (ppm) of CO_2 (this does not include the five other GHGs, the total of which, when combined with CO_2, is already well above 450ppm). The Cross-Cutting TWG considered the IPCC goal of 450 ppm CO_2 when recommending their goals. The IPCC recognizes that this requires developed nations to achieve reductions of 25-40% below 1990 CO_2 emissions by 2020 and 80-95% reductions below 1990 levels by 2050. Another IPCC scenario is to consider a goal of 550 ppm CO_2e, which means GHG emission reductions of 10-30% below 1990 levels by 2020 and 40-90% below 1990 levels by 2050 for developed nations.[15]

By a small majority, the MAG recommends the Sub-Cabinet consider establishing an aspirational (not legislated) numeric state goal using the above information for guidance. Some of those who objected would prefer not to have a numeric goal.

[15] Pachauri, Dr. R.K., Chairman, IPCC. "New Knowledge on Climate Change: Global Efforts for Meeting the Challenge." Presentation at GCEP Research Symposium, Stanford University, Oct. 2007. http://gcep.stanford.edu/pdfs/kUXNHroC3cAssx6wJoz_Mg/Pachauri-20071001-GCEP.pdf

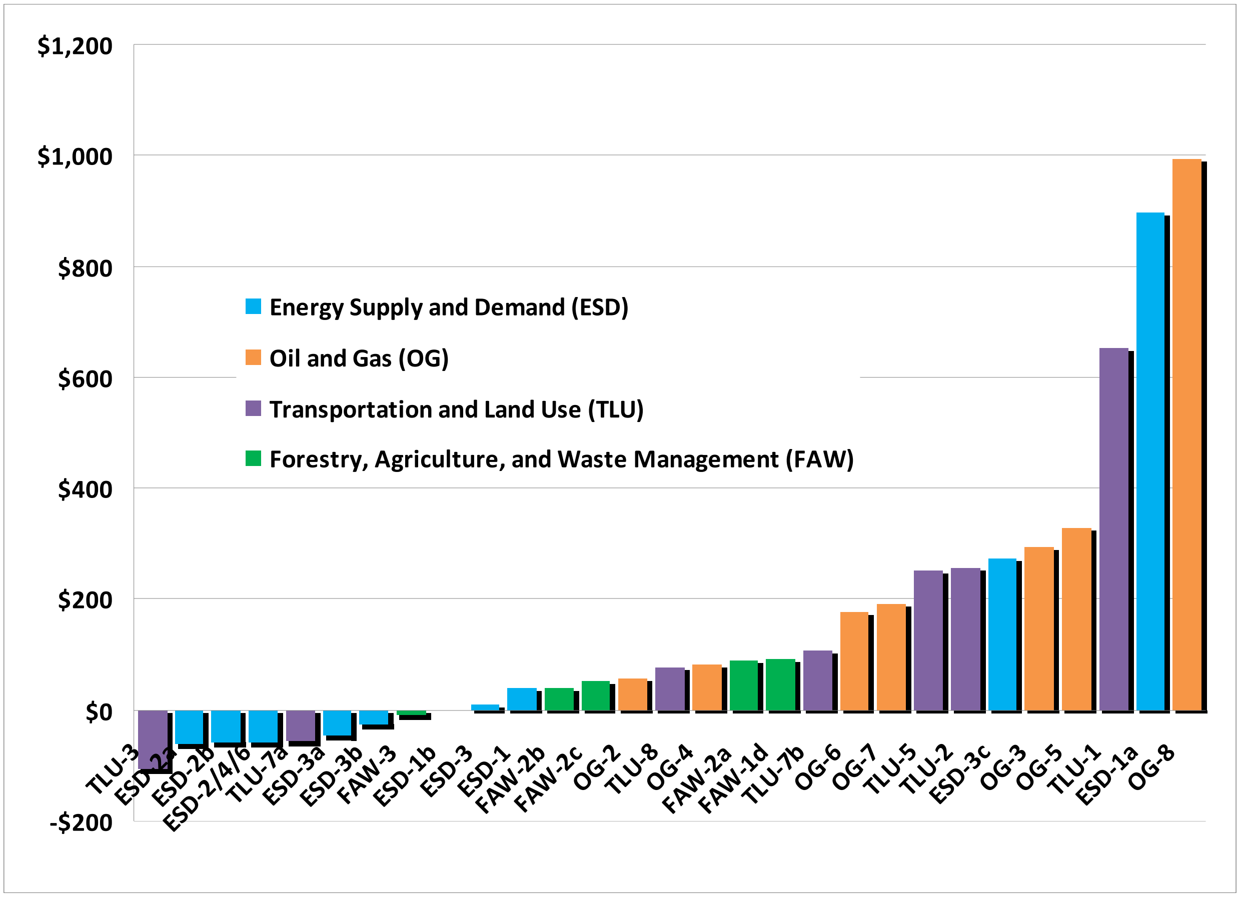
Figure EX-6 displays the cumulative GHG emission reductions projected over the life of each recommended policy option from 2010-2025. Each policy option is identified by the sector it represents and its specific number, which can be cross-referenced in the report's chapters and appendices. Figure EX-7 displays the quantified policy options by their costs or savings per $MMtCO_2e$ reduced. Potential carbon costs associated with a federal cap and trade policy was not included. Note that bars below the base line indicate cost savings.

Figure EX-6. Cumulative GHG reduction potential for each individual Alaska policy recommendation over the period 2010-2025



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

Figure EX-7. Alaska policy recommendations ranked by cost/savings per ton of GHG reduced, 2010–2025



Negative values indicate a cost-savings.

Table EX-3 shows the cumulative emission reductions expected from implementing quantifiable policy recommendations. Any potential double counting from overlaps in policy design and implemenation measures has been eliminated. The costs presented are directly related to the implementation of specific measures, and do not consider ancillary benefits/costs or indirect expenditures or savings. Potential carbon costs associated with a federal cap and trade policy was not included. Negative costs indicate savings.

Table EX-3. Alaska cumulative emissions reductions and costs or savings by sector over the period 2010-2025.

Alaska Cumulative Reductions and Costs/Savings	2015 $MMtCO_2e$	2020 $MMtCO_2e$	2025 $MMtCO_2e$	2010-2025 $MMtCO_2e$	NPV 2010–2025 Cost/ Cost Savings (Million $)	Cost/Savings per Ton CO_2e
Energy Supply and Demand	1.9	3.0	5.3	40.7	–$191	–$5
Oil and Gas	0.75	4.8	4.8	46.2	$7,530	$163
Transportation and Land Use	0.19	0.31	0.42	3.85	$364	$95
Forestry, Agriculture, and Waste Management	0.47	0.8	1.11	9.5	$84	$9
Cross-Cutting						
Total	**3.3**	**9.0**	**11.7**	**100.2**	**$7,787**	**$78.0**

CO_2e = carbon dioxide equivalent; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; NPV = net present value. Negative values reflect savings.

Technical Work Group Recommendations Approved by the Mitigation Advisory Group

Cross-Cutting Issues Policy Recommendations

This TWG reviewed and considered policies related to government lead-by-example actions, outreach, education, GHG inventories and reporting, GHG goals and targets, and financial policies related to climate change.

The CC TWG considered policy options of relevance or benefit across several or all of the sector-specific TWGs. In addition to evaluating emission mitigation activities that cut across sectors, the CC TWG examined policies that enable or provide overall support for other climate actions. The specific GHG reductions and costs of these cross-cutting policies are generally difficult to quantify. Nonetheless, if successfully implemented, the recommended actions presented in Table 4 will support the implementation of other policy recommendations described in the chapters and appendices of this report, and will contribute to GHG emission reductions overall.

Setting a statewide goal occupied much thought and debate throughout the MAG process. A thorough discussion of options, rationale, and findings is found in Chapter 3 and Appendix F, under policy recommendation CC-2. The MAG recognized that the recommendation (CC-1) to establish an Alaska emissions reporting system may be needed, but recommended no action until the status of related federal legislation is known.

Table EX-4 provides an overview of the specific CC recommendations.

Table EX-4. Summary list of Mitigation Advisory Group policy recommendations for Cross-Cutting Issues sector

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 2015–2025			
CC-1	Establish an Alaska Greenhouse Gas Emission Reporting Program	*Not Quantified*						Unanimous (to put on hold)
CC-2	Establish Goals for Statewide GHG Emission Reduction	*Not Quantified*						Majority
CC-3	Identify and Implement State Government Mitigation Actions	*Not Quantified*						Unanimous
CC-4	Integrate Alaska's Climate Change Mitigation Strategy With the Alaska Energy Plan	*Not Quantified*						Unanimous
CC-5	Explore Various Market-Based Systems to Manage GHG Emissions	*Not Quantified*						Unanimous
CC-6	Coordinate Implementation of Alaska's Efforts to Address Climate Change	*Not Quantified*						Super-majority

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

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization of these important policy recommendations.

Energy Supply and Demand Policy Recommendations

This TWG reviewed and analyzed issues related to energy production and consumption in the residential, commercial, and industrial sectors.

The Energy Supply and Demand (ESD) TWG explored various aspects of ESD issues affecting the daily lives of Alaskans. Overall optimization and expansion of transmission grids, including the feasibility of rural village-to-village lines and renewable energy grants for upgrades, was one area of concern. Energy efficiency across the broad spectrum of residential and commercial customers, along with energy efficiency for industrial installations provided another set of recommendations. Building standard improvements compatible with cold-climate construction and energy efficiency are also recommended.

After careful review, the MAG determined that several other options required more research before policies could be crafted for implementation. Those include efficiency improvements for generators, construction of small nuclear power plants, research and development for cold-climate renewable technologies, and implementation of advanced supply-side technologies. These were forwarded to the Research Needs Work Group for further study.

Table EX-5 presents the ESD policy recommendations, along with their expected GHG emission reductions and the costs of or cost savings from their implementation.

Table EX-5. Summary list of Mitigation Advisory Group policy recommendations for Energy Supply and Demand sector

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)				Net Present Value 2010–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2020	2025	Total 2010–2025			
ESD-1a	Rural Village-to-Village Transmission	*0.00*	*0.00*	*0.01*	*0.05*	*$44*	*$897*	Unanimous
ESD-1b	Renewable Energy Grants for Transmission Upgrades	*0.06*	*0.08*	*0.09*	*1.06*	*–$2*	*–$2*	Unanimous
ESD-1	Transmission Optimization and Expansion (Total of ESD-1a & ESD-1b)	0.07	0.08	0.09	1.11	$42	$38	Unanimous
ESD-2	Energy Efficiency for Residential and Commercial Customers	*Quantified with ESD-2/4/6*						*See below*
ESD-2/4/6	Energy Efficiency for Residential, Commercial, and Industrial Customers, 2% per year	0.34	1.07	1.84	12.41	–$728	–$59	Unanimous
ESD-3	Implementation of Renewable Energy	1.99	2.35	3.86	32.52	$297	$9	Unanimous
ESD-4	Building Standards/Incentives	*Quantified with ESD-2/4/6*						*See above*
ESD-5	Efficiency Improvements for Generators	*Moved to Research Needs Work Group*						
ESD-6	Energy Efficiency for Industrial Installations	*Quantified with ESD-2/4/6*						*See above*
ESD-7	Implementation of Small-Scale Nuclear Power	*Moved to Research Needs Work Group*						
ESD-8	Research and Development for Cold-Climate Renewable Technologies	*Moved to Research Needs Work Group*						
ESD-9	Implementation of Advanced Supply-Side Technologies	*Moved to Research Needs Work Group*						
	Sector Total After Adjusting for Overlaps*	**1.93**	**2.77**	**4.67**	**37.51**	**–$19.46**	**–$4.24**	
	Reductions From Recent Actions				**0.34**			
	Sector Totals	**1.93**	**2.77**	**4.67**	**37.85**	**–$19.46**	**–$4.24**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent. Note: Sector Total is indicative of potential savings, see note in chapter.

Negative numbers indicate cost savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations.

Forestry, Agriculture, and Waste Management Policy Recommendations

This TWG considered and analyzed policy options related to forest management, land conservation, biomass, soil carbon sequestration and sinks, agriculture, and waste management.

The Forest, Agriculture, and Waste Management (FAW) TWG identified three broad policies for MAG approval. The first, forest management, focused on management strategies for coastal and boreal forests, wildfire risk reduction, and forest restoration. The second area of recommendations dealt with biomass-to-energy issues, using biomass to offset fossil fuel-based heating, power, and fuel needs. The final area of study was municipal solid waste, specifically strategies for reducing waste and recycling.

All four FAW-1 options have the potential to produce biomass that can be used for fuel feedstocks under FAW-2. The GHG reductions for using the biomass from FAW-1 or other sources were quantified under FAW-2. The MAG 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.

One other policy, not listed Table EX-6, is 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 are no overlaps between the FAW biomass policies and the policies in the ESD or Transportation and Land Use (TLU) appendices. Biomass demand from ESD-3 has been accounted for in the biomass availability analysis found in Appendix H. FAW Policy Recommendations.

Table EX-6 displays specific results for each recommended policy and subcategories within those policies.

Table EX-6. Summary list of Mitigation Advisory Group Policy recommendations for Forestry, Agriculture, and Waste Management sector

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	2020	2025	Total 2010–2025	Net Present Value 2010–2025 (Million 2005$)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
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 + Recent Actions	0.47	0.78	1.11	9.5	$234	$25	

CAFÉ = Corporate Average Fuel Economy; FAW = Forestry, Agriculture, and Waste Management (Technical Work Group); GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Negative numbers indicate cost savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations.

Oil and Gas Policy Recommendations

This TWG considered and analyzed policy options related to the full spectrum of oil and gas production, processing, transmission and associated fuel use for all related GHG emissions.

The Oil and Gas TWG carefully analyzed a wide variety of options to reduce GHG emissions from oil and gas operations in Alaska. To do so required assessing actual outputs and production projections from discrete facilities; these are identified geographically. Some facilities lend themselves to effective implementation of certain recommendations, whereas those same recommendations may not be effective elsewhere due to size, scope, or projected longevity of production. Facility-specific recommendations are clearly identified in Appendix I: Oil and Gas Policy Recommendations.

The TWG examined conservation; reduction of fugitive methane emissions; centralized electrification of North Slope operations; upgrades and efficiency of fossil fuel consuming equipment; renewable energy substitutes for fossil fuel energy; and carbon capture. Various ways of dealing with carbon post-capture were examined. Use of the carbon depended on location and source of the GHG (see Policy Recommendations OG-6, 7 and 8).

In quantifying the options, it became clear that besides conservation, most would be very expensive to implement and had other attendant issues that need to be resolved prior to implementation. What these recommendations represent is a suite of the best opportunities to reduce GHG emissions from oil and gas sector operations, but that does not mean they are cheap, easy or ready to implement. Rather, the investigations within this report recommend the areas for further study. Note that a federal cap and trade policy or other added costs for carbon emissions may change the economics.

Table EX-7 describes the Oil and Gas sector policies, their projected GHG emission reductions and the direct costs. There is overlap amongst the options, that is, options that accounting for the same GHG emissions. Depending on which policies are implemented, the overlap would vary. For that reason, the overlap figures are presented as a range.

Table EX-7. Summary list of Mitigation Advisory Group policy recommendations for the Oil and Gas sector

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)				Net Present Value 2010–2025 (Million 2009$)	Cost-Effective-ness (2009$ /tCO_2e)	Level of Support
		2015	2020	2025	Total 2010–2025			
OG-1	Best Conservation Practices	*Not Quantified*						Unanimous
OG-2	Reductions in Fugitive Methane Emissions	0.2	0.2	0.2	3.2	$181.4	$57	Unanimous
OG-3	Electrification of North Slope Oil and Gas Operations, With Centralized Power Production and Distribution	—	3.0	4.4	26.6	$7,791.0	$293	Unanimous
OG-4	Improved Efficiency Upgrades for Oil and Gas Fuel-Burning Equipment	0.5	2.1	2.1	19.7	$1,600.1	$81	Unanimous
OG-5	Renewable Energy Sources in Oil and Gas Operations	0.7	0.7	0.7	8.0	$2,603.4	$327	Unanimous
OG-6	Carbon Capture (From North Slope High-CO_2 Fuel Gas) and Geologic Sequestration With Enhanced Oil Recovery	—	0.9	0.9	7.8	$1,368.8	$176	Unanimous
OG-7	Carbon Capture (From Exhaust Gas at a Centralized Facility) and Geologic Sequestration With Enhanced Oil Recovery	—	1.8	1.8	16.1	$3,094.1	$192	Unanimous
OG-8	Carbon Capture (From Exhaust Gas) and Geologic Sequestration Away From Known Geologic Traps	0.7	0.7	0.7	8.0	$7,937.7	$994	Unanimously not recommended at this time
	Sector Total Before Adjusting for Overlaps	**2.1**	**9.4**	**10.8**	**89.4**	**$24,576.5**		
	Sector Total After Adjusting for Different Implementation Strategies*	**0.2/ 0.8**	**6.7/ 4.8**	**10.0- 4.8**	**62.9/ 46.2**	**$15,300/ $7,500**	**$243/$163**	
	Reductions From Recent Actions (CAFE Standards)	**0**	**0**	**0**	**0**	**0**		

NOTES:

Policy options were modeled on generic, publicly available industry data from North Slope oil and gas operations. Thus, the results must only be used to help direct more precise modeling, which would include, for example, taxes, royalties, individual oil and gas facility data, and specific engineering studies.

"'Net Present Value" used in the summary table above would be regarded in the oil and gas industry as "Net Present Cost." Positive numbers in the two right-hand columns indicate that an investment in the policy would generate a financial loss.

"Net Present Value" and "Cost-Effectiveness" values do not apply in Cook Inlet or any other oil and gas basin, due to vastly different production life, geographic distribution, and physical constraints.

Due to the analytical methodology, "Cost Effectiveness" is likely lower than the break-even cost of carbon needed to make a project economically feasible.

None of the modeling included the impact of short-term production loss to implement the policies OG-2 though OG-7.

These policies are technology-based opportunities for reducing greenhouse gas emissions (GHG), not policies to be directly implemented by Alaska.

The GHG savings estimates presented here are not additive. Policies have significant, sometimes complete, overlap in targeted GHG emissions.

CAFE = corporate average fuel economy; CO_2 = carbon dioxide; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; OG = oil and gas.

*This range shows emissions reductions and costs if only the more cost-effective options were implemented, i.e., dropping sequestration away from geologic sources (OG-8) and keeping the rest (the first set of figures). The second set represents removal of the central electrification (OG-3) and sequestration away from geologic sources (OG-8).

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations.

Transportation and Land Use Policy Recommendations

This TWG considered and analyzed policy options related to transportation methods, modalities, efficiencies, infrastructure, planning, land use and development as they relate to and/or generate GHG emissions.

The TLU TWG focused on and analyzed vehicle and transportation policy recommendations, specifically pertaining to public transit and commuter options; heavy-duty vehicle idling, fleet management and other efficiencies; land transportation systems; marine vessel efficiencies; and aviation emission reductions. Land use policies recommended include efficient development patterns (smart growth) and using vehicle-miles-traveled and GHG emission reduction as planning metrics.

Table EX-8 displays the policy recommendations, and where they could be quantified, the amount of expected GHG emission reductions and the direct costs for such action.

Table EX-8. Summary list of Mitigation Advisory Group policy recommendations for the Transportation and Land Use sector

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			
TLU-1	Transit, Ridesharing, and Commuter Choice Programs	0.002	0.003	0.005	0.046	$29.9	$651	Unanimous
TLU-2	Heavy-Duty Vehicle Idling Regulations and/or Alternatives	0.004	0.009	0.009	0.095	$24.3	$255	Unanimous
TLU-3	Transportation System Management	0.006	0.006	0.006	0.092	–$9.7	–$105	Unanimous
TLU-4	Promote Efficient Development Patterns (Smart Growth)	0.019	0.043	0.066	0.501	Net Savings	NQ	Unanimous
TLU-5	Promotion of Alternative-Fuel Vehicles	0.026–0.084	0.054–0.173	0.09–0.288	0.669–2.139	$207.3–$494.8	$135–$740	Unanimous
TLU-6	VMT and GHG Reduction Goals in Planning	0.019	0.043	0.066	0.501	NQ	NQ	Unanimous
TLU-7	On-Road Heavy-Duty Vehicle Efficiency Improvements: a. SmartWay®	0.050	0.075	0.084	0.930	–$52.3	–$56	Unanimous
	b. Phase Out	0.025	0.012	0.000	0.198	$20.9	$106	
	c. Public Fleets	0.016	0.033	0.037	0.364	NQ	NQ	
TLU-8	Marine Vessel Efficiency Improvements	0.012	0.022	0.032	0.269	$20.4	$76	Unanimous
TLU-9	Aviation Emission Reductions	NQ	NQ	NQ	NQ	NQ	NQ	Unanimous
TLU-10	Alternative Fuels Research and Development	NQ	NQ	NQ	NQ	NQ	NQ	Unanimous
	Sector Total Before Adjusting for Overlaps	**0.210**	**0.363**	**0.500**	**4.444**	**$364.3**	**$82**	
	Sector Total After Adjusting for Overlaps	**0.187**	**0.313**	**0.423**	**3.850**	**$364.3***	**$95***	
	Reductions From Recent Actions	**0.397**	**0.531**	**0.732**	**5.995**	**NQ**	**NQ**	
	Sector Total Plus Recent Actions	**0.412**	**0.844**	**1.155**	**9.845**	**NQ**	**NQ**	

*Does not include any cost for policies TLU-4, TLU-6, or TLU-7c, but does include emission reductions for those policies.

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; NQ = not quantified; VMT = vehicle miles traveled.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations.

Negative numbers indicate cost savings.

Chapter 1
Background and Overview

Important Introductory Note

The Mitigation Advisory Group (MAG) was tasked by the Alaska Climate Change Sub-cabinet with preparing recommendations on measures that might be included in a strategy to mitigate (i.e. reduce) greenhouse gas emissions in Alaska. It was not within the scope of the MAG's charge to evaluate what effect any recommended measure, if developed and implemented in Alaska, might have on climate in Alaska. The MAG was not asked to, and did not, take any position on the extent or causes of climate change in Alaska.

This report contains a range of potential mitigation measures identified by the (MAG. These include measures the MAG believes need more analysis and development before they should be considered for implementation. If ultimately included in the Alaska Climate Change Strategy recommended by the Governor's Climate Change Sub-Cabinet, these measures should be identified as options for further study only.

This report also describes measures where the benefits and feasibility of implementation are more certain. These may require much less analysis or development before they could be considered for implementation. A similar short boxed statement appears at the beginning of the "Oil and Gas" and "Energy, Supply and Demand" sections of the report identifying those measures – or "recommendations" as they are called in the report – that clearly fall in the "options for further study" side of this continuum.

Regardless, the MAG believes no "recommendation" discussed in this report should be included in the set of recommendations provided by the Sub-Cabinet to the Governor for his consideration without first evaluating the economic impacts that adoption of the recommendation would have in Alaska. It was not within the scope of the MAG's charge to fully quantify the macro-economic costs or benefits of any recommendations that might be developed and eventually implemented to reduce greenhouse gas emissions from sources within Alaska.

The Governor's Initiative

On September 14, 2007, Governor Sarah Palin signed Administrative Order 238, establishing the Alaska Climate Change Sub-Cabinet to advise her office on the preparation and implementation of a comprehensive Alaska Climate Change Strategy. The members of this Sub-Cabinet include the Commissioners of the Departments of Environmental Conservation (DEC); Natural Resources; Commerce, Community and Economic Development; Fish and Game; and Transportation and Public Facilities.

Governor Palin directed that the Strategy include, among other efforts, building the state's knowledge of the actual and foreseeable effects of climate warming in Alaska, developing appropriate measures and policies to prepare communities in Alaska for the impacts from climate change, and providing guidance regarding Alaska's participation in regional and national efforts addressing the cause and effects of climate change.

To accomplish the objectives of Administrative Order 238, the Sub-Cabinet formed a work group to address Immediate Actions that should be undertaken, and a second work group to identify critical Research Needs. In addition, two Advisory Groups were established to recommend measures that could be undertaken in Alaska to reduce greenhouse gas (GHG) emissions (mitigation) from sources in the state and better prepare the state for a changing climate (adaptation). This report details the process, analyses, and recommendations of the former, the Mitigation Advisory Group (MAG).

Consistent with Administrative Order 238, the MAG addressed opportunities to reduce GHG emissions from Alaska sources, including the expanded use of alternative fuels, energy conservation, energy efficiency, renewable energy, land-use management, and transportation planning. Also of concern was identifying opportunities to reduce GHG emissions from the operations of the Alaska state government and opportunities to participate in carbon-trading markets, including the potential for carbon sequestration.

The MAG was not tasked with a review of the underlying science of GHG emissions and did not address this in its deliberations. The MAG also did not undertake any evaluation of the effect(s) any of its recommendations might have on the future climate of Alaska if a recommendation were further developed and implemented.

Structure of the Mitigation Advisory Group Report

This report documents the results of the work of the Alaska Climate Change Strategy MAG's deliberations and recommended policies. It begins with an Executive Summary, Acknowledgments, a list of MAG members, and a summary of the MAG's recommendations.

This chapter details the MAG process and an overview of its findings. Chapter 2: Inventory & Forecast, provides a summary of Alaska's historic and forecasted GHG emissions, incorporating recent actions that have already been planned or implemented in the state to reduce GHG emissions, and displays the potential to achieve significant GHG reductions. The work of the MAG was substantially assisted by the efforts of Technical Work Groups (TWGs) convened to consider sector-specific issues and opportunities. Chapters 3 through 8 summarize each TWG sector and the MAG's recommended policies. Those sectors are Energy Supply and Demand; Forestry, Agriculture and Waste Management; Oil and Gas; Transportation and Land Use; and Cross-Cutting Issues. In a number of cases, the recommended policies outline scenarios but point out that further studies and analyses may be necessary prior to consideration for implementation. The recommendations are further documented, by sector, in greater detail in the appendices.

Appendix A of the report contains Governor Palin's Administrative Order. Appendix B provides a copy of the memorandum that outlines the process used by the state and its consultant, the

Center for Climate Strategies (CCS), to guide the MAG process. Appendix C lists TWG members and their affiliations, and Appendix D provides Alaska's GHG emissions inventory and reference case projections. Details on how quantifiable recommendations were measured for direct costs or savings and the amount of emissions reduced are found in Appendix E.

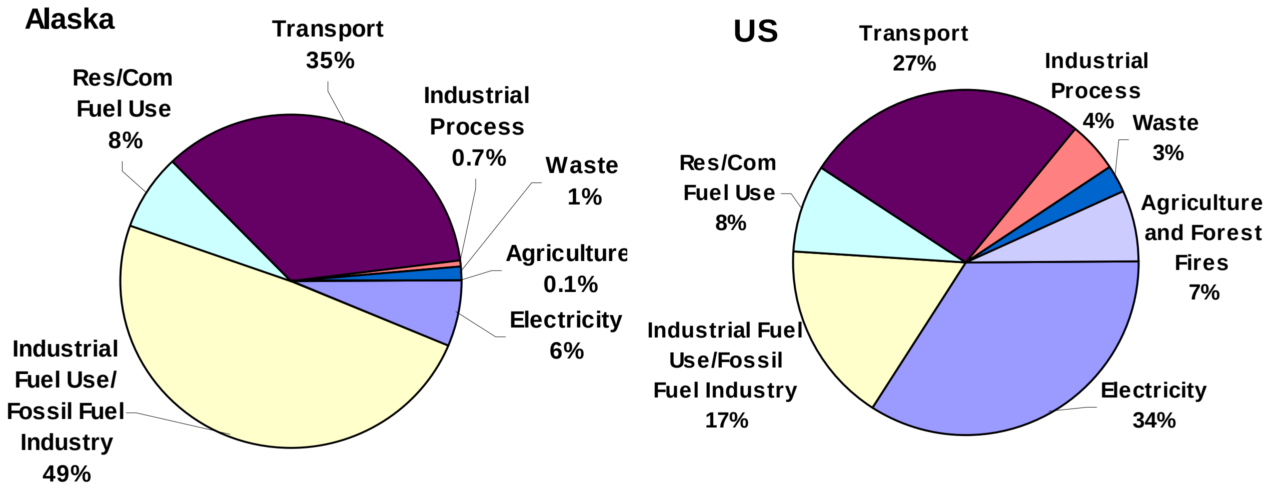
Appendices F though J represent each TWG sector and provide extensive details for each policy recommendation, including policy descriptions and designs, implementation measures, quantification methodologies and results, and qualitative discussions of indirect costs and benefits. Additionally the level of agreement and barriers to implementation are addressed in these analyses.

Alaska's Greenhouse Gas Inventory and Forecast

An initial step in developing the mitigation strategy was to gain an understanding of the sources of GHG gas emissions by sector. Alaska's GHG Inventory and Forecast (I&F)[1] looked at historical and projected emissions from 1990 to 2025. Specific sectors were reviewed and compiled with assistance of national and in-state subject matter experts. A comparison with U.S. overall emissions is useful in identifying the significant ways in which Alaska differs from the lower 48 states (Figure 1-1).

[1] See Appendix D: Greenhouse Gas Emissions Inventory and Reference Case Projections.

Figure 1-1. 2005 Alaska emissions by sector



Notes: Res/Com = Residential and commercial fuel use sectors. Emissions for the residential and commercial fuel use sectors are associated with the direct use of fuels (natural gas, petroleum, coal, and wood) to provide space heating, water heating, process heating, cooking, and other energy end uses. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county, and state), and other commercial establishments.

The industrial fuel use/fossil fuel industry sector accounts for direct fuel combustion in the industrial sector as well as fugitive methane that occurs from leaks and venting during the production, processing, transmission, and distribution of fossil fuels.

The industrial processes sector accounts for emissions associated with manufacturing and excludes emissions included in the industrial fuel use/fossil fuel industry sector.

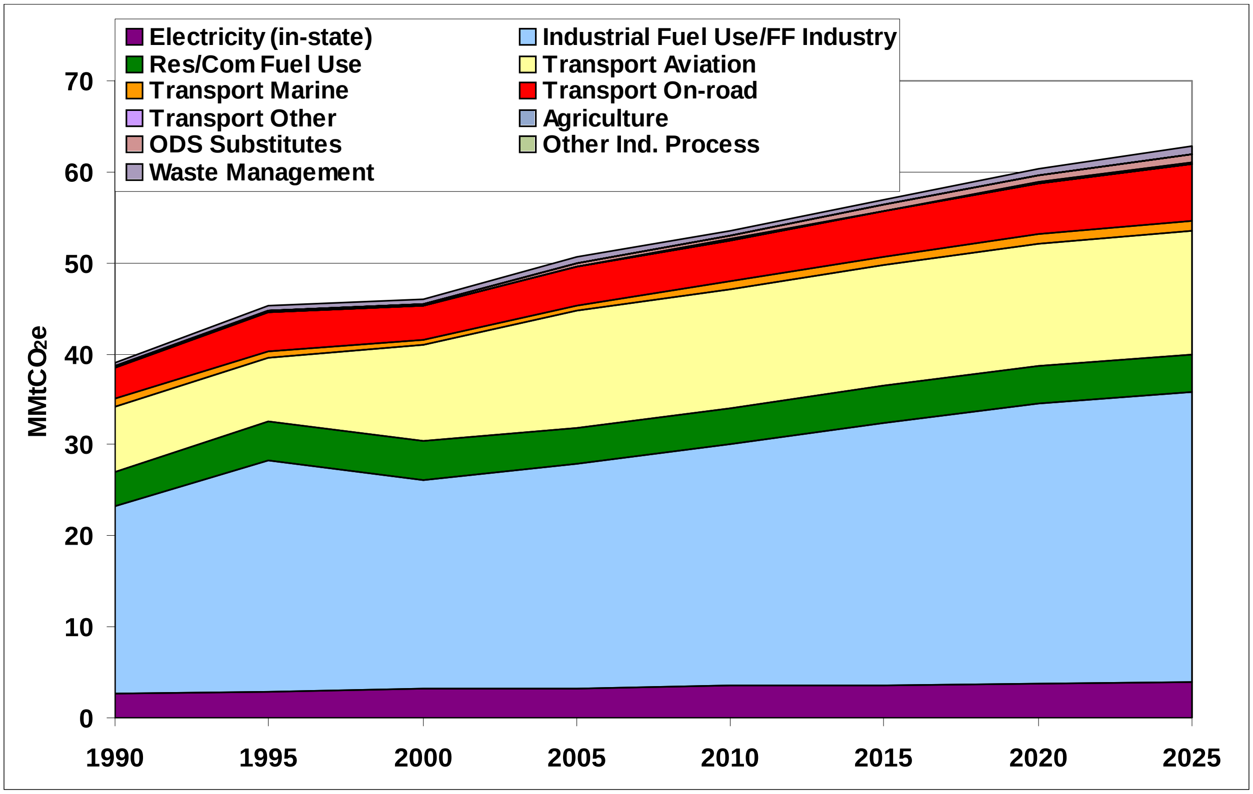
The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, railway locomotives, boats, and ships. Emissions from non-highway agricultural and construction equipment are included in the industrial sector.

Electricity = Electricity generation sector emissions on a consumption basis. In Alaska, the electricity consumed is assumed to be the same as the electricity produced in the state.

The summary of historical emissions formed the basis of a projection of how emissions are likely to change over time should the state continue on its current course, adjusted for any known or anticipated activity. This baseline emissions trajectory is often referred to as “business as usual” or BAU. CCS and DEC made this preliminary GHG emissions inventory and reference case projection available to assist everyone involved in developing the Alaska Climate Change Strategy in understanding past, current, and projected future GHG emissions in Alaska and thus informs the policy development process. Results show substantial emissions growth since 1990 and, absent mitigation measures, emissions are expected to grow through 2025 (Figure 1-2).

Updates to the I&F continued throughout the development of the mitigation policy recommendations with assistance from DEC, CCS, and the TWGs. Refinements relied not only on established, reliable sources of data but also on the expertise of MAG and TWG members. When all input was finalized, the I&F was approved for use by the MAG and considered in its deliberations.

Figure 1-2. Gross Alaska GHG emissions by sector, 1990–2025: historical and projected



GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent; FF = fossil fuel; Res/Com = direct fuel use in the residential and commercial sectors; ODS = ozone-depleting substance; Ind. = industrial.

Note: The Industrial Fuel Use/FF Industry category accounts for direct fuel combustion in the industrial sector as well as fugitive methane that occurs from leaks and venting during the production, processing, transmission, and distribution of fossil fuels.

One dilemma of seeking to reduce GHG emissions in Alaska is identifying those emissions that are normally counted toward a state's total emissions but where—in Alaska's case —the activity is beyond the control of the state. For example, by convention, aviation fuel dispensed in a state results in a per-gallon conversion to GHG emissions attributed to that state. However, aircraft refueling in Alaska are frequently just passing through en route to destinations outside of Alaska. Thus, some emissions are "charged" to Alaska but occur outside of Alaska as far as commerce or other purposes are concerned. Further, neither Alaskan fuel providers nor state authority can control the location or use of these fossil fuels and their related GHG emissions.

To ensure a more thorough understanding of Alaska's opportunities and limitations in addressing GHG emissions, forecast graphs show business as usual (BAU) projections with and without aviation fuel related to transit aircraft refueling (31% of jet fuel dispensed).

GHG emissions related to off-shore vessels, again most being from transient vessels in Alaskan waters which never come in to port, have been removed from all historic and future projections.

A full discussion of this issue is found in both Chapter 7: Transportation and Land Use Sectors and Appendix J: Transportation and Land Use Policy Recommendations.

Recent actions, such as the weatherization bonding initiative, fuel energy efficiency improvements, and other steps that result in GHG emission reductions are also included in the I&F, calculated separately from GHG reductions that would result from actions recommended in this plan. Appendix G: Energy Supply and Demand Policy Recommendations describes this effort in detail.

The Alaska Climate Change Strategy Mitigation Advisory Group Process

A Climate Change Strategy for Alaska must build upon the knowledge, expertise, and concerns of a broad representation of Alaskans because climate change is not just an environmental issue in the state. It also has far-reaching social, cultural, and economic consequences of great importance to all Alaskans. The Sub-Cabinet thus required that the draft recommendations on adaptation and mitigation be a product of a deliberative process embracing Alaska concerns and Alaska solutions from Alaska citizens. Based on the work of the MAG, additional input, and its own deliberations, the Sub-Cabinet will distill final recommendations to form, in aggregate, the Alaska Climate Change Strategy for the Governor's consideration.

To investigate opportunities for reducing GHG emissions in Alaska, the Sub-Cabinet sought advice from a cross-section of 26 stakeholders from widely diverse backgrounds asked to serve as members of the MAG. To assist the MAG, 75 other individuals and some MAG members were organized into five TWGs that provided in-depth, sector-specific expertise and uniquely Alaskan experiences and perspectives. The MAG also interfaced with the Research Needs Work Group by gaining information from it about latest research efforts and by forwarding to it recommended research topics. Likewise, the Immediate Action Work Group provided valuable insights to the MAG into the most pressing problems of Alaskans related to impacts from climate change.

The state chose CCS to facilitate the deliberative, consensus-building efforts of the MAG and its TWG members. CCS TWG facilitators and project coordinators also provided subject-matter expertise in analyses and methodologies for identifying GHG emission reductions and calculated direct costs for quantifiable policy options recommended by the MAG. CCS is a well-known organization that has assisted over 20 states in the development of state climate change action plans. They were assisted by a number of other contractors listed in the Acknowledgements section below.

To ensure that the process possessed a clear state focus and strong connection to the state's academic institutions, Brian Rogers, Chancellor of University of Alaska Fairbanks, served as meeting facilitator for all formal meetings of the MAG.

As the convening body of the mitigation stakeholder process, the Sub-Cabinet provided ultimate oversight, with specific leadership and support from the Alaska DEC, whose staff provided vital assistance throughout, particularly with respect to existing measures and issues, data and analytical assistance, and logistical support.

The MAG met in seven formal meetings and two teleconferences to direct, review and approve the work of the TWGs and to provide strategic and technical guidance in the selection and development of policy recommendations. TWG members frequently attended and presented material at MAG meetings. The five TWGs each met from 12 to 25 times, primarily via teleconference, to first recommend specific policy options to the MAG and then to expand upon and analyze each approved option. Options were quantified, where possible, as to projected reductions of GHG emissions and the direct costs of such reductions. Qualitative observations and analyses were included in the detailed discussion of each policy option.

The process sought but did not require achieving consensus to bring a recommendation forward. Where unanimous consent could not be achieved, barriers to full support were identified. Where those barriers could not be eliminated through further discussion and modification, the number of dissenting opinions and the context of the dissention are noted. Of the 32 policy recommendations, only two did not secure unanimous consent for inclusion in the set of recommendations to be forwarded to the Sub-cabinet for its further consideration.

After a draft GHG Emissions Inventory and Forecast was developed and presented to members, the MAG and TWGs were offered a draft catalog of GHG reduction policies and opportunities considered in other states. This catalog, a comprehensive compendium of over 350 ideas and opportunities that have surfaced during CCS's state efforts over the last five years, was just a starting point. The MAG's first task was to identify missing options, and the catalog grew further.

Each of those options was reviewed by the TWGs and rejected, modified, or expanded upon to reflect Alaska's unique values and conditions. After months of iteration, each TWG crafted a list of priority policy options, which the MAG reviewed, refined, and approved or turned back to the TWGs for further examination, clarification, and detail. The TWGs spent countless hours examining and refining the policy options as directed by the MAG. The MAG ultimately conducted multiple reviews on each policy option before approving them.

In most instances, the TWGs were able to characterize policy options with sufficient detail to allow their potential GHG emission reductions and the accompanying costs to be estimated. Assumptions, data sources, and methodologies were developed by the TWGs and approved by the MAG. All quantified options were evaluated consistently in terms of such constants as discount rate, time period, etc. Detailed quantification information is documented in the appendices to this report.

Emission reductions focused on the six GHGs most commonly measured, and included in the U.S. Greenhouse Gas Inventory:[2] carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Emissions of these GHGs are presented using a common metric, CO_2 equivalence, which indicates the relative contribution of each gas to atmospheric change as compared to CO_2. This commonly used approach assumes not all of these gasses have the same climate impact per unit. For example, nitrous oxide is 310 times more potent than CO_2, methane 21 times more potent, and sulfur hexafluoride 23,900 times more potent. Therefore, a common unit of measurement is essential. Accordingly, all GHGs are compared to CO_2 in terms of their "global warming potential" and are then reported in

[2] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, EPA 430-R-08-005, April 15, 2008. Available at: http://epa.gov/climatechange/emissions/usinventoryreport.html.

terms in million metric tons of carbon dioxide equivalents ($MMtCO_2e$). A metric ton is approximately 2,200 pounds, or 10% more than a common, or “short,” ton of 2,000 pounds.

The costs of the policy recommendations that would bring about GHG reductions were quantified where possible. Only direct economic costs and savings were considered; indirect costs and benefits, ecological economics, social impacts and the cost of inaction were not quantified. Costs were not estimated for the federal government imposing a cost for carbon either through a cap and trade program or through a carbon tax, thus carbon costs were set at zero. If costs are established for emitting carbon and other greenhouse gases, then the net costs to reduce emissions need to be adjusted accordingly. Indirect effects are qualitatively discussed in each sector's policy option document where appropriate. Additional, more refined analysis, as well as assessment of broader macroeconomic impacts, is needed as the state refines and further considers possible implementation of the MAG recommendations.

After policy options were quantified, they were examined closely for potential overlaps with other policy options. The data were then adjusted as necessary to avoid double counting. Areas of overlap are identified and discussed in the appendices, and the adjusted values are reflected in the quantification tables that precede each sector's policy recommendations.

Overview of the MAG Recommendations

The policy recommendations covered a wide spectrum of possible actions. The Energy Supply and Demand (ESD) sector recommendations include: transmission optimization and expansion; energy efficiencies for residential, commercial, and industrial customers; renewable energy implementation; building standards; and energy efficiency for industrial installations. Other options deemed to require more knowledge were forwarded to the Research Needs Work Group.

The Forest, Agriculture and Waste Management (FAW) sector’s recommended policies address forest management and reforestation strategies for carbon sequestration in coastal and boreal forests; community wildfire risk reduction plans; expanded use of biomass feedstocks for energy production (heat, power, alternative fuels); and advanced waste reduction and recycling.

The Oil and Gas (O&G) sector provided challenges due to the complex nature of the O&G industry in the state, but invited close scrutiny due to the contribution of this sector to Alaska's overall GHG emissions. A number of recommendations were generated, but many will require significant investments and further research to ensure technical efficacy and that the costs justify the benefits gained. The recommendations include: conservation practices; reducing fugitive methane emissions; electrification of North Slope operations with centralized power; improved equipment efficiency; renewable energy in O&G operations; and carbon capture, sequestration, and enhanced oil recovery strategies within and away from known geologic traps.

Transportation and Land Use (TLU) offers numerous opportunities for GHG emission reductions. The MAG recommends that the state consider greater commuter choices; heavy-duty vehicle idling; transportation system management; efficient development patterns; promotion of alternative-fuel vehicles; vehicle-miles-traveled and GHG reduction goals; efficiency improvements in heavy-duty vehicles and marine vessels; aviation emission reduction strategies; and alternative fuels research and development.

A number of policy recommendations that cover multiple sectors were addressed in the Cross-Cutting Issues (CC) sector. Establishing an Alaska GHG emission reporting program; establishing goals for statewide GHG emission reductions; encouraging the state government to lead by example; integrating this Climate Change Mitigation Strategy with Alaska's Energy Plan; exploring market-based systems to manage GHG emissions; and coordinating implementation of numerous existing and proposed statewide efforts to address climate change comprised the suite of CC analyses and recommendations.

Table 1-1 shows the cumulative emission reductions expected from implementing quantifiable policy options. Any potential double counting from overlaps in policy design and implemenation measures has been eliminated. The costs illustrated are directly related to the implementation of specific measures, and do not consider ancillary benefits/costs or indirect expenditures or savings. Negative costs indicate savings.

Table 1-1. Alaska cumulative emission reductions and costs and savings by sector for the period 2010-2025

Alaska Cumulative Reductions and Costs/Savings	2015 ($MMtCO_2e$)	2020 ($MMtCO_2e$)	2025 ($MMtCO_2e$)	2010–2025 ($MMtCO_2e$)	NPV 2010–2025 Cost/Cost Savings (Million $)	Cost/Savings per tCO_2e
Energy Supply and Demand	1.9	3.0	5.3	40.7	–$191	–$5
Oil and Gas	0.751	4.8	4.8	46.2	$7,530	$163
Transportation and Land Use	0.19	0.31	0.42	3.85	$364	$95
Forestry, Agriculture, Waste Management	0.47	0.8	1.11	9.5	$84	$9
Cross-Cutting	NQ	NQ	NQ	NQ	NQ	NQ
Total	**3.3**	**9.0**	**11.7**	**100.2**	**$7,787**	**$78.0**

CO_2e = carbon dioxide equivalent; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; NPV = net present value.; NQ = Not Quantified

The issue of when, whether, and if so, who should set statewide GHG reduction goals created lively debate throughout the MAG process. Ultimately, a slim majority of MAG members (8-6) recommend that the Sub-Cabinet adopt an aspirational (not legislated) numeric GHG emission reduction goal.

The CC TWG recommended 20% below 1990 GHG emission levels by 2020, and 80% below 1990 levels by 2050, keeping in mind the emissions that are beyond the control of the State. The 2050 goal is consistent with the United Nations Intergovernmental Panel on Climate Change recommendation to keep atmospheric CO_2 levels at 450 parts per million[3] or lower to avoid

[3] Pachauri, Dr. R.K., Chairman, IPCC. "New Knowledge on Climate Change: Global Efforts for Meeting the Challenge." Presentation at GCEP Research Symposium, Stanford University, Oct. 2007. http://gcep.stanford.edu/pdfs/kUXNHroC3cAssx6wJoz_Mg/Pachauri-20071001-GCEP.pdf

major irreversible damage to the planet's ecosystems. In addition, Alaska should establish a baseline of emissions that will help measure progress toward these goals and refine it after federal legislation related to this matter is determined.

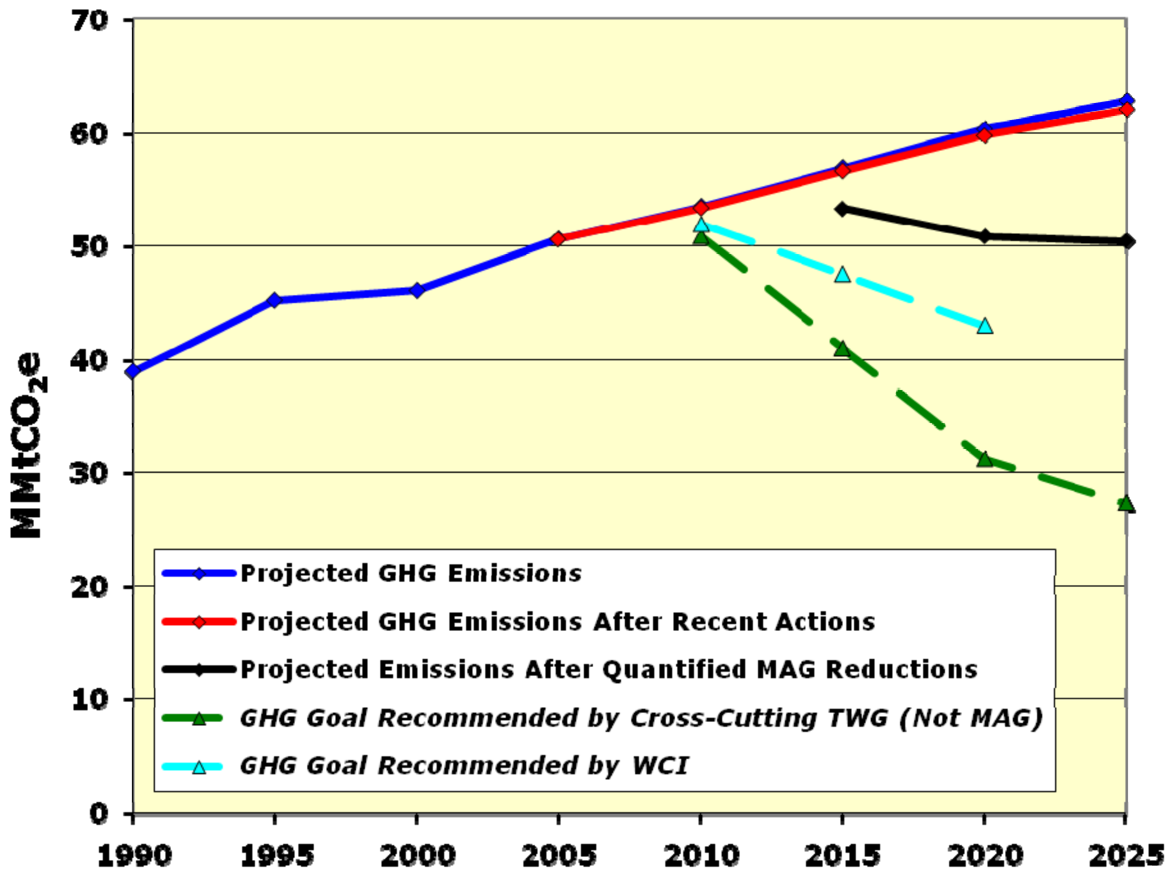
Members objecting to this recommendation noted that many of Alaska's emissions are caused by activities out of the state's control, and that the Sub-Cabinet should not set a numeric goal.4

When the quantifiable recommendations were tallied, the trajectory of increasing emissions over time could be curtailed and reduced by almost 12 MMtCO2e, or 19% from projected levels by 2025. More specifically, if all quantified actions were implemented, there would be a reduction in GHG emissions from 62.1 to 50.4 MMtCO2e by 2025, or 11.7 MMtCO2e below the BAU projection of no actions beyond federal corporate average fuel efficiency standards implemented. Figure 1-3a illustrates the projected results from different reduction strategies. Figure 1-3b illustrates the projected results after removing emissions from aviation refueling unrelated to Alaska activities and beyond the state's control from the baseline BAU. If all quantified actions were implemented, the BAU GHG emissions without transient aviation refueling would be reduced from 58.5 to 46.8 MMtCO2e by 2025.

The lowest line on both these figures illustrates the reduction target that the Cross-Cutting Issues (CC) TWG recommended that the Sub-Cabinet consider as a statewide goal. This represents reductions of 20% below 1990 GHG emissions levels by 2020, and 80% below 1990 levels by 2050. For comparison purposes, the recommended emission reduction goal from the Western Climate Initiative (WCI) is also shown on each. WCI is comprised of seven western states and four Canadian provinces as members; seven other U.S. states and six Mexican states are observers. Alaska is an observer state.

[4] See Chapter 3: Cross-Cutting Issues and Appendix F: Cross-Cutting Issues Policy Recommendations for more in-depth discussion.

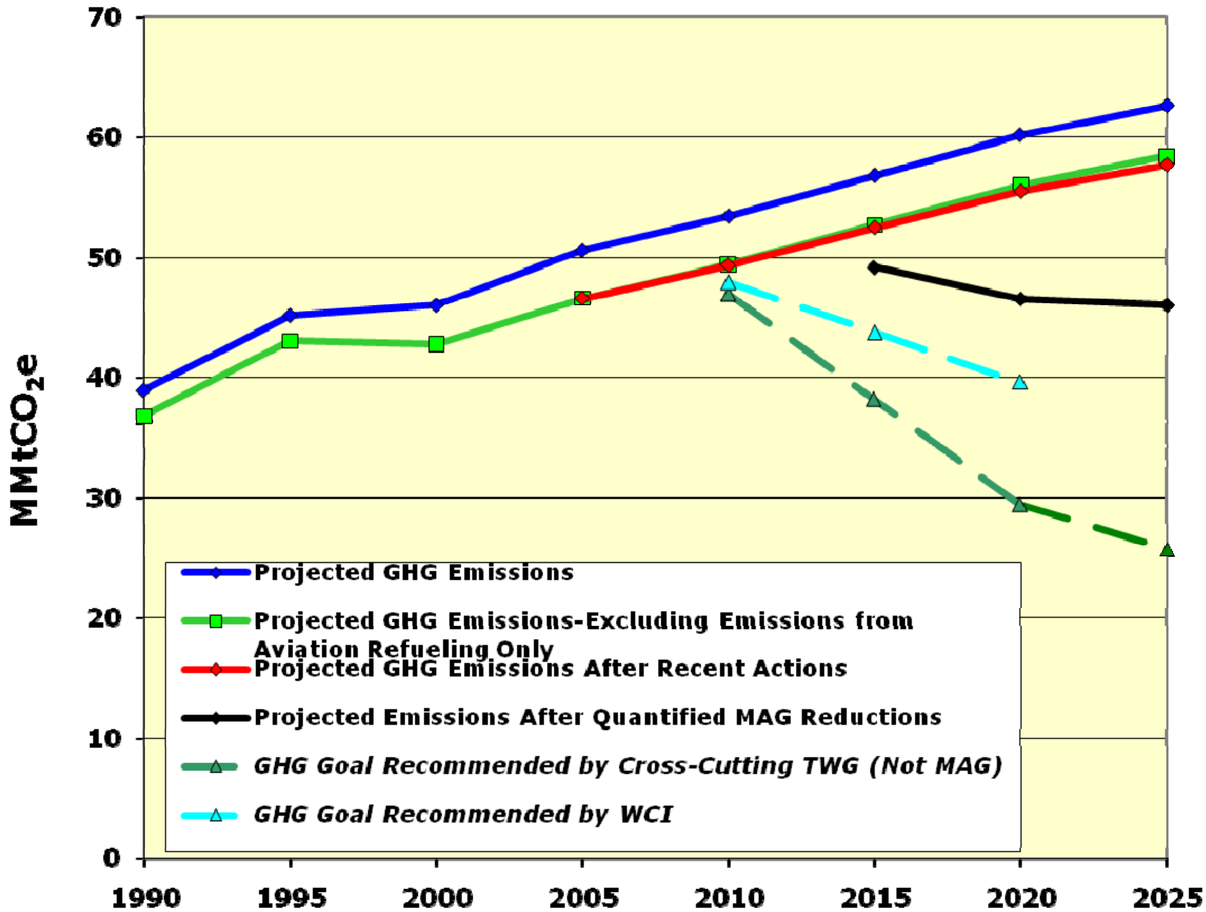
Figure 1-3a. Projected Alaska GHG emission scenarios: historical to 2025 (gross consumption)



GHG = greenhouse gas; MAG = Mitigation Advisory Group; $MMtCO_2e$ = million metric ton of carbon dioxide equivalents; TWG = Technical Work Group; WCI = Western Climate Initiative.

As is evident on both Figure 1-3a and Figure 1-3b, the quantified options recommended in this report are not sufficient to reach any of the potential numeric goals shown. Unquantified options, such as conservation and state government leading-by-example, will reduce emissions further. Other emission-reducing actions beyond the scope of this report are anticipated. In particular, actions that save money and energy will be very advantageous for a broad range of individuals and businesses to implement independent of recommendations from the Sub-Cabinet. For example, a MAG member from an aviation-dependent delivery corporation outlined the aggressive sustainability measures implemented by the company that not only save money and fuel but also reduce GHG emissions.

Figure 1-3b. Projected Alaska GHG emission scenarios: historical to 2025 (consumption-based, gross emissions excluding refueling transient aircraft)



GHG = greenhouse gas; MAG = Mitigation Advisory Group. $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; TWG = Technical Work Group; WCI = Western Climate Initiative.

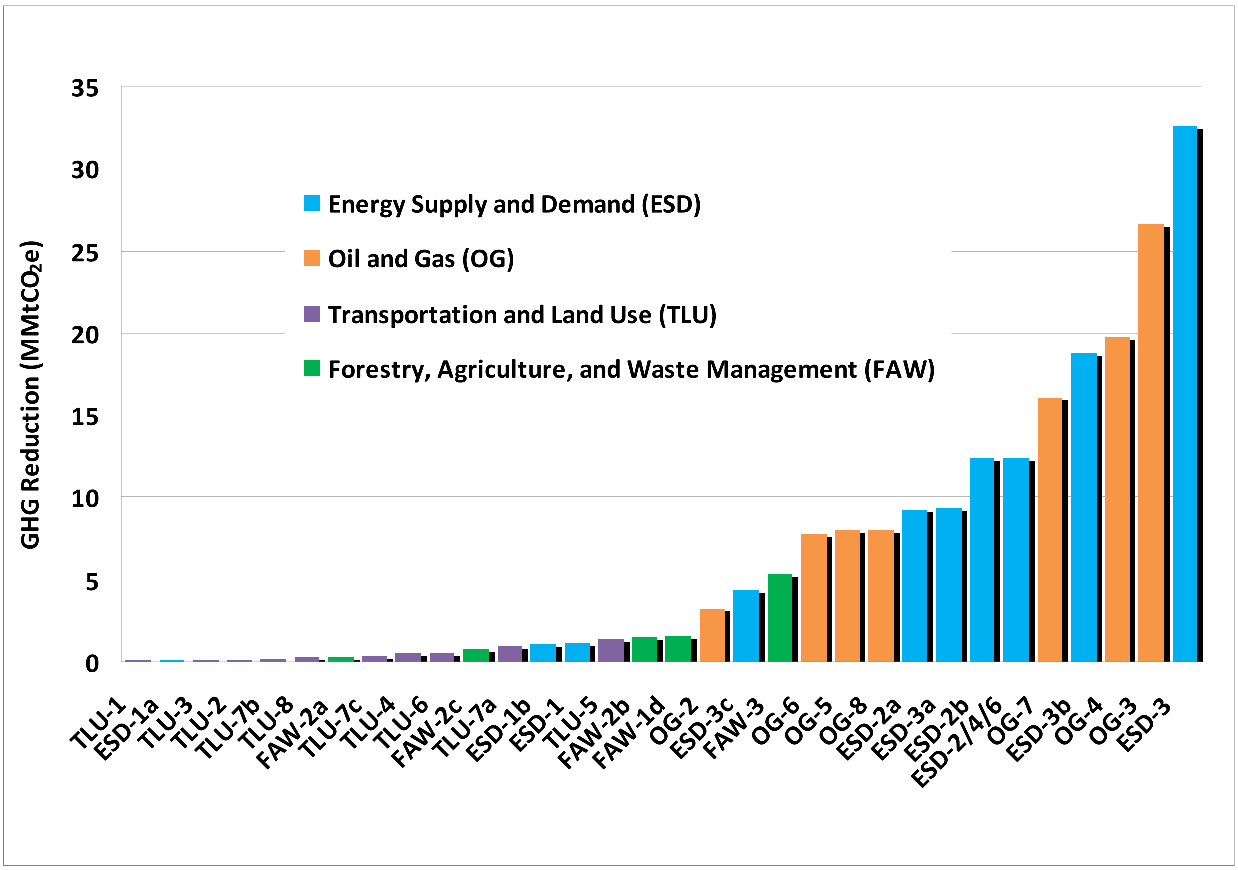
Not shown on the graphs but of interest to the MAG is the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report goal of stabilizing the global atmosphere at 450 parts per million (ppm) of CO_2 (this does not include the five other GHGs, which when combined with CO_2 is already well above 450ppm). The CC TWG considered the IPCC goal of 450 ppm CO_2 when recommending the goals they did. The IPCC recognizes that this requires developed nations to achieve reductions of 25-40% below 1990 CO_2 emissions by 2020 and 80-95% reductions below 1990 levels by 2050. Another IPCC scenario is to consider a goal of 550 ppm CO_2e, which means GHG emission reductions of 10-30% below 1990 levels by 2020 and 40-90% below 1990 levels by 2050 for developed nations.[5]

[5] Pachauri, Dr. R.K., Chairman, IPCC. "New Knowledge on Climate Change: Global Efforts for Meeting the Challenge." Presentation at GCEP Research Symposium, Stanford University, Oct. 2007. http://gcep.stanford.edu/pdfs/kUXNHroC3cAssx6wJoz_Mg/Pachauri-20071001-GCEP.pdf

Again, by a small majority, the MAG recommends the Sub-Cabinet consider establishing an aspirational (not legislated) numeric state goal using the above information for guidance. Those who objected would prefer not to have a numeric goal, or perhaps any GHG reduction goal at all.

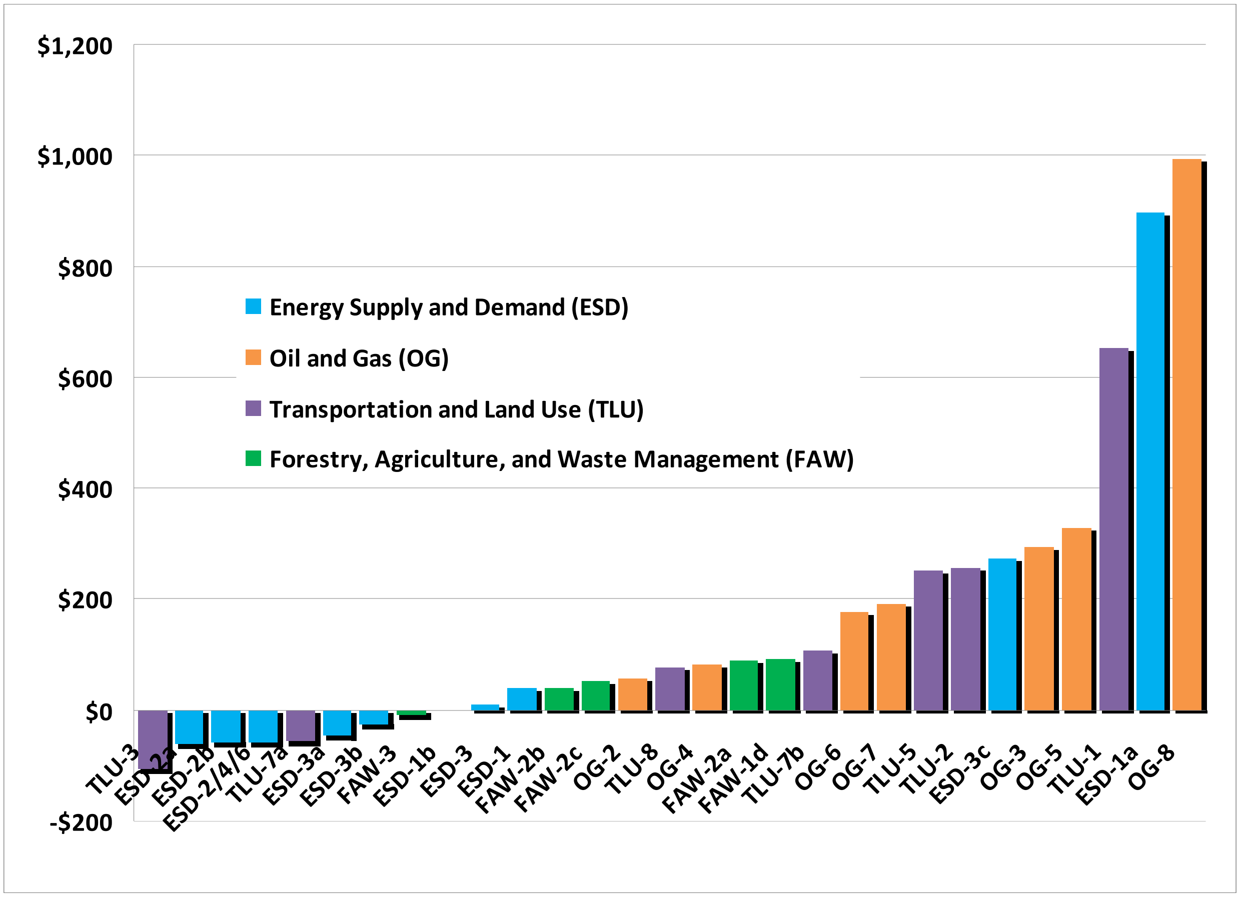
The recommended policies are displayed below in terms of relative amount of GHG reductions over the life of the strategy (Figure 1-4). For ease in identification, each policy is identified by the sector it represents and given a number. These identifiers can be cross-referenced in the chapters that follow; there is one chapter per sector. Figure 1-5 displays the quantified options by their cost or savings per $MMtCO_2e$ reduced. Note that bars below the baseline indicate cost savings.

Figure 1-4. Cumulative GHG reduction potential for each individual Alaska policy recommendation over the period 2010-2025



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

Figure 1-5. Alaska policy options ranked by cost/savings per ton of GHG reduced, 2010–2025



Negative values indicate a cost savings. GHG = greenhouse gas.

Public Involvement and Transparency

Consistent with CCS's emphasis on transparency and non-partisanship, and the desire of the Sub-Cabinet to keep Alaska citizens well informed throughout the process, the development of the mitigation recommendations was fully public. The state and CCS maintained Web sites that announced all meetings and provided relevant meeting materials, including policy options at each stage of development, the I&F, and notes from previous meetings. That is, any materials provided for the MAG were accessible by the public at each step of the process, and will continue to be available for at least the next year.

All MAG and TWG meetings were open to the public, and call-in numbers to join the discussion by telephone were provided. The public was likewise invited to attend MAG meetings in person, and five to fifteen members of the public were typically in attendance. In addition, each meeting and teleconference provided a specific opportunity on its agenda for public comments and input.

As lead facilitator, CCS compiled input from MAG and TWG members and edited it for clarity but did not generate original material other than the technical explanations and approach for the quantification task. Each iteration of each policy option was reviewed and approved by the relevant TWG before being forwarded for review and approval by the MAG.

Members of the public attending the Alaska Forum on the Environment were also able to attend a day-long workshop devoted to the Alaska Climate Change Strategy. Presentations by TWG members covered each sector of concern thoroughly. DEC Commissioner Larry Hartig, other government officials, and process leaders held an open discussion with attendees to elicit personal stories of impacts, concerns, and ideas for enhancing Alaska's effectiveness in responding to global warming.

The Sub-Cabinet anticipates further analysis of the MAG's recommendations by state agencies and experts along with further opportunities for public input and involvement as the draft Alaska Climate Change Strategy is developed for the Governor's consideration. This will enable the Sub-Cabinet to benefit from an even broader range of opinions and contributions from around the state.

Collaboration and Education

Numerous efforts are ongoing in Alaska and the region concurrent with this process. DEC brought in subject-matter experts to provide presentations to MAG meetings at nearly every meeting, and arranged for instructive field trips to facilitate awareness, knowledge exchange, and deeper understanding. Experts on cold-climate housing, permafrost research, arctic research, weather, volcanology, cross-cultural communication, geographical information system and climate mapping, green building, cap-and-trade systems, and federal policy developments helped educate MAG and TWG members. Likewise, leaders in the Alaska Energy Plan, WCI, and the Research Needs and Immediate Needs Work Groups also addressed the MAG.

A Continuing Spirit of Collaboration

Throughout the last 15 months of highly focused discussion and exchange of views, the MAG and its supporting TWGs have participated in lively debates. At their heart were always concerns for Alaska's prosperity and quality of life, a reasonable and effective response to climate changes, ensuring efficient and sufficient energy for healthy communities, providing jobs for the economic security of the state, and conserving its natural resources for this and future generations. The understanding and relationships that have grown in this process will serve Alaska well as its citizens move forward, in a continuing spirit of collaboration, to create Alaska's future.

Chapter 2
Inventory and Forecast of Alaska's GHG Emissions

Introduction

This chapter summarizes Alaska's greenhouse gas (GHG) emissions and sinks (carbon storage) from 1990 to 2025. Under an agreement with the Western Governors' Association, the Center for Climate Strategies (CCS) prepared a draft of Alaska's GHG emissions inventory and reference case projections for the Alaska Department of Environmental Conservation (DEC), which appears in Appendix D of this report. The draft inventory and reference case projections provided DEC with an initial, comprehensive understanding of current and possible future GHG emissions. The draft report was provided to the Alaska Climate Change Mitigation Advisory Group (MAG) and its Technical Work Groups (TWGs) to assist them in understanding past, current, and possible future GHG emissions in Alaska, and thereby inform the policy recommendation development process. The MAG and TWGs have reviewed, discussed, and evaluated the draft inventory and methodologies, as well as alternative data and approaches for improving the draft GHG inventory and forecast (I&F).[1] The I&F has since been revised to address the comments provided by the MAG. The information in this chapter reflects the information presented in the final *Alaska Greenhouse Gas Inventory and Reference Case Projections* report (hereafter referred to as the Inventory and Projections report).

Historical GHG emission estimates (1990–2005)[2] were developed using a set of generally accepted principles and guidelines for state GHG emission inventories, relying to the extent possible on Alaska-specific data and inputs. The reference case projections (2006–2025) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the final Inventory and Projections report.

The Inventory and Projections report covers the six types of gases included in the U.S. GHG inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence, which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential-weighted basis.[3]

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[1] Center for Climate Strategies. *Final Alaska Greenhouse Gas Inventory and Reference Case Projections: 1990–2025*. Prepared for the Alaska Climate Change Mitigation Advisory Group, July 2009, available at http://www.akclimatechange.us/Inventory_Forecast_Report.cfm.

[2] The last year of available historical data for each sector varies between 2000 and 2005.

[3] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth–atmosphere system. Holding all else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth). See: Boucher, O., et al. "Radiative Forcing of Climate Change." Chapter 6 in Climate Change 2001: The Scientific Basis. Contribution of Working Group 1 of the Intergovernmental Panel on Climate

It is important to note that the emission estimates reflect the GHG emissions associated with the electricity sources used to meet Alaska's demands, corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the GHG emissions produced by electricity generation facilities in the state, a production-based method. The study covers both methods of accounting for emissions, but for consistency, all total results are reported as consumption-based. Because Alaska has very limited electricity imports or exports, the GHG emissions on a production basis are the same as GHG emissions from a consumption basis. In contrast, electricity imports and exports are an important issue in other states.

Alaska GHG Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for Alaska by sector for 1990, 2000, 2005, 2010, 2020, and 2025. As shown in this table, Alaska is estimated to be a net source of GHG emissions (positive, or gross, emissions). Alaska's forests serve as sinks of GHG emissions (removal of emissions, or negative emissions). Alaska's net emissions subtract the equivalent GHG reduction from emission sinks from the gross GHG emission totals. The following sections discuss GHG emission sources and sinks, trends, projections, and uncertainties.

Historical Emissions

Overview

In 2005, on a gross emissions consumption basis (i.e., excluding carbon sinks), Alaska accounted for approximately 50.6 million metric tons of carbon dioxide equivalent (MMtCO2e) emissions, an amount equal to 0.7% of total U.S. gross GHG emissions. On a net emissions basis (i.e., including carbon sinks), Alaska residents accounted for approximately 49.2 MMtCO2e of emissions in 2005, an amount equal to 0.8% of total U.S. net GHG emissions.4 Alaska's GHG emissions are growing at a much faster pace than those of the nation as a whole. From 1990 to 2005, Alaska's gross GHG emissions increased by 30%, while national gross emissions rose by 16%.5

On a per-capita basis, Alaska residents emitted about 79 metric tons (t) of gross CO_2e in 2005, significantly higher the national average of 24 tCO_2e. Figure 2-1 illustrates the state's emissions per capita and per unit of economic output. Per-capita emissions have increased somewhat in Alaska through the 1995–2005 period, while national per-capita emissions have remained relatively constant over this period. The higher per capita emission rates and growth in Alaska are driven by emissions from the industrial and transportation sectors, which are much higher than the national average. In both Alaska and the nation as a whole, economic growth exceeded

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Change, Cambridge University Press, Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

[4] The national emissions used for these comparisons are based on 2008 emissions from U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006, April 15, 2008, EPA 430-R-08-005. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[5] The growth in Alaska's emissions from 1990 to 2005 is primarily associated with the transportation and the residential, commercial, and industrial (RCI) fuel consumption sectors.

emissions growth throughout the 1990–2005 period. From 1990 to 2005, emissions per unit of gross product dropped by 26% nationally, and by 17% in Alaska.[6]

Table 2-1. Alaska GHG emissions, historical and reference case projection, by sector*

Sector	1990	2000	2005	2010	2020	2025
	MMtCO$_2$e					
Energy (Consumption Based)	**38.6**	**45.3**	**49.6**	**52.5**	**58.8**	**60.9**
Electricity Use (Consumption)	**2.76**	**3.19**	**3.20**	**3.58**	**3.74**	**4.02**
Electricity Production (in-state)	2.76	3.19	3.20	3.58	3.74	4.02
Coal	*0.40*	*0.42*	*0.48*	*0.50*	*0.79*	*0.79*
Natural Gas	*2.00*	*2.29*	*2.14*	*2.22*	*2.36*	*2.36*
Oil	*0.37*	*0.48*	*0.57*	*0.86*	*0.58*	*0.86*
Imported/Exported Electricity	0.00	0.00	0.00	0.00	0.00	0.00
Residential/Commercial Fuel Use	**3.77**	**4.33**	**3.88**	**3.91**	**4.12**	**4.07**
Coal	*0.76*	*0.79*	*0.70*	*0.69*	*0.67*	*0.66*
Natural Gas	*1.79*	*2.22*	*1.87*	*1.91*	*2.09*	*2.13*
Petroleum	*1.21*	*1.30*	*1.29*	*1.29*	*1.34*	*1.26*
Wood (CH_4 and N_2O)	*0.012*	*0.013*	*0.023*	*0.023*	*0.023*	*0.023*
Industrial Fuel Use/Fossil Fuel Industry	**20.5**	**22.9**	**24.7**	**26.5**	**30.9**	**31.8**
Coal/Coal Mining	*0.009*	*0.010*	*0.009*	*0.009*	*0.009*	*0.010*
Natural Gas/Natural Gas Industry	*13.4*	*17.7*	*19.1*	*20.5*	*25.1*	*26.1*
Petroleum/Oil Industry	*7.10*	*5.18*	*5.57*	*5.98*	*5.78*	*5.60*
Wood (CH_4 and N_2O)	*0.012*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Transportation	**11.5**	**14.9**	**17.8**	**18.5**	**20.1**	**21.1**
Aviation	*7.15*	*10.6*	*12.9*	*13.1*	*13.4*	*13.7*
Marine Vessels	*0.83*	*0.48*	*0.61*	*0.72*	*1.00*	*1.17*
On-road Vehicles	*3.41*	*3.71*	*4.19*	*4.55*	*5.57*	*6.20*
Rail and Other	*0.082*	*0.075*	*0.056*	*0.057*	*0.062*	*0.063*
Industrial Processes	**0.051**	**0.20**	**0.33**	**0.45**	**0.75**	**0.96**
Limestone and Dolomite Use (CO_2)	0.000	0.000	0.008	0.008	0.009	0.009
Soda Ash (CO_2)	0.006	0.006	0.006	0.006	0.007	0.007
ODS Substitutes (HFC, PFC)	0.001	0.17	0.30	0.42	0.72	0.94
Electric Power T&D (SF_6)	0.044	0.025	0.024	0.017	0.010	0.008
Waste Management	**0.32**	**0.53**	**0.63**	**0.52**	**0.73**	**0.86**
Solid Waste Management	0.26	0.46	0.56	0.45	0.65	0.78
Wastewater Management	0.057	0.067	0.068	0.071	0.076	0.079
Agriculture	**0.053**	**0.054**	**0.053**	**0.056**	**0.066**	**0.073**
Enteric Fermentation	0.013	0.015	0.020	0.023	0.029	0.034
Manure Management	0.001	0.002	0.004	0.005	0.009	0.012
Agricultural Soils	0.039	0.037	0.030	0.029	0.028	0.028
Gross Emissions (Consumption Basis)	**39.0**	**46.1**	**50.6**	**53.5**	**60.3**	**62.8**
Increase relative to 1990		*18%*	*30%*	*37%*	*55%*	*61%*
Emissions Sinks	**–0.3**	**–1.4**	**–1.4**	**–1.4**	**–1.4**	**–1.4**
Forestry and Land Use	–0.3	–1.4	–1.4	–1.4	–1.4	–1.4

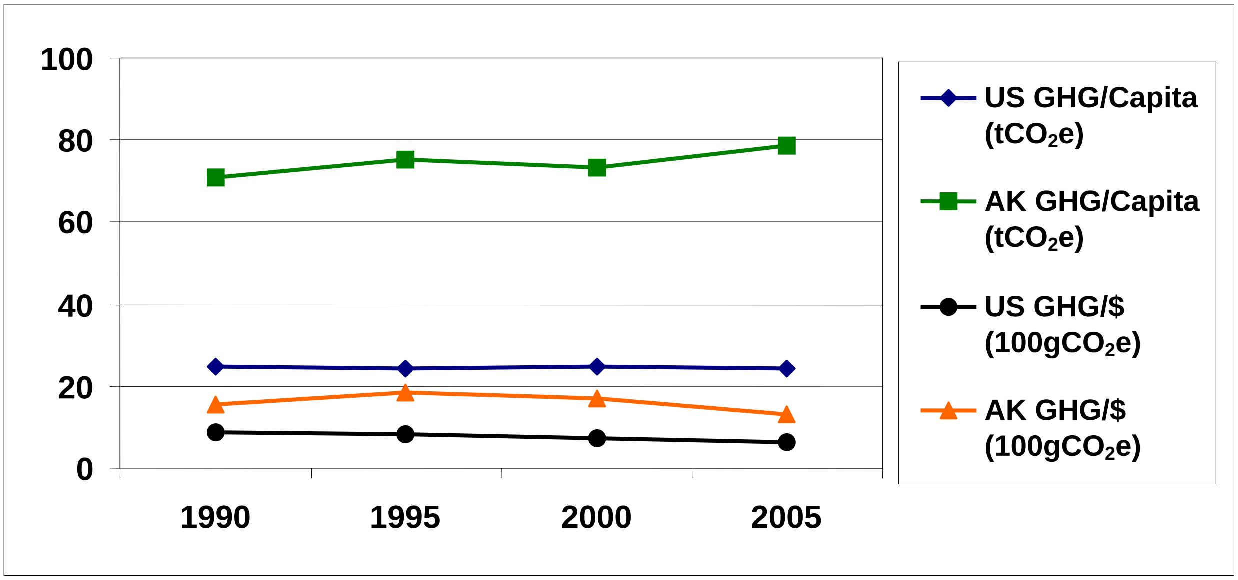
[6] Based on real gross domestic product (millions of chained 2000 dollars) that excludes the effects of inflation. U.S. Department of Commerce, Bureau of Economic Analysis. "Gross Domestic Product by State." Available at: http://www.bea.gov/regional/gsp/.

Net Emissions (Consumption Basis) (Including Forestry and Land Use Sinks)	**38.7**	**44.7**	**49.2**	**52.1**	**58.9**	**61.4**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; CH_4 = methane; CO_2 = carbon dioxide; N_2O = nitrous oxide; ODS = ozone-depleting substance; HFC = hydrofluorocarbon; PFC = perfluorocarbon; SF_6 = sulfur hexafluoride; T&D = transmission and distribution.

* Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

Figure 2-1. Alaska and U.S. gross GHG emissions, per-capita and per-unit gross product

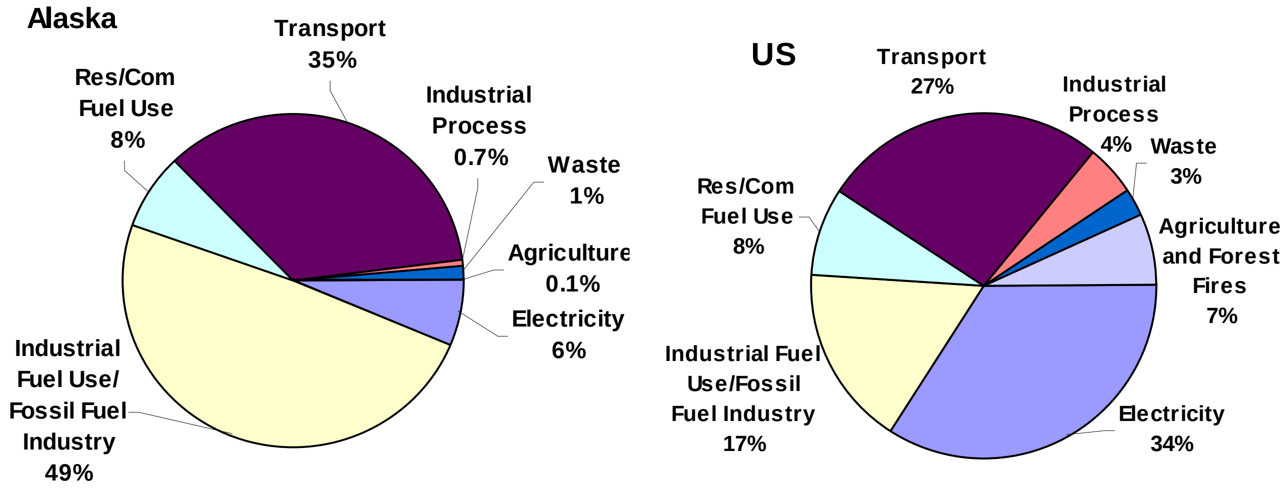


AK = Alaska; g = gram; GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent

The principal sources of Alaska's GHG emissions in 2005 are the industrial and transportation sectors, accounting for 49% and 35% of Alaska's gross GHG emissions, respectively (Figure 2-2). The industrial sector includes fossil fuel combustion at industrial sites as well as fossil fuel industry emissions associated with natural gas production, processing, transmission and distribution (T&D), flaring, and pipeline fuel use, as well as with oil production and refining and coal mining emission releases. The next-largest contributor is the combustion of fossil fuel by the residential and commercial sectors, accounting for 8% of gross GHG emissions in 2005. Electricity production accounted for 7% of gross GHG emissions in 2005. The remaining sectors—agriculture, landfills and wastewater management facilities, and industrial processes—accounted for about 2% of the state's emissions in 2005. Industrial process emissions comprised only 0.7% of state GHG emissions in 2005, but these emissions are rising due to the increasing use of HFCs as substitutes for ozone-depleting chlorofluorocarbons.[7] Other industrial process emissions result from CO_2 released during soda ash, limestone, and dolomite use. In addition, SF_6 is released due to the use of electric power T&D equipment.

[7] Chlorofluorocarbons are also potent GHGs. However, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol on Substances That Deplete the Ozone Layer. See Appendix J in the Final Inventory and Projections report for Alaska, available at http://www.akclimatechange.us/Inventory_Forecast_Report.cfm.

Figure 2-2. Gross GHG emissions by sector, 2005: Alaska and U.S.



Notes: Res/Com = Residential and commercial fuel use sectors. Emissions for the residential and commercial fuel use sectors are associated with the direct use of fuels (natural gas, petroleum, coal, and wood) to provide space heating, water heating, process heating, cooking, and other energy end uses. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county, and state), and other commercial establishments.

The industrial fuel use/fossil fuel industry sector accounts for direct fuel combustion in the industrial sector as well as fugitive methane that occurs from leaks and venting during the production, processing, transmission, and distribution of fossil fuels. The industrial processes sector accounts for emissions associated with manufacturing and excludes emissions included in the industrial fuel use/fossil fuel industry sector.

The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, railway locomotives, boats, and ships. Emissions from non-highway agricultural and construction equipment are included in the industrial sector.

Electricity = Electricity generation sector emissions on a consumption basis. In Alaska, the electricity consumed is assumed to be the same as the electricity produced in the state.

Forestry emissions refer to the net CO_2 flux[8] from forested lands in Alaska, which account for about 35% of the state's land area.[9] Alaska's forests are estimated to be net sinks of CO_2 emissions in the state, reducing net GHG emissions by 1.4 $MMtCO_2e$ in 2005.

Reference Case Projections

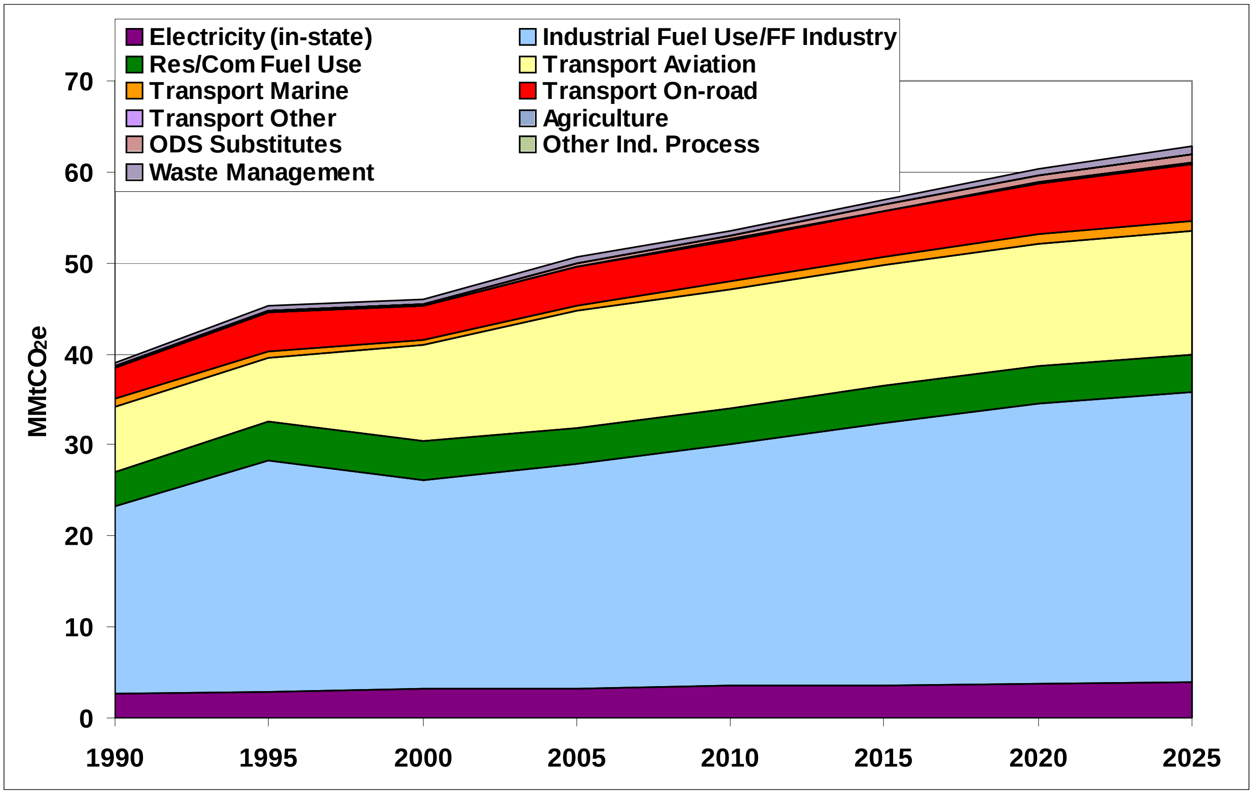
Relying on a variety of sources for projections, as noted in the Inventory and Projections report, a simple reference case projection of GHG emissions through 2025 was developed. As illustrated in Figure 2-3 and shown numerically in Table 2-1, under the reference case projections, Alaska's gross GHG emissions continue to grow steadily, climbing to about 62.8 $MMtCO_2e$ by 2025, or 61% above 1990 levels. This equates to a 1.4% annual rate of growth from 1990 to 2025. Relative to 2005, the share of emissions associated with industrial sector and industrial processes increases somewhat to 51% and 2%, respectively, by 2025. The shares of emissions from the transportation and residential and commercial fuel use sectors both decrease

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

[9] Alaska Forest Association, http://www.akforest.org/facts.htm, reports 129 million acres of forested lands. The total land area in Alaska is 365 million acres (http://www.netstate.com/states/geography/ak_geography.htm).

slightly to 34% and 7%, respectively. The shares of emissions from the electricity, waste, and agriculture sectors remain the same in 2025 as in 2005.

Figure 2-3. Alaska gross GHG emissions by sector, 1990–2025: historical and projected

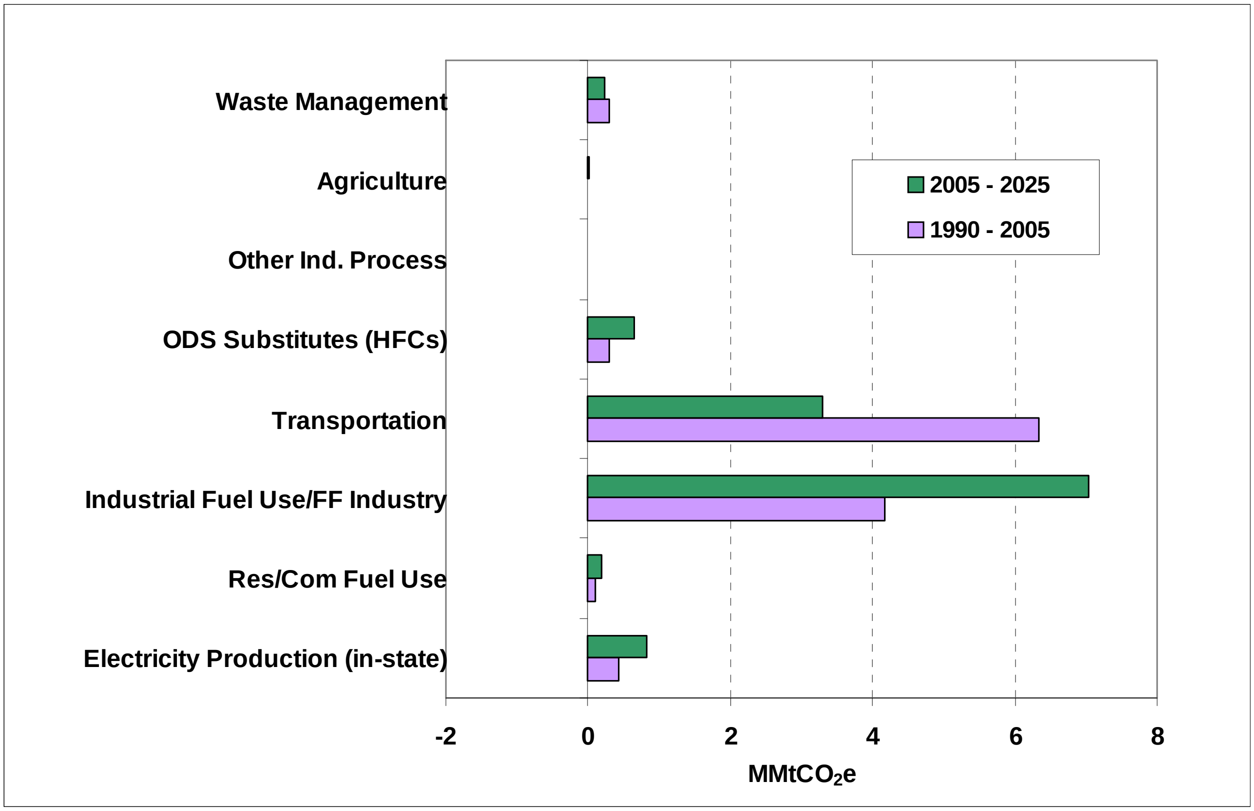


GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; FF=fossil fuel; Res/Com = direct fuel use in the residential and commercial sectors; ODS = ozone-depleting substance; Ind. = industrial.

Note: The Industrial Fuel Use/FF Industry category accounts for direct fuel combustion in the industrial sector as well as fugitive methane that occurs from leaks and venting during the production, processing, transmission, and distribution of fossil fuels.

Emissions associated with the industrial sector are projected to be the largest contributor to future GHG emissions growth, with a total increase in GHG emissions from 2005 to 2025 of 7.0 $MMtCO_2e$, as shown in Figure 2-4. The next-largest source of emissions growth in this time period is the transportation sector, with an increase of 3.3 $MMtCO_2e$. Other sources of emissions growth include the electricity production, ozone-depleting substance substitutes, waste management, and agriculture sectors. Table 2-2 summarizes the growth rates that drive the growth in the Alaska reference case projections, as well as the sources of these data.

Figure 2-4. Sector contributions to gross emissions growth in Alaska, 1990–2025: reference case projections



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; Ind. = industrial; ODS = ozone-depleting substance; HFCs = hydrofluorocarbons; FF= fossil fuel; Res/Com = residential and commercial sectors.

Table 2-2. Key annual growth rates for Alaska, historical and projected

Annual Growth Rate	1990–2005	2005–2025	Sources
Population	1.0%	0.6%	Alaska Department of Labor and Workforce Development, 2004-2014.
Employment Goods Services	 2.1% 1.7%	 0.9% 1.1%	Alaska Department of Labor and Workforce Development, 2004-2014. Forecast trend assumed to continue through 2025.
Electricity Sales	2.2%	0.8%	Historic rates are from EIA data. Projections are CCS assumptions as described in Appendix A of the Inventory and Projections report.
Vehicle Miles Traveled	1.7%	1.3%	Alaska Department of Transportation and Public Facilities, Western Region Air Partnership Mobile Source Inventory.

* Population and employment projections for Alaska were used together with the U.S. Department of Energy's Energy Information Administration *Annual Energy Outlook 2006* projections of changes in fuel use per capita and per employee, as relevant for each sector (http://www.scag.ca.gov/rcp/pdf/publications/1_2006AnnualEnergyOutlook.pdf). For instance, growth in Alaska's residential natural gas use is calculated as the Alaska population growth times the change in per-capita natural gas use for the Pacific region.

EIA = Energy Information Administration; CCS = Center for Climate Strategies.

A Closer Look at the Two Major Sources: Industrial Sector and Transportation

As shown in Figure 2-2, the industrial sector, comprised of industrial fuel combustion as well as emissions associated with the production, processing, transmission, and distribution of fossil fuels, accounted for 49% of Alaska's gross GHG emissions in 2005 (about 25 $MMtCO_2e$), which was much higher than the national average share of emissions from the industrial sector (17%). Activities in the industrial[10] sector produce GHG emissions when fuels are combusted to provide space heating, process heating, and other applications. This sector also includes emissions released during the production, processing, transmission, and distribution of fossil fuels. Known as fugitive emissions, these are methane and carbon dioxide gases released via leakage and venting at coal mines, oil and gas fields, processing facilities, and pipelines. A majority of the industrial sector emissions resulted from the use of natural gas and the natural gas industry (19.1 $MMtCO_2e$). Industrial oil combustion and the oil industry together contributed 5.6 $MMtCO_2e$ of GHG emissions in 2005. An insignificant amount of the industrial sector emissions was contributed by coal use and coal mining. GHG emissions for the industrial sector (excluding those associated with electricity consumption) are expected to increase by 28% between 2005 and 2025, reaching 31.8 $MMtCO_2e$ by 2025.[11]

The transportation sector accounted for 35% (17.8 $MMtCO_2e$) of Alaska's gross GHG emissions in 2005. Emissions are projected to increase to 21.1 $MMtCO_2e$ (34% of gross GHG emissions) in 2025. Jet fuel consumption accounts for the largest share of transportation GHG emissions. Emissions from jet fuel consumption increased by about 84% from 1990 to 2005, accounting for 72% of total transportation emissions in 2005. Emissions from on-road gasoline grew by 15% between 1990 and 2005, and on-road diesel emissions grew by 37% during this period. In 2005, on-road gasoline and diesel accounted for 14% and 10% of total transportation emissions, respectively. GHG emissions from marine fuel consumption decreased by 26% from 1990 to 2005, and in 2005 accounted for 3% of GHG emissions from the transportation sector. Emissions from all other categories combined (aviation gasoline, locomotives, natural gas and liquefied petroleum gas, and oxidation of lubricants) contributed slightly over 0.3% of total transportation emissions in 2005.

From 2005 to 2025, emissions from transportation fuels are projected to rise by 0.85% per year. This leads to an increase of 3.3 $MMtCO_2e$ in transportation emissions during the period, for a total of 21.1 $MMtCO_2e$ in 2025. The largest percentage increase in emissions over this time period is seen in on-road diesel fuel consumption, which is projected to increase by 92% from 2005 to 2025.

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[10] The industrial sector includes emissions associated with agricultural energy use and fuel used by the fossil fuel production industry.

[11] See Appendix B of the Inventory and Reference Case Projections report for more details, available at http://www.akclimatechange.us/Inventory_Forecast_Report.cfm. Given the forecasted decline in non-combustion emissions for the fossil fuel industry, the increase in the industrial fossil fuel consumption seems odd; however, DEC contacts indicate that natural gas combustion is expected to increase significantly in future years, since more fuel is consumed to extract oil and gas as the production in existing fields declines. This is an area that should be investigated further during future work. The industrial fossil fuel consumption projections are based on the regional Energy Information Administration *Annual Energy Outlook 2006* forecast data for the Pacific Region (http://www.scag.ca.gov/rcp/pdf/publications/1_2006AnnualEnergyOutlook.pdf).

It is important to note that the jet fuel emissions include fuel that is purchased in Alaska but is not necessarily consumed within Alaska's airspace. This accounting issue is also present in the inventories of other states prepared by CCS, where international passenger and cargo transportation emissions are concerned. On the other hand, fuel purchased outside of the state for aircraft that enter the state are not included in the emission estimates presented in this report. The size of the contribution from the transportation aviation sector shown in Figure 2-3 reflects the importance of this industry in Alaska.

Mitigation Advisory Group Revisions

Following are the revisions that the MAG made to the inventory and reference case projections, thus explaining the differences between the final Inventory and Projections report and the initial assessment completed in July 2007:

All Sectors

The initial assessment included GHG emission projections to 2020. This was revised to extend the GHG projections to 2025 for all sectors.

Electric Supply

The Energy Supply and Demand TWG generated forecasts for RCI fuel and electricity consumption for the purposes of deriving sub-sector emission reductions from various policies. Historical RCI uses, growing at regional rates, were used to estimate future non-oil and gas use. Electricity-sector emissions were designed to be consistent with the current fuel mix in Alaska, as well as specific expected changes in the fuel mix based on expert opinion in the TWG. It is expected that, in absence of new infrastructure, new demand in the future would be met through petroleum combustion. The 60-megawatt Healy Clean Coal Project is expected to be brought on line in 2013 (displacing natural gas), and Fairbanks is expected to obtain natural gas delivery service by 2019 (displacing petroleum consumption), according to panel experts.

Transportation

The Transportation and Land Use TWG recommended that the marine emissions inventory exclude emissions from vessels that pass through Alaskan waters but do not call on Alaskan ports. This approach is consistent with the treatment of aviation emissions, which exclude emissions from aircraft that pass through Alaskan airspace but do not stop in Alaska. It was estimated that the offshore marine emissions previously calculated consisted largely of emissions from vessels that do not call on Alaska ports. Approximately 1%–2% of ships passing through Alaska's Exclusive Economic Zone, which extends 200 miles from the shore, actually stop at an Alaska port. In addition, some of those offshore emissions are already accounted for in the nearshore emissions component. As a result, the offshore emissions have been removed from the GHG I&F. Historical fuel consumption data and vehicle miles traveled through 2005 were added, where available. In addition, several minor errors were corrected, including the baseline on-road fuel economy values.

Waste Management

The Forestry, Agriculture, and Waste Management (FAW) TWG recommended that open-burning emissions be assumed to occur based on 50% of all waste received at Class III landfills.

In addition, open-burning emissions were removed from the controlled burning category. Controlled burning was then updated based on input from DEC. The 2005 and future year emission totals for the controlled burning category were also adjusted to account for the fact that Juneau no longer used controlled burning as a waste management practice. For municipal solid waste (MSW) landfills, the total tonnage disposed of in Class II and Class III landfills was adjusted based on the population of the areas served by those landfills and an assumed 5.9 pounds MSW/person/day. The initial I&F overestimated the number of Class III landfills by 78 and the number of Class II landfills by 36. The allocation of potential landfill gas emissions among uncontrolled, flared, and landfill-gas-to-energy (LFGTE) landfills was adjusted, based on TWG input that the Anchorage and Juneau landfills began flaring in 2006 and 2008, respectively, and the Anchorage Regional Landfill will begin an LFGTE project in 2015. All revised landfill data were provided by members of the FAW TWG.

Key Uncertainties

Some data gaps exist in this I&F, particularly in the reference case projections. Key tasks for future refinement of this I&F include review and revision of key drivers, such as the industrial and transportation fuel use growth rates that will be major determinants of Alaska's future GHG emissions (see Table 2-2 and Figure 2-4). These growth rates are driven by uncertain economic, demographic, and land-use trends (including growth patterns and transportation system impacts), all of which deserve closer review and discussion. Perhaps the variables with the most important implications for the state's GHG emissions are the assumptions regarding air travel and industrial sector growth, particularly the oil and gas industry.

Chapter 3
Cross-Cutting Issues

Overview of Cross-Cutting Issues

Developing policies to mitigate greenhouse gases (GHG) in some cases requires consideration of options that affect many sectors. The Alaska Climate Change Mitigation Advisory Group (MAG) not only established sector-specific Technical Working Groups (TWGs), but also launched a Cross-Cutting Issues (CC) TWG to consider policy options of relevance or benefit across several or all of the sector-specific TWGs. In addition to evaluating emission mitigation activities that cut across sectors, the CC TWG examined policies that enable or provide overall support for other climate actions. The specific GHG reductions and costs of these cross-cutting policies are generally difficult to quantify. Nonetheless, if successfully implemented, these activities will support implementation of other policy recommendations described in the various chapters of this report and contribute to GHG emission reductions overall.

The CC TWG developed six policy recommendations (see Table 3-1) that were then reviewed and revised by the MAG. The MAG members present and voting at the final meeting approved all of the options presented at the meeting.

Table 3-1. Summary list of Cross-Cutting 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 2015–2025			
CC-1	Establish an Alaska Greenhouse Gas Emission Reporting Program	*Not Quantified*						Unanimous, but on hold
CC-2	Establish Goals for Statewide GHG Emission Reduction	*Not Quantified*						Majority
CC-3	Identify and Implement State Government Mitigation Actions	*Not Quantified*						Unanimous
CC-4	Integrate Alaska's Climate Change Mitigation Strategy With the Alaska Energy Plan	*Not Quantified*						Unanimous
CC-5	Explore Various Market-Based Systems to Manage GHG Emissions	*Not Quantified*						Unanimous
CC-6	Coordinate Implementation of Alaska's Efforts to Address Climate Change	*Not Quantified*						Super-majority

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

Key Challenges and Opportunities

Similar to many other states and regions, Alaska recognized the need for action to address climate change, and initiated the development of state-level climate policies. Recent recognition of climate change at the federal level may provide national guidance to states, as well as reinforce state-level activities. However, the undefined time frame for emerging federal rules is presenting challenges for Alaska and other states. The U.S. Environmental Protection Agency (EPA) published a draft rule for mandatory reporting of GHG emissions from large sources on April 10, 2009[1], but it is unclear when a final rule will be approved. In addition, the U.S. Congress is working to establish national GHG goals and a market-based climate program, with an unknown implementation schedule. In the interim, states such as Alaska, face the challenge of developing policies that will address climate change mitigation interests at the state level, while being sufficiently flexible to complement expected federal rules.

The MAG is aware of this timing conflict. Various means have been used to address it in various ways in recommending cross-cutting (CC) issue policies. In policy recommendation CC-1, the TWG recommended that Alaska create a mandatory GHG reporting program, but the MAG has put the policy on hold until the federal rule is released in its final form. Regarding CC-2, the MAG concurred, by a slim margin, with the TWG's recommendation that Alaska adopt aspirational GHG emission reduction goals, but declined to set specific numerical targets. The MAG recommends that the Sub-Cabinet review the available data, including that contained in this report, in setting an aspirational goal. These goals, detailed in Table 3-2, are based on and consistent with the goals of other states, as well as the recommendations of the United Nations Intergovernmental Panel on Climate Change (IPCC), and will be met with a combination of the activities laid out in this strategy and continuing efforts to reduce Alaska emissions. The MAG recognizes that if other federal goals are adopted, Alaska may need to reconsider these goals.

Table 3-2. Mitigation Advisory Group recommended goals for GHG reduction

Year	Reduction From 1990 Levels
2012	Begin Reductions
2020	20% Below 1990
2050	80% Below 1990

CC-3 suggests ways to implement and identify activities for Alaska to continue to "lead by example" in energy reduction measures. Additional coordination across agencies within Alaska is needed to accomplish these types of actions to realize the potential GHG emission reductions from state government activities. One way to do this is proposed in CC-4, which recommends coordinating the Alaska Climate Change Mitigation Strategy and the Alaska Energy Plan. Additionally, CC-6 proposes formal coordination in implementation of all policy recommendations across the various sectors within state agencies, by designating a lead and/or establishing a coordinating committee. This coordinating entity will also address the need to provide outreach and education to the state's citizens on state climate change efforts. Finally, the MAG, in policy CC-5, recommends the commission of a study to understand the potential impacts of different market-based programs on Alaska. Again, a federal program could be

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[1] U.S. Environmental Protection Agency. *Proposed Mandatory Greenhouse Gas Reporting Rule*. Available at: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

adopted before this study is complete, but given that Alaska poses many unique conditions, better understanding the effects of market-based programs on the state is important even as federal efforts proceed.

Alaska is continuing to participate as an observer to the Western Climate Initiative (WCI).[2] The WCI provides a forum for Alaska to observe regional climate negotiations and proceedings, and potentially join as a partner. Watching both federal and regional efforts, Alaska will be better able to position itself to collaborate on initiatives that offer opportunities to reach its goals and support regional and national objectives in GHG reductions.

Overview of Policy Recommendations

The MAG recommends all six CC actions. All are enabling activities that do not directly contribute to GHG mitigation, and are not quantified in terms of metric tons of GHG reduction or costs.

Detailed descriptions of the individual CC policy recommendations presented by the TWG and approved by the MAG can be found in Appendix F of this report. The following section provides highlights of the MAG recommendations.

Cross-Cutting Issues Policy Descriptions

CC-1. Establish an Alaska Greenhouse Gas Emission Reporting Program

The TWG recommended the establishment of an Alaska GHG reporting program, along with the associated administrative, reporting, and database needs. The MAG forwards this recommendation to the Climate Change Sub-Cabinet, with the caveat that any further action on it be held until more information on timing and implementation of the recent federal rule proposal is available. The release of federal rules could result in reporting requirements for GHG emissions from large sources (i.e., those emitting at least 25,000 metric tons of carbon dioxide equivalents [tCO_2e]). The effects of federal rules on states is unknown at this time, including whether they will have requirements to develop their own reporting programs. Components of the TWG recommendation may require implementation under federal rules, such as reporting structures at the state level,, but other components may not be necessary.

Under the proposed Alaska GHG reporting program, Alaska's Department of Environmental Conservation (DEC) would collect, verify, and analyze GHG emissions data to establish a baseline of anthropogenic (human-caused) GHG emissions for Alaska, and identify the types and magnitude of anthropogenic GHG emission sources in Alaska and their relative contributions. These data would be used to inform state leaders and the public on statewide GHG emission trends, identify opportunities for reducing GHG emissions, and allow the state to assess its climate change mitigation efforts over time.

[2] Western Climate Initiative. More information is available at: http://www.westernclimateinitiative.org.

The MAG unanimously approved this policy, but recommended that it not be acted on until the status of a proposed federal program is known.

CC-2. Establish Goals for Statewide GHG Emission Reduction

The TWG recommended the establishment of an aspirational GHG emission reduction goal with reductions of 20% below 1990 GHG emissions levels by 2020, and 80% below 1990 levels by 2050. The 2050 goal is consistent with the IPCC recommendation to keep atmospheric CO_2 levels at 450 parts per million or lower to avoid major irreversible damage to the planet's ecosystems. In addition, Alaska should establish a baseline of emissions that will help measure progress toward these goals. By a small majority (8-6), the MAG agreed with the recommendation to establish an aspirational goal, with numeric values, but leaves the decision of actual values to the Sub-Cabinet.

These goals were developed in the context of federal actions, other states' efforts, and Alaska's GHG footprint. Almost half of all U.S. states have established state-specific goals and targets to reduce their emissions, with many setting aspirational goals of reducing emissions up to 80% below 1990 levels by 2050.[3] In the federal budget released in February 2009 for fiscal year 2010, the Obama Administration proposed a 14% reduction in emissions below 2005 levels by 2020.[4] In addition, the American Clean Energy and Security Act of 2009, commonly referred to as the Waxman-Markey bill, proposes a number of measures related to U.S. climate policy, including the establishment of nationwide goals associated with a cap-and-trade system. The current language proposed in the bill calls for a 20% reduction in GHG emissions below 2005 levels by 2020, a 42% reduction by 2030, and an 80% reduction by 2050.[5] Finally, leaders at BP America, Shell Oil, and ConocoPhillips have all issued statements or public goals for reducing GHG emissions in their operations.

This policy could be implemented in Alaska through either legislation or executive order. For example, in Oregon, the Climate Change Integration Act established Oregon's GHG reduction goals in statute.[6] In Washington, the state's GHG reduction goal was established in 2007 when Governor Gregoire issued Executive Order 02-07; it was later committed to legislative statute. Other policy recommendations approved by the MAG will help meet these aspirational goals.

[3] States with state-specific goals and targets include Arizona, California, Colorado, Connecticut, Oregon, Florida, New Mexico, Illinois, Minnesota, Utah, and Washington. At this time, California is the only state with a mandatory economy-wide emissions cap that includes enforceable penalties. The Pew Center Web site contains detailed information on emission targets and other activities at the state level at: www.pewclimate.org/what_s_being_done/in_the_states/state_action_maps.cfm.

[4] U.S. Office of Management and Budget. *A New Era of Responsibility: Renewing America's Promise—Budget for Fiscal Year 2010.* Accessed at: http://www.whitehouse.gov/omb/assets/fy2010_new_era/a_new_era_of_responsibility2.pdf.

[5] U.S. Congress. American Clean Energy and Security Act of 2009. House Resolution 2454. Accessed at: http://energycommerce.house.gov/Press_111/20090331/acesa_discussiondraft.pdf.

[6] Oregon Department of Environmental Quality. "GHG Reporting Rule." Oregon Administrative Rule 340-215-0010. Accessed at: http://www.deq.state.or.us/aq/climate/docs/FinalGHGRule.pdf.

By a small majority (8-6), the MAG agreed with the recommendation to establish an aspirational goal, with numeric values, but leaves the decision of actual values to the Sub-Cabinet. Some MAG members objected to the decision, noting that many of Alaska's emissions are caused by activities out of the state's control.

CC-3. Identify and Implement State Government Mitigation Actions

The MAG recommends that Alaska "lead by example" by identifying and implementing no-cost and low-cost "early actions" that can be taken without new funding or legislative approval in the immediate future to reduce the state's GHG emissions footprint. These actions provide a first step toward implementing more complex and expensive actions by the state and also set an example and demonstrate the state's willingness for action. The MAG recommends that the state publicize the successes of this effort through a "Report Card" to encourage others to act and to generate political momentum.

The objective of this policy is for state agencies to implement actions within their purview and authority, with a priority toward immediate and meaningful reductions in GHG emissions by changes in day-to-day state activity. To facilitate this, the CC TWG has developed a preliminary matrix outlining potential lead-by-example actions, time frames, needed resources and authorities, potential GHG reductions, and potential savings (see Appendix F). State agencies can use this list as a starting point and develop additional policies suitable for their operations.

This policy recommends that DEC initially take the lead to communicate and implement the immediate actions, using ideas and feedback from other state climate offices and relevant non-governmental organizations. In the future, if any state climate change program or coordinating body is established, it would take over the function of implementing and coordinating state lead-by-example actions, including identifying, tracking, and implementing more complex and expensive actions.

This policy was unanimously approved by the MAG.

CC-4. Integrate Alaska's Climate Change Mitigation Strategy With the Alaska Energy Plan

In January 2009, the Alaska Energy Authority (AEA) released a plan for managing Alaska's energy resources in local communities to support the goals of energy independence, economic vitality, and energy conservation. This plan is built on past AEA energy plans and provides specific information for local communities interested in developing new energy projects or improving existing ones.[7]

The MAG recommends that the state develop Alaska's 10-year "Climate Protection & Energy Plan" immediately, to commence in 2010. This plan will provide the structure to achieve Alaska's Climate Change Mitigation Strategy objectives and energy consumption goals through

[7] Alaska Energy Authority. *Alaska Energy Report.* January 2009. Accessed at: http://www.aidea.org/AEA/PDF%20files/AK%20Energy%20Final.pdf.

the year 2020. Both the Alaska Energy Plan and the strategic direction of Alaska's energy and climate goals incorporated in the Alaska Climate Change Strategy should be incorporated.

To support this effort of tracking and managing Alaska's energy use and resultant climate effects, this policy also recommends the development of an energy database that will track commercial, residential, industrial, and transportation energy consumption and production, GHG emissions, and climate change mitigation actions throughout Alaska.

This policy was unanimously approved by the MAG.

CC-5. Explore Various Market-Based Systems to Manage GHG Emissions

The MAG recommends that a study be commissioned to explore the implications to Alaska of participating in the various market-based approaches for managing GHG emissions, including cap-and-trade programs, carbon taxes, and cap-and-dividend programs. The study would include investigation into the experiences of entities that have implemented market-based systems, such as the European Union and the U.S. Northeast. The study could further make a recommendation on the type of market-based system that would be most beneficial to Alaska or the type of system that the state should prepare for based on likely or impending federal rules. An appropriately designed market-based program can help ensure that GHG emissions are achieved in the most cost-effective manner possible. Revenues generated from a market-based program can be used to cover program costs, generate jobs, establish loan or grant programs, or offset impacts.

This study would focus on the following pieces related to market-based climate programs:

- How a market-based program interacts with existing and proposed emission reduction measures, including regulations, performance-based standards, price subsidies, tax credits, and other technology promoting initiatives.
- How to oversee and manage revenues generated by any future market-based program and determine whether changes to existing laws will be needed.

In parallel and in coordination with this study, Alaska would continue to participate in federal and regional discussions on market-based approaches for managing carbon and GHG emissions.

This policy was unanimously approved by the MAG.

CC-6. Coordinate Implementation of Alaska's Efforts to Address Climate Change

The MAG recommends the establishment of a coordinating entity that could track climate change efforts across state agencies in Alaska; communicate between Alaska and other efforts (e.g., federal activities); provide focus to state agency efforts as recommendations from the Climate Change Sub-Cabinet are implemented; proactively engage with and respond to expected federal initiatives on climate change; provide access to information and education resources; and improve outreach to citizens and businesses on climate change. At a minimum, to accomplish this coordination, an individual would be designated at a high level within state government (e.g., within the Governor's office). This individual could bring together representatives of state agencies charged with responsibilities of carrying out the Sub-Cabinet recommendations to ensure that efforts are not duplicative and that progress is measured. With a strong coordination effort, resources and funding can be identified, secured, and leveraged to further Alaska's climate change policies and goals.

The MAG approved this policy by a supermajority. Members objecting to this policy noted that more government agencies are not needed, and that it could duplicate existing efforts.

Chapter 4
Energy Supply and Demand

Important Introductory Note

This report contains a range of potential mitigation measures identified by the Alaska Mitigation Advisory Group (MAG). These include measures the MAG believes need more analysis and development before they should be considered for implementation. If ultimately included in the Alaska Climate Change Strategy recommended by the Governor's Climate Change Sub-Cabinet, these measures should be identified as options for further study only.

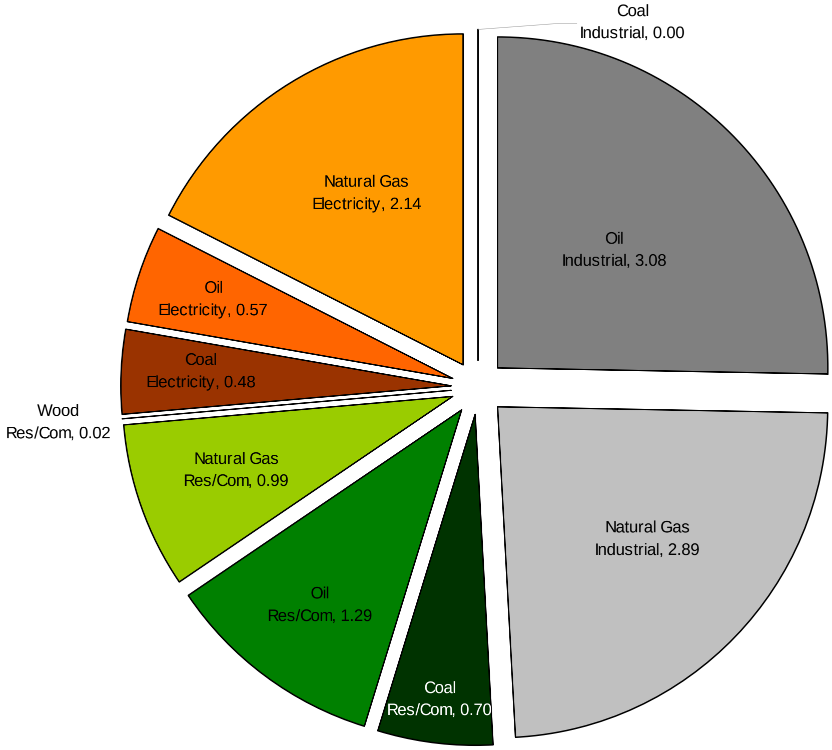
This report also describes measures where the benefits and feasibility of implementation are more certain. These may require much less analysis or development before they could be considered for implementation. Although called "recommendations" in this report, the following options fall into the former category – those requiring further study:

- *ESD-1 – Transmission Optimization and Expansion (includes ESD-1a – Rural Village-to-Village Transmission and ESD-1b – Renewable Energy Grants for Transmission Upgrades)*
- *ESD-5 – Efficiency Improvements for Generators (moved to Research Needs Work Group)*
- *ESD-7 – Implementation of Small-Scale Nuclear Power (moved to Research Needs Work Group)*
- *ESD-8 – Research and Development for Cold-Climate Renewable Technologies (moved to Research Needs Work Group)*
- *ESD-9 – Implementation of Advanced Supply-Side Technologies (moved to Research Needs Work Group)*

Overview of GHG Emissions

Energy supply and demand (ESD) covers policies that can reduce greenhouse gas (GHG) emissions from electricity production, and residential, commercial, and industrial (RCI) processes, not fuels used exclusively for the oil and gas industry. In Alaska, ESD use resulted in an estimated 12.2 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) emissions in 2005 (see Figure 4-1), or just under one-quarter of all of Alaska's human-caused GHG emissions.

Figure 4-1. Estimated 2005 emissions by sector and fuel in energy supply and demand ($MMtCO_2e$)



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; Res./Com. = residential and commercial

Electricity use, defined as fuel used for the purposes of explicitly generating electricity for both grid and distributed generation, accounts for just over one-quarter of ESD emissions (over two-thirds of this is due to natural gas burned in Railbelt generators). Industrial oil and gas use—here defined as fuels consumed on site for heat or power by industries in Alaska (such as fisheries, manufacturing, mills, and mining, but not oil and gas extractive facilities[1])—accounts for nearly half of ESD emissions. Finally, residential and commercial uses account for the last quarter of ESD emissions.

Electricity sales are projected to increase at a rate of 0.8% annually during 2005–2025. Residential on-site fossil fuel use is estimated to fall by 0.2% per year; while industrial and commercial use is forecasted to fall in 2009–2010, but then begin rising after 2010 at a rate of about 0.7% per year.

Key Challenges and Opportunities

This chapter focuses on ESD policies that can help reduce Alaska's GHG emissions. Alaska presents challenges in finding policy solutions that will address energy-based emissions broadly. The size of the state, the lack of a state-wide electrical grid, and unique regional challenges and

[1] Oil and gas extractive processes and facilities emitted approximately 20 $MMtCO_2e$ in 2005. The policies which address these emissions can be found in Appendix I—Oil and Gas Recommended Policy Options

opportunities may require policies with disparate results across the state. In Alaska, ESD policies were considered side by side to balance considerations of both centrally located and highly distributed power producers, as well as urban and rural needs and requirements.

Alaska's electrical topography may be categorized as follows:

- The Railbelt, which serves the majority of Alaska's population, includes the Anchorage and Fairbanks metropolitan areas, and features a reliable electricity grid that connects these areas (76% of energy served);
- Southeast Alaska, with several larger towns and cities such as Juneau, Ketchikan, and Sitka, has a series of discontinuous local grids serving a mix of hydroelectric and diesel-based power (13%); and
- Rural villages and towns, some of which, like Nome and Kotzebue, are home to several thousand residents, but are more often small villages that rely on diesel-fired generation to provide electricity, and that are often not interconnected by an electricity grid (11% of energy served).

The cost of providing electricity varies widely throughout the state. From hydroelectric-supplied cities in the Southeast to diesel fuel generators in the central Yukon, electricity prices can vary by several hundred percent.[2] The Power Cost Equalization (PCE) Program, administered by the Alaska Energy Authority (AEA), helps reduce this discrepancy for high-cost rural areas.[3] However, policies to reduce GHG emissions will not only impact average costs, they will also certainly have widely varying regional impacts in both costs and benefits.

The principal supply policies to meet Alaska's needs of improved electricity reliability and lower GHG emissions include improving transmission and distribution systems, installing new renewable generation, creating more efficient fossil-fired generators, and exploring new technologies, such as small-scale nuclear power. Already, Alaska is working quickly toward improving renewable energy availability; House Bill (HB) 152 (2008) authorized and provided funding for AEA to increase renewable energy generation through seed funds.[4] In 2009, Governor Palin called for 50% of Alaska's energy to be supplied by renewable sources by 2025.[5]

The principal demand-side policies include RCI sector energy efficiency. The state has pursued specific energy efficiency programs in the past, often toward reducing energy bills for low-income residents. Senate Bill (SB) 214 (2006) dramatically increased funding toward a low-income housing Weatherization Program and a Home Energy Rebate Program for housing improvements.[6] However, the state does not yet have institutional experience in comprehensive

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[2] See Alaska Energy Authority (2003), Alaska Electric Power Statistics, 1960–2001. Pro-forma electricity prices in Juneau ($0.10/KWh) and Tanana ($0.60/KWh).

[3] PCE Program. AS 42.45.100-170. Guide and link to statute available at: http://www.aidea.org/aea/programspce.html

[4] HB 152, 25th Leg. (May 22, 2008). Statutes available online at: *http://www.legis.state.ak.us*

[5] State of Alaska, "Governor Palin Releases Energy Guide," news release, January 16, 2009. Available online at: *http://gov.state.ak.us/archive.php?id=1783&type=1*

[6] SB 214, 24th Leg. (March, 24, 2006). Statutes available online at: *http://www.legis.state.ak.us*

utility, private, or state-run efficiency programs, or state-mandated efficiency standards for buildings, appliances, or industrial processes.

Overview of Policy Recommendations and Estimated Impacts

The ESD Technical Work Group (TWG) recommends a set of three comprehensive policies for the ESD sector that offer the potential for significant GHG emission reductions in the state. The GHG emission reductions and costs were quantified for eight of these policies, which could lead to emission savings from reference case projections of:

- Nearly 4.7 $MMtCO_2e$ per year by 2025, and
- Cumulative savings of approximately 37.5 $MMtCO_2e$ from 2010 through 2025.

The three quantified policies could result in net cost savings of over $19 million for 2010–2025 on a net present value (NPV) basis.[7] The weighted-average cost of these policies is a net savings of $4.2 per $MMtCO_2e$.The Alaska Climate Change Mitigation Advisory Group (MAG) approved all of the ESD policy recommendations by unanimous consent. These recommendations and results are summarized in Table 4-1 and laid out in detail in Appendix G.

[7] The net cost savings, based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs, are shown in constant 2008 dollars. All NPV analyses here use a 5% real discount rate. Costs, investments and grants were amortized over the life of the project; they were not truncated at nor compressed to the 2025 timeframe.

Table 4-1. Summary list of Energy Supply and Demand policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)				Net Present Value 2010–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2020	2025	Total 2010-2025			
ESD-1a	Rural Village-to-Village Transmission	*0.00*	*0.00*	*0.01*	*0.05*	*$44*	*$897*	Unanimous
ESD-1b	Renewable Energy Grants for Transmission Upgrades	*0.06*	*0.08*	*0.09*	*1.06*	*–$2*	*–$2*	Unanimous
ESD-1	Transmission Optimization and Expansion (Total a & b)	0.07	0.08	0.09	1.11	$42	$38	Unanimous
ESD-2	Energy Efficiency for Residential and Commercial Customers	*Quantified with ESD-2/4/6*						*See below*
ESD-2/4/6	Energy Efficiency for Residential, Commercial, and Industrial Customers, 2% per year	0.34	1.07	1.84	12.41	–$728	–$59	Unanimous
ESD-3	Implementation of Renewable Energy	1.99	2.35	3.86	32.52	$297	$9	Unanimous
ESD-4	Building Standards/Incentives	*Quantified with ESD-2/4/6*						*See above*
ESD-5	Efficiency Improvements for Generators	*Moved to Research Needs Work Group*						
ESD-6	Energy Efficiency for Industrial Installations	*Quantified with ESD-2/4/6*						*See above*
ESD-7	Implementation of Small-Scale Nuclear Power	*Moved to Research Needs Work Group*						
ESD-8	Research and Development for Cold-Climate Renewable Technologies	*Moved to Research Needs Work Group*						
ESD-9	Implementation of Advanced Supply-Side Technologies	*Moved to Research Needs Work Group*						
	Sector Total After Adjusting for Overlaps*	**1.93**	**2.77**	**4.67**	**37.51**	**–$19.46**	**–$4.24**	
	Reductions From Recent Actions				**0.34**			
	Sector Total Plus Recent Actions	**1.93**	**2.77**	**4.67**	**37.85**	**–$19.46**	**–$4.24**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent. Note: Sector Total is indicative of potential savings, see note in chapter.

Energy Supply Sector Policy Descriptions

ESD-1. Transmission Optimization and Expansion

ESD-1 will offset sources of GHGs by linking load centers with existing and new renewable energy, and improving the efficiency of rural generators by increasing capacity-sharing capabilities. The best renewable resources may not be near existing transmission lines. New transmission, as well as upgrades to existing transmission lines, may be needed to accommodate extensive deployment of renewable generation capacity. Implementation of this policy will also decrease the state's reliance on inefficient diesel generators. ESD-1 is intended to target transmission projects with established scopes and budgets submitted and accepted for seed funding by AEA's Renewable Energy Fund, as well as broadly defined transmission systems between remote rural areas. The benefits and costs/cost savings from this policy are sensitive to the distances between villages that would be connected. Table G-1.2 in Appendix G illustrates this sensitivity.

This policy was unanimously approved by the MAG.

ESD-2/4/6. Energy Efficiency for Residential, Commercial, and Industrial Customers, 2% per year

ESD-2/4/6 is a consolidation of three original policy options:

- ESD-2. Energy Efficiency for Residential and Commercial Customers.
- ESD-4. Building Standards/Incentives.
- ESD-6. Energy Efficiency for Industrial Installations.

These policies were designed to reduce electricity, natural gas, and fuel oil consumption in the RCI sectors through energy efficiency and demand-side management measures using a variety of programs and policies, including state and utility efficiency programs, appliances standards, and building codes. Because of wide-ranging and cross-sector overlaps, these policies were bundled into a single analysis. The combined policy includes strategies building on the recommendations included in the July 2008 *Alaska Energy Efficiency Program and Policy Recommendations* report completed by the Cold Climate Housing Research Center.[8] This policy was originally analyzed using two scenarios: an assumption that energy efficiency could reduce use from baseline growth by (a) 1% per year, or (b) 2% per year. The cost of saved energy for both of these assumptions is the same: a 2% energy efficiency program (already common in leading states) achieves more reductions, but requires significant management, state commitment, and creative approaches to reduce energy consumption.

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[8] Cold Climate Housing Research Center (2008), *Alaska Energy Efficiency Program and Policy Recommendations*. Prepared for the Alaska Energy Authority and Alaska Housing Finance Corporation. Available at: http://www.cchrc.org/alaska+energy+efficiency+program+and+policy+recommendations.aspx.

This policy was unanimously approved by the MAG, using scenario (b), 2% energy efficiency per year.

ESD-3. Implementation of Renewable Energy

ESD-3 focuses on encouraging renewable energy development through implementation of legislation passed by the Alaska legislature in 2008, and the recent Alaska Energy Authority report on energy independence.[9] The goals of this policy are to generate 50% of all electricity from renewable sources by 2025, and cost-effective implementation of renewable energy systems for direct heating, where "cost-effective" includes a monetized value of avoided GHG emissions as determined by prevailing national or state policy. This policy includes the benefits and costs/cost savings associated with projects included in rounds one and two of AEA's renewable energy portfolio. To reach the 50% goal by 2025, additional renewable resources are assumed to be provided by large-scale hydroelectric projects that are currently under discussion.

This policy was unanimously approved by the MAG.

ESD-5. Efficiency Improvements for Generators,

ESD-5 was conceived for to increase the efficiency of electricity generators. Originally developed to estimate the efficacy of tuning, improving, or replacing current generating units, it was envisioned that these marginal improvements could save 3%–30% of fuel in any given unit simply by upgrading to more efficient equipment. However, it was decided that these improvements would, in the absence of direct state subsidies to support capital improvements, fall under the purview of actions taken and funded by utilities.[10] Instead, the policy was re-formed as a research and development (R&D) encouragement policy to create highly-efficiency next-generation generators.

The MAG unanimously opted to move the R&D policy to the Research Needs Work Group, and unanimously supported a non-quantified policy to encourage utility operators to invest in currently available efficient generators.

ESD-7. Implementation of Small-Scale Nuclear Power

ESD-7 seeks to develop technologies for small-scale nuclear generation in outlying rural areas. A series of low-maintenance, low-running-cost nuclear generators could reduce the need to import fuel to small villages and towns and reduce emissions from diesel engines. There are currently no small-scale nuclear units available on the market (or that have passed federal

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[9] Alaska Energy Authority (January 2009), *Alaska Energy: A First Step Toward Energy Independence*. Available at: http://www.akenergyauthority.org/

[10] Utility operators expressed that any generator improvements are intrinsically a utility cost-based decision. Capital costs for improvements and savings from reduced fuel use are passed through to utility ratepayers. Ultimately, if efficiency upgrades resulted in a net benefit for consumers, utilities would undergo these improvements regardless of GHG implications.

regulatory hurdles), and thus this policy could not be quantified for costs or potential benefits. The significant research agenda required to implement this policy rendered it appropriate as a research need.

The MAG unanimously opted to move the R&D policy to the Research Needs Work Group.

ESD-8. Research and Development for Cold-Climate Renewable Technologies

ESD-8 recognizes that Alaska's unique climatic conditions render some technologies difficult or impossible to deploy. The policy seeks to create one or more centers of expertise on cold-climate-compatible renewable energy in Alaska.

The MAG unanimously opted to move the R&D policy to the Research Needs Work Group.

ESD-9. Implementation of Advanced Supply-Side Technologies

ESD-9 would examine Alaska’s capacity for significant improvements in generation technology, and look to develop and implement new or emerging forms of energy supply. Research in this area would focus on biomass gasification, coal-to-liquids conversion, carbon capture and storage, and enhanced geothermal systems, among others.

The MAG unanimously opted to move the R&D policy option to the Research Needs Work Group Policy Overlap and Currently Enacted Policies

There is potential for overlap in the expected emission reductions and costs between ESD-3 and ESD-2/4/6. Overlap reduces required energy production and baseline because of energy efficiency and standards. It is assumed that many of the renewable energy projects will still move forward, but will displace less energy and subsequently, fewer GHGs. Because energy efficiency mechanisms introduced in ESD-2/4/6 will reduce the need for significant new generation, this analysis removes select renewable energy projects that displace diesel to prevent overcounting petroleum requirements.[11] Indeed, if Alaska pursued aggressive, cost-effective energy efficiency at 2% reduction per year, built significant new renewable energy projects and a large hydroelectric facility, and still pursued the baseline expected repowering of the Healy coal plant and new natural gas facilities in Fairbanks with no retirements, then the state would appear to be over-powered. For the purposes of this analysis, it is not feasible to predict what types of existing power would be displaced by a significant new portfolio of resources. Therefore, the combined sector totals for ESD should be considered as indicative only.

Between sectors, there is potential minimal overlap between ESD-3 and Forestry, Agriculture, and Waste Management (FAW)-2, where biomass for combined heat and power is counted in both the FAW analysis and the ESD analysis. Renewable energy projects that rely on biomass were removed from the ESD analysis to prevent double counting.

[11] To prevent over-counting expected diesel offsets.

At the time of this analysis, AEA and the Alaska Housing Finance Corporation had received a $300,000,000 state and federal appropriation of funds for a residential weatherization improvement program and low-income household weatherization program. Using assumptions from public literature, it was estimated that these funds would weatherize nearly 20,000 low-income residences, and reduce emissions by approximately 0.34 $MMtCO_2e$.

The policy recommendations above, as well as the analysis of the weatherization program, are described in more detail in Appendix G. These policies result not only in significant emission reductions and costs savings, but also offer a host of additional benefits as well, including reduction in spending on energy by homeowners and businesses; reduced risk of power shortages, energy price increases, and price volatility; and improved public health as a result of reduced pollutant emissions by power plants.

Chapter 5
Forestry, Agriculture, and Waste Management Sectors

Overview of GHG Emissions

The forestry, agriculture, and waste management (FAW) sectors are responsible for small amounts of Alaska's current greenhouse gas (GHG) emissions. The combined contribution from the agriculture and waste management sectors to carbon dioxide equivalent (CO_2e) gross emissions in 2005 was 0.68 million metric tons (MMt), or about 1.3% of the state's gross emissions (excluding forest carbon sinks). Of the FAW sectors' total gross emissions, the emissions from the agriculture sector are minimal, comprising about 0.1% of the state's gross emissions. Alaska's coastal forests were responsible for the sequestration of 1.4 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2005. It is important to note that the FAW sector emissions exclude combustion-related GHGs, such as diesel fuel consumption in the agriculture and forestry sectors. These fuel combustion emissions are included as part of the industrial fuel combustion sector and are covered in the Residential, Commercial, and Industrial (RCI) Sectors chapter. Within the waste management sector, only direct emissions from landfills, waste combustion, and wastewater treatment plants are counted toward the waste management sector emissions. Indirect emissions from the collection of waste and on-site operations that include fossil fuel combustion and electricity use are not counted in the waste management inventory (these are represented in the transportation, industrial combustion, and electricity generation sectors, respectively).

Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric (intestinal) fermentation, manure management, agriculture soils, and agriculture residue burning. As shown in Figure 5-1, N_2O emissions from nitrogen inputs to soils (agricultural soils: crops, livestock, and fertilizer) represent about half of the sector emissions, while livestock production (manure management, enteric fermentation) contribute the other half. Note again the Y-axis of Figure 5-1, indicating the very small contributions from the agriculture sector in Alaska.

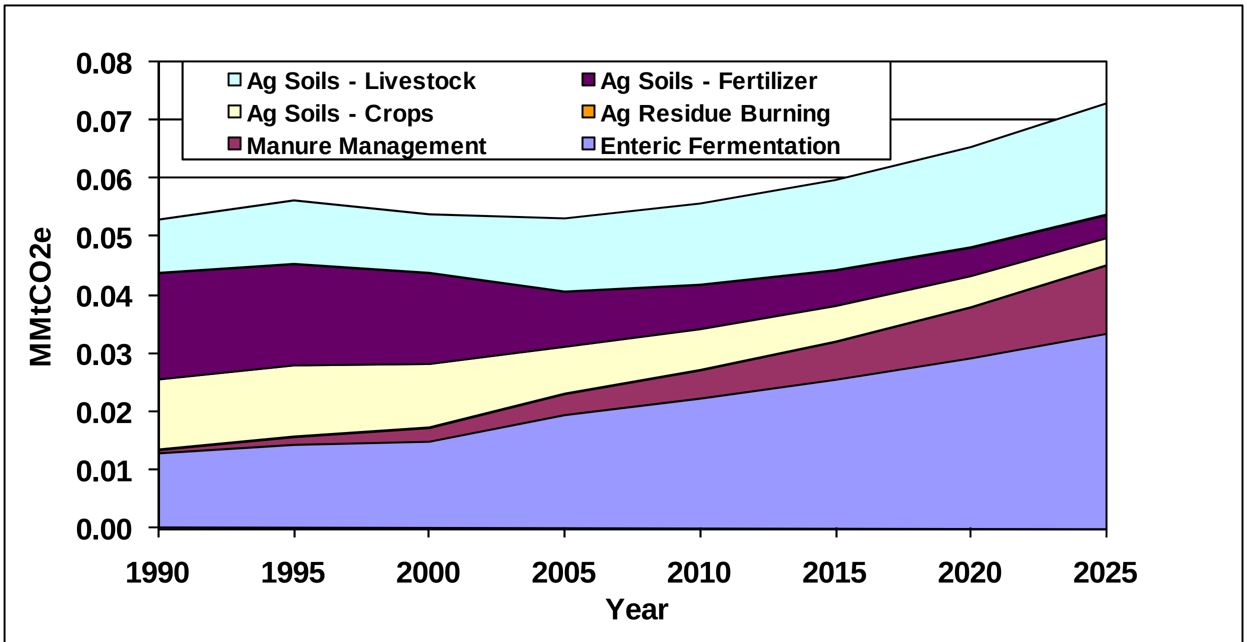
Forestland emissions refer to the net carbon dioxide (CO_2) flux[1] from forested lands in Alaska, which account for about 35% of the state's land area.[2] About 10% of Alaska's forests are temperate coastal forests, with the remainder being the interior boreal forests. Sitka spruce, hemlock, and cedar are the dominant species in the southeast and south-central coastal parts of the state, while white spruce, black spruce; black cottonwood, aspen, and paper birch are found in the interior forests. As described further below, the Alaska inventory and forecast (I&F), Appendix D, included an assessment of the CO_2 flux from natural and managed forests, although only the net emissions from the managed forests are counted toward the anthropogenic (human-caused) GHG inventory of Alaska's forestry sector.

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

[2] Alaska Forest Association, http://www.akforest.org/facts.htm, reports 129 million acres of forested lands. The total land area in Alaska is 365 million acres (http://www.netstate.com/states/geography/ak_geography.htm). Data used in this appendix from the University of Alaska-Fairbanks are based on geographic information indicating that Alaska has about 162 million acres of forested lands (about 23 million acres are in the temperate [coastal] maritime forest).

In keeping with U.S. Environmental Protection Agency (EPA) methods and international reporting conventions, the Alaska I&F covers sources of GHGs from human activities. There are also notable natural sources of GHGs that are addressed in the forestry sector of the I&F; however, these are not included as part of the state's baseline (anthropogenic) emissions. The most notable of these are CO_2 emissions from forest carbon stock losses in the boreal forest, which are thought to be significant (see the Forestry appendix of the I&F report for more details). In Alaska's I&F, the boreal forest is treated as a natural source, since there is minimal forest management. In contrast, the state's coastal forests are actively managed for the production of wood products and are treated as anthropogenic sources (as are all forests in the contiguous United States). GHG reporting conventions treat all managed forests as anthropogenic sources. Sources, such as CO_2 from forest fires and decomposing biomass, are captured within the I&F (as part of the carbon stock modeling performed by the U.S. Forest Service). However, CH_4 emissions from decomposition of organic matter/biomass in forests are not currently captured due to a lack of data. This methane is from decomposition in oxygen-free (anaerobic) areas, particularly marshes and bogs.

Figure 5-1. Historical and projected gross greenhouse gas emissions from the agriculture sector, Alaska, 1990–2025



Ag = agriculture. MMtCO_2e = million metric tons of carbon dioxide equivalent. Agricultural burning emissions are too small to show on the chart.

As shown in Table 5-1, University of Alaska-Fairbanks (UAF) data suggest that Alaska's coastal (managed) forests sequestered about 1.4 MMtCO_2e/year in 2005. According to UAF data, there are minimal non-CO_2 emissions from managed fire in the coastal forests of Alaska. The negative numbers in Table 5-1 indicate a CO_2 sink rather than a source. Hence, during this period, forest carbon losses due to forest conversion, wildfire, disease, and removals were estimated to be smaller than the CO_2 sequestered in forest carbon pools, such as live trees, debris on the forest floor, and forest soils. The forecast for the sector out to 2025 remains a net sequestration of –1.4

$MMtCO_2e$, which is the total for just the managed coastal forests in the state for the reasons described above.

For a more complete understanding of the estimated GHG emissions from managed and unmanaged forests in the state, Table 5-1 provides information developed by UAF researchers for both. These estimates are not included in the statewide GHG inventory of anthropogenic emissions for the reasons described above. In 2025, it is shown that these forests (mostly interior boreal forests) are estimated to produce a net emission of over 53 $MMtCO_2e$ (state-level flux total minus the estimate for managed forests, which rivals the state's total anthropogenic emissions (see Chapter 2). About two-thirds of this is contributed by CH_4 emissions in both forested areas of the state, excluding the coastal forests (for which estimates were not available). While not included in Table 5-1, methane emissions from the tundra (treeless) ecosystems of the state could be even more significant than those shown here for the inland forested areas (potentially a factor of 3 or more).

Table 5-1. Forestry and land-use flux and reference case projections ($MMtCO_2e$)

Source	CO_2e Flux ($MMtCO_2e$)[a]					
	1990	**2000**	**2005**	**2010**	**2020**	**2025**
	State-Level Forest Flux					
CO_2 Flux	4.6	12	12	12	12	12
Non-CO_2 Gases From Fire	4.5	4.9	4.9	4.9	4.9	4.9
CH_4 Flux[b]	16	21	24	26	31	36
Total—State Level	**25**	**38**	**41**	**43**	**48**	**53**
	Flux for Managed Forests[c]					
CO_2 Flux	–0.3	–1.4	–1.4	–1.4	–1.4	–1.4
Non-CO_2 Gases From Fire	0.0	<0.01	<0.01	<0.01	<0.01	<0.01
CH_4 Flux	N/A	N/A	N/A	N/A	N/A	N/A
Total—Managed Forests	**–0.3**	**–1.4**	**–1.4**	**–1.4**	**–1.4**	**–1.4**

Positive values represent net CO_2e emissions. Non-CO_2 gases are methane and nitrous oxide.

[a] Values reported are 10-year averages of annual data surrounding the year reported (e.g., 1990 average is the average of data for 1985–1994). For 2000, data are only available through 2002. After 2000, flux estimates are assumed to remain constant.

[b] Includes total statewide emissions from forested areas, excluding the coastal forests. The UAF estimate for the 1980–1996 period was used for 1990. The UAF growth rate of 0.5 $MMtCO_2e$/yr was used for forecast years. See the section on CH_4 emissions from Alaskan ecosystems in the Forestry appendix of the I&F report.

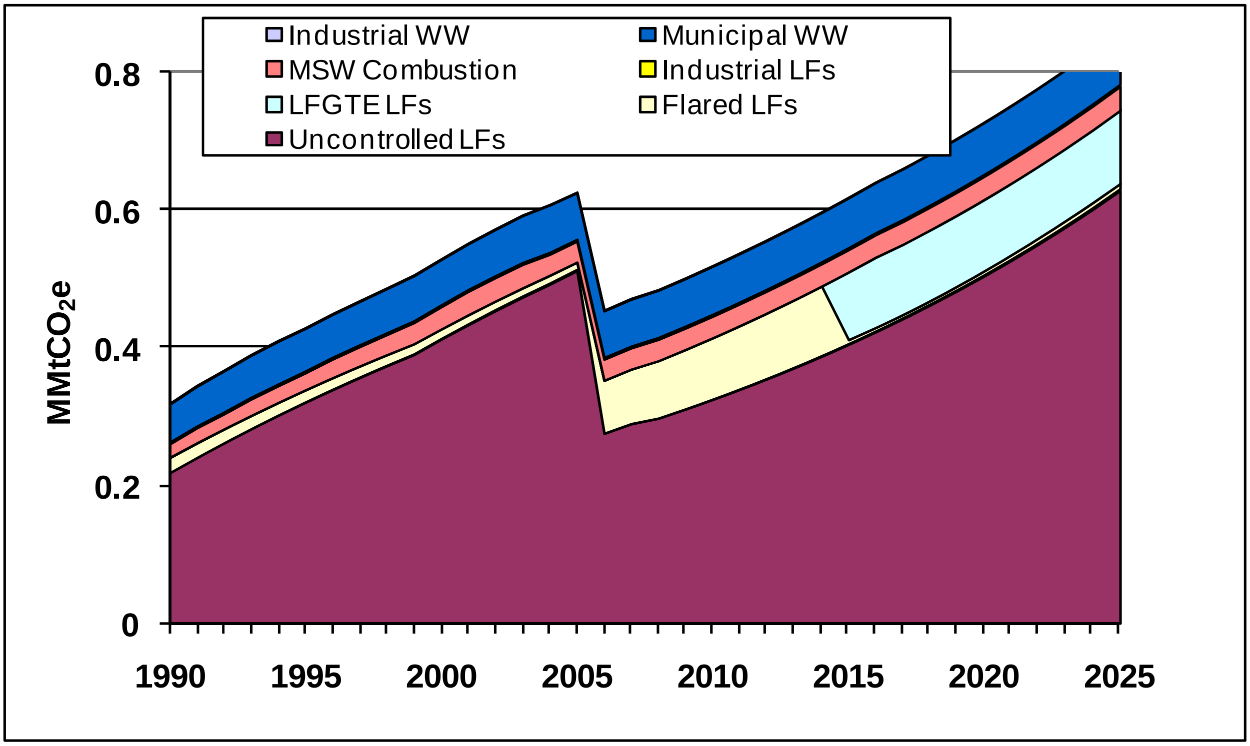
[c] Managed forests are the coastal maritime forests of the state. CH_4 flux estimates were not available for managed forests.

CH_4 = methane; CO_2 = carbon dioxide; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; N/A = not applicable.

Figure 5-2 shows estimated historical and projected emissions from the management and treatment of solid waste and wastewater. Emissions from waste management consist largely of CH_4 emitted from landfills, while emissions from wastewater treatment include both CH_4 and N_2O. Emissions are also included for municipal solid waste (MSW) combustion. Overall, the waste management sector accounted for about 1.2% of Alaska's total gross emissions in 2005. While emissions are expected to grow significantly by 2025, the contribution to the state's total is expected to increase to only 1.4%.

For municipal solid waste landfills (LFs), emissions were estimated for three categories: uncontrolled sites; sites with methane collection and flaring; and sites with methane collection and landfill gas-to-energy (LFGTE) equipment. The landfill emissions shown in Figure 5-2 represent the methane emissions that are not collected and combusted. The first key shift in Figure 5.2 occurs around 2006, when the Anchorage landfill began flaring landfill gas. This action accounts for the noticeable reduction in emissions around 2006 in Figure 5-2. The second shift in emissions is predicted for 2015, when an LFGTE project comes online at the Anchorage landfill, generating energy from the landfill gas that was previously flared. (Levels of uncaptured methane emissions remain the same; however, the landfill category changes from flared to LFGTE.) The direct emissions from the waste management sector are expected to increase by more than a factor of 2.5 from 1990 to 2025 under business-as-usual conditions.

Figure 5-2. Estimated historical and projected greenhouse gas emissions from waste and wastewater management in Alaska, 1990–2025



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MSW = municipal solid waste; LFs = landfills; LFGTELFs = landfill gas-to-energy landfills; WW = wastewater.

Key Challenges and Opportunities

While the FAW sectors are not shown to contribute substantially to Alaska's net GHG emissions, they still have substantial opportunity to reduce emissions within both their own sectors as well as other sectors. The principal means identified to reduce emissions from actions taken in the FAW sectors were to:

- Adopt management practices to increase carbon sequestration or mitigate future carbon losses in forestlands;

- Improve production and utilization of biomass for use in both solid fuel and liquid fuel applications offsetting the use of fossil fuels; and

- Improve methods for managing and recycling MSW.

Opportunities for GHG mitigation in the FAW and other sectors include advanced recycling of MSW emissions from end-of-life management (landfilling, waste combustion), as well as the emissions associated with the embodied energy in the waste materials (i.e., the energy associated with the production and transport of packaging and products). Production and use of biofuels can offset emissions from fossil fuel combustion in the electricity supply, RCI, energy use, and transportation sectors.

Enhanced management of the state's forests can lead to higher levels of carbon sequestration. These enhancements can be achieved through reforestation projects in the state's boreal forest following severe wildfires or infestation by insects or disease. Wildfire fuel treatment projects reduce the risk of severe wildfires and minimize the subsequent losses of forest carbon sequestration in addition to protection of property around boreal communities. These fuel reduction projects have the potential to generate biomass for use as solid fuel or liquid/gaseous fuel feedstock that would offset the use of fossil fuels in other sectors.

In the state's coastal forest, pre-commercial thinning (PCT) projects in managed forests create higher levels of carbon storage per unit area in trees that will ultimately yield carbon sequestered in durable wood products (e.g., building frames, furniture).[3] These durable wood products can sequester carbon for decades or longer.

Overview of Policy Recommendations and Estimated Impacts

The Alaska Climate Change Mitigation Advisory Group (MAG) recommends a set of three policies for the FAW sector that offer the potential for economic benefits and emission savings. Implementing these policy recommendations could lead to emission reductions of:

- 1.1 MMtCO_2e/year by 2025, and
- 9.5 MMtCO_2e cumulative from 2009 through 2025, after adjusting for overlaps with other sectors.

The overall cost-effectiveness of the FAW recommended policies is about $25 per metric ton of CO_2 equivalent. (tCO_2e). This average value includes policies that have both cost savings and much higher likely costs per ton (see Table 5-2).

The three policy recommendations for the FAW sectors address a diverse array of activities capturing emission reductions both within and outside of these sectors (e.g., energy consumption in the energy supply and demand (ESD) and transportation and land use (TLU) sectors). The estimated impacts of the individual policies are shown in Table 5-2. The MAG policy recommendations are described briefly here and in more detail in Appendix H of this report. The

[3] 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.

recommendations not only result in significant emission reductions, but also offer a host of additional benefits, including protection of biodiversity and watersheds, economic development, and job growth. To yield the levels of savings described here, the recommended policies need to be implemented in a timely, aggressive, and thorough manner.

The following are primary opportunities for GHG mitigation identified and approved unanimously by the MAG:

- **Forest management for carbon sequestration:** One of the ways in which the state's coastal forests could be managed to increase the potential for long-term carbon sequestration would be through conducting more PCT and commercial thinning (CT) projects (FAW-1A).[4] Over time, these projects shift the carbon in biomass from smaller-diameter to larger-diameter trees that can be harvested for use in durable wood products. The carbon in durable wood products is stored over long periods in the form of structures, furniture, and other products. At the time of harvest, a forest stand that has received management via PCT will yield more timber for durable wood products than a similar stand that has not been thinned. As indicated in Table 5-2 below, the MAG opted not to report the future incremental carbon sequestered as a result of forest thinning projects, since the reductions are not assured until harvest, which would occur outside of the policy period (i.e., beyond 2025).

- **Enhancement/protection of forest carbon sinks:** Through a variety of programs, enhanced levels of CO_2 sequestration can be achieved and carbon can be stored in the state's forest biomass. These include reforestation programs, particularly in the boreal forest in areas impacted by severe wildfire (FAW-1D). These tend to be areas that might not regenerate and come back under forest cover for many decades. While the cost-effectiveness was estimated at the higher end of the range of all quantified options (~\$92/tCO_2), achieving the goals of FAW-1D was estimated to produce 150,000 tCO_2 reductions annually by 2025 (see Table 5-2).

- **Wildfire Fuel Treatment Programs:** Forest protection can be achieved through fuel treatment programs that reduce the risk of catastrophic (stand-replacement) wildfires (FAW-1B and 1C). These programs protect existing carbon stocks, along with their annual potential for continued carbon sequestration. Due to a current lack of information to quantitatively assess the GHG reductions for reduced wildfire risk achieved by fuel treatment programs, the MAG approved FAW-1 elements B and C as non-quantified policies (as shown in Table 5-2).

- **Expanded use of biomass feedstocks to produce energy:** Expanded use of renewable energy from biomass removed from forests during wildfire risk reduction programs, mill residues, lawn and garden waste, or MSW can achieve GHG benefits by offsetting fossil fuel consumption (to produce either electricity or heat/steam). FAW-2A and 2B offer two recommendations for achieving GHG reductions in this area. Combined, these two elements would produce 220,000 tCO_2e in reductions annually in 2025. Production of renewable fuels, such as ethanol from forestry biomass or MSW, can produce significant reductions when they are used to offset consumption of fossil fuels (e.g., gasoline in transportation).

[4] 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.

This is particularly true when these fuels are produced using processes and/or feedstocks that have much lower fossil fuel inputs than those from conventional sources (sometimes referred to as "advanced" or "next-generation" biofuels). The goals of FAW-2C produced an estimated reduction of 90,000 tCO_2e in 2025 at a cost of $52/$tCO_2e$.

- **Changes in MSW management practices:** By promoting source reduction, advanced MSW recycling practices, and improved organics management, the overall GHG emissions associated managing MSW can be reduced. The reductions come from lower landfill methane emissions and lower CO_2, CH_4, and N_2O emissions from waste combustion in the state. Even larger reductions are achieved when product life-cycle emissions are considered. By generating less waste in the first place or recycling waste that is generated, the emissions associated with product/packaging production and transport are reduced. It is important to note that these life-cycle emission reductions occur both within and outside Alaska, depending on where the product/packaging originated. When the life-cycle GHG reductions of source reduction/recycling/organics management are considered, these programs yield 650,000 tCO_2e/yr in reductions by 2025. An overall cost savings was estimated for this policy (–$8/$tCO_2e$), primarily through avoided landfill costs.

Table 5-2. Summary list of Forestry, Agriculture, and Waste Management policy recommendations

Policy No.	Policy Recommendation	GHG Reductions MMtCO$_2$e)				Net Present Value 2010–2025 (2005 $MM)	Cost-Effective-ness ($/tCO$_2$e)	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; $MM = million dollars; MMtCO$_2$e = million metric tons of carbon dioxide equivalent; $/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent.

Note that negative costs represent a monetary savings.

Overlap Discussion

The amount of GHG emissions reduced or sequestered and the costs of a policy recommendation within the sectors considered in the MAG process in some cases overlap with other policies in the same sector. For the FAW Technical Work Group recommendations to the MAG, there is overlap between FAW-1 and FAW-2 for the production and utilization of biomass. 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 MAG 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 was added to the FAW biomass supply assessment (see Appendix H). 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 ESD or TLU sectors. Biomass demand from ESD-3 has been accounted for in the biomass supply/demand assessment provided in Appendix H.

Forestry, Agriculture, and Waste Management Sector Policy Descriptions

The FAW sectors include emission mitigation recommendations related to the protection and enhancement of forest carbon sinks, the use of biomass energy and production of renewable biomass fuels, and lower MSW management emissions through source reduction and advanced recycling waste. Details on the structure of these recommendations, possible implementation methods, and their estimated GHG reductions and costs can be found in Appendix H.

As part of the work conducted by the MAG and to support work in other sectors, an assessment of biomass feedstock supply and demand was conducted in the FAW sectors. The results of this assessment are provided in Appendix H following the initial summary table. Briefly, the total biomass feedstock that would be available at a delivered cost of less than $40/dry ton was nearly 500,000 dry tons/yr considering all feedstocks. With a delivered cost estimate of less than $100/dry ton, the total available feedstocks were estimated to be about 1.2 million dry tons/yr. The total demand from recommendations in the FAW and other sectors was estimated to be 527,000 dry tons/yr.

FAW-1. Forest Management Strategies for Carbon Sequestration

Alaska forests can play a unique role in both preventing and reducing GHG emissions while providing for a wide range of social and environmental benefits. These benefits include clean air and water, wildlife habitat, recreation, subsistence activities, forest products, and a host of other uses and values. Carbon is stored in the above-ground biomass and in the organic and mineral 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 Policy 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;
- PCT or commercial thinning CT of young-growth stands of timber;
- Fertilization treatments; and
- Other silvicultural treatments that would meet the intent of this policy recommendation.

- 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 (e.g., cement, steel, and plastic).

The quantification of GHG reductions from management options in the coastal forest were based on a goal of thinning 4,000 acres/yr by 2010, 8,000–10,000 acres/yr by 2015, and 6,000 acres/yr by 2025. See Appendix H, FAW-1 Element A for more details.

Boreal Forest Policy 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 wildland fires.
- Complete Community Wildfire Protection Plans 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.

The quantification of GHG reductions from management options applied in the boreal forest included three approaches: Element B—mechanical fuel treatments of 2,500 acres annually by 2025, Element C—development and implementation of community wildfire risk reduction plans (75 plans by 2025), and Element D—complete boreal forest reforestation projects on 25% of high-site-class lands by 2025.[5] See Appendix H, FAW-1 Elements B–D for more details.

This option was unanimously approved by the MAG.

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

This policy recommendation would increase the amount of biomass available from forestry and 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.

The FAW-2 recommendation included three elements. FAW-2A is a goal to use biomass feedstocks to offset 10% of the state's heating oil use in commercial and residential applications

[5] An estimate of high-site-class lands (areas with significant potential for soil erosion as a result of severe wildfire) is not yet available for Alaska. As a surrogate estimate, the Center for Climate Strategies used estimates of areas with "high burn severity" as defined by the U.S. Geological Survey and U.S. Forest Service in the Monitoring Trends in Burn Severity Program, available at: http://mtbs.gov/index.html.

by 2025. The quantification of this goal envisioned the use of community-scale biomass combustion units to provide distributed heating in Alaska communities that have access to biomass feedstocks and that currently rely on heating oil to supply much of their commercial and residential heating. In the latter part of the policy period (after 2015), the recommendation assumes that these types of applications will also be able to economically provide both heating as well as co-generation of electricity for community use (again, these combined heating and power units would displace local fossil fuel-based generation units).

FAW-2B is a goal to use biomass feedstocks to produce 5% of the state's electricity by 2025. The analysis of reductions and costs for this element assumed that biomass would be used to co-fire with coal in the state's existing coal-fired power plants, although the analysis considers the net reductions and costs of using biomass as a fuel source as compared to the mix of fossil fuels that make up the state's current generating capacity (72% coal, 15% oil, 13% natural gas).

Finally, FAW-2C is a goal to use biomass feedstocks to produce sufficient biofuels to offset 5% of the state's fossil transportation fuels. The analysis of this policy assumes that the goal is met through production and consumption of cellulosic ethanol. Under this scenario for meeting the recommendation's goal, by 2025, the state would need five cellulosic ethanol plants that would produce 12 million gallons of ethanol. Biomass feedstock requirements are estimated at 124,000 dry tons/yr by 2025.

This policy was unanimously approved by the MAG.

FAW-3. Advanced Waste Reduction and Recycling

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 goal will be documented via a reduction in the volume of waste deposited into landfills.

The overall goal of FAW-3 is to reduce the overall waste stream (MSW directed into either landfills or waste combustion) by 25% by 2025. The recommendation envisions achieving this goal through a combination of MSW management approaches. Source reduction and reuse reduce the waste stream by addressing and minimizing waste generation at its source. For waste that can not be reduced at the source, increased MSW diversion (from landfills or waste combustion) can produce substantial net GHG benefits through recycling programs or organics management approaches, including composting. As described in detail under FAW-3 in Appendix H, the significant life-cycle GHG reductions in 2025 totaled 650,000 tCO_2e. A net cost savings was estimated for this policy largely through avoided landfilling costs.

This policy was unanimously approved by the MAG.

Chapter 6
Oil and Gas Sector

Important Introductory Note

This report contains a range of potential mitigation measures identified by the Alaska Mitigation Advisory Group (MAG). These include measures the MAG believes need more analysis and development before they should be considered for implementation. If ultimately included in the Alaska Climate Change Strategy recommended by the Governor's Climate Change Sub-Cabinet, these measures should be identified as options for further study only.

This report also describes measures where the benefits and feasibility of implementation are more certain. These may require much less analysis or development before they could be considered for implementation. Although called "recommendations" in this report, the following options fall into the former category – those requiring further study:

- *OG-2 – Reductions in Fugitive Methane Emissions*
- *OG-3 – Electrification of North Slope Oil and Gas Operations, With Centralized Power Production and Distribution*
- *OG-4 – Improved Efficiency Upgrades for Oil and Gas Fuel-Burning Equipment*
- *OG-5 – Renewable Energy Sources in Oil and Gas Operations*
- *OG-6 – Carbon Capture (From North Slope High-CO2 Fuel Gas) and Geologic Sequestration With Enhanced Oil Recovery*
- *OG-7 – Carbon Capture (From Exhaust Gas at a Centralized Facility) and Geologic Sequestration With Enhanced Oil Recovery*
- *OG-8 – Carbon Capture (From Exhaust Gas) and Geologic Sequestration Away From Known Geologic Traps (Not recommended at this time)*

Reducing the greenhouse gas (GHG) emissions of oil and gas (O&G) operations in Alaska will be expensive. These expenses, which will be borne by industry, the state, and the consumer, could be decreased by policies developed by the state.

The best chance to implement any of the O&G policy options is through improved economics. This could be accomplished by reducing the technological and regulatory costs of implementing these options, and by increasing the benefits from carbon sequestration (e.g., enhanced oil recovery and value for carbon.)

To enable the actions necessary for major emission reductions, Alaska can provide and/or continue leadership in a number of broad policy areas, including:

- Adopting a straightforward carbon regulatory framework;
- Recognizing and addressing existing regulatory conflicts and complexities;

- Developing a workforce ready for a GHG-constrained world;
- Understanding impacts on Alaska's revenues and investment;
- Analyzing developments over time that can make reductions more viable; and
- Advocating the importance of Alaska O&G to national energy security.

Each of these policy areas is discussed in this chapter. Also provided are the background necessary to understand the Alaska O&G setting with respect to emission reductions, and an overview of the individual policy recommendations, their potential for reducing GHG emissions, and their possible costs.

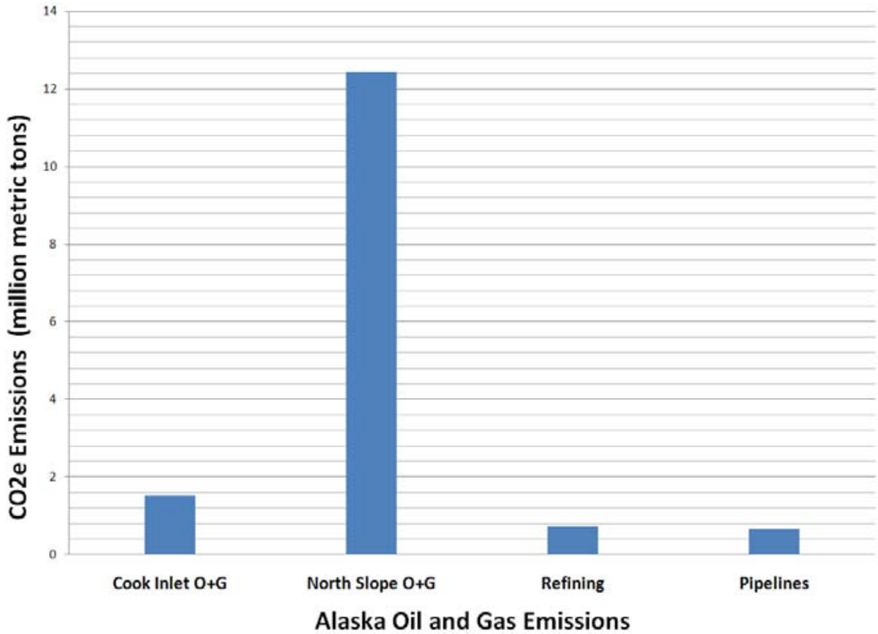
Overview of GHG Emissions

While Alaska contributes a very small percentage (0.7%) of U.S. GHG emissions, significantly reducing the concentration of GHG in the atmosphere will require all states to contribute to the reductions. It is important for the state to understand the implications and tradeoffs that will be inherent in reducing its GHG emissions. The O&G industry—including production, exploration, refining, and pipelines—is Alaska's largest stationary source of GHG emissions, accounting for 29% of all anthropogenic (human-related) sources.[1] As such, the industry has been the focus of much effort by the Alaska Climate Change Mitigation Advisory Group (MAG).

Currently there are two areas of O&G production in Alaska—the North Slope, which generates ~81% of O&G emissions, and Cook Inlet, which generates ~10% of the emissions. Refining and pipelines each contributes about 5%. (Figures 6-1 and 6-2). The industry emissions are primarily related to combustion products from natural gas turbines.

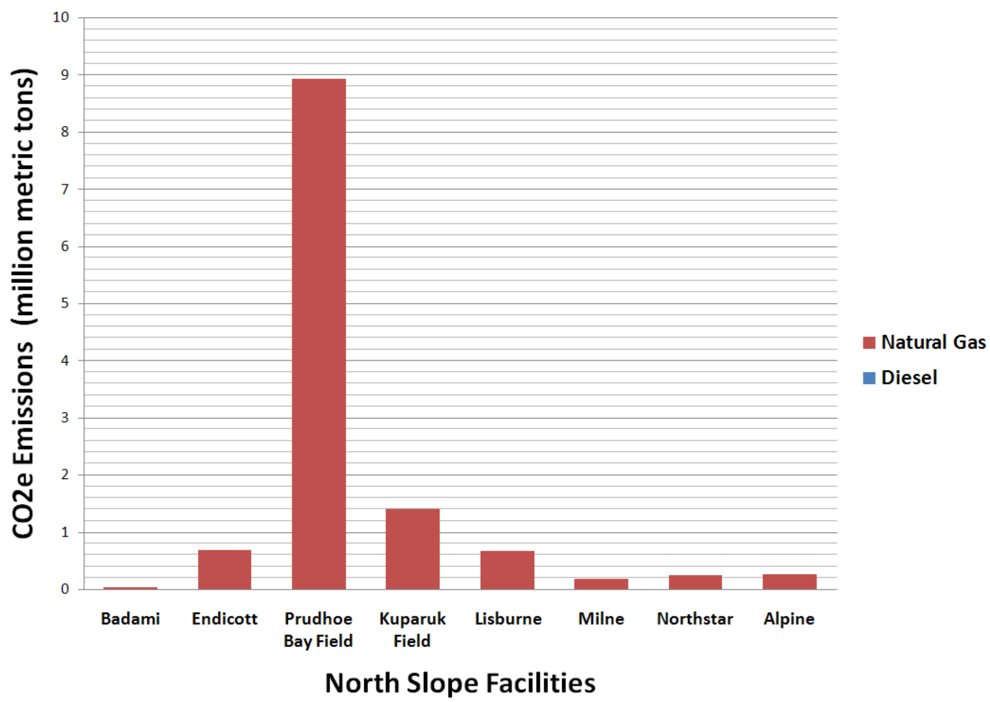
[1] DRAFT Alaska Department of Environmental Conservation , "Report of Improvements to the Alaska Greenhouse Gas Emission Inventory" (includes Final Alaska GHG Inventory and Reference Case Projection), January 2008. Available at: http://www.climatechange.alaska.gov/docs/ghg_ei_rpt.pdf.

Figure 6-1. Total CO_2e emissions (~15 $MMtCO_2e$) sorted by Alaska oil and gas production, refining, and pipelines



CO_2e = carbon dioxide equivalent; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; O+G = oil and gas.

Figure 6-2. Total CO_2e emissions (~12 $MMtCO_2e$) sorted by North Slope facility



CO_2e = carbon dioxide equivalent; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; O+G= oil and gas.

The majority of the known and developed Cook Inlet oil and gas operations are nearing the end of their economic life. Cumulative oil production of 1,335 million barrels of oil represents about

95-96 % of the estimated ultimate recovery (EUR) and cumulative gas production of 7,112 billion cubic feet of gas represents nearly 84 % of EUR.[2] Because of the diverse nature of the Cook Inlet facilities they were determined to be extremely difficult to quantify and had a limited remaining life over which to amortize the investments; therefore, Cook Inlet was not quantified in these deliberations.

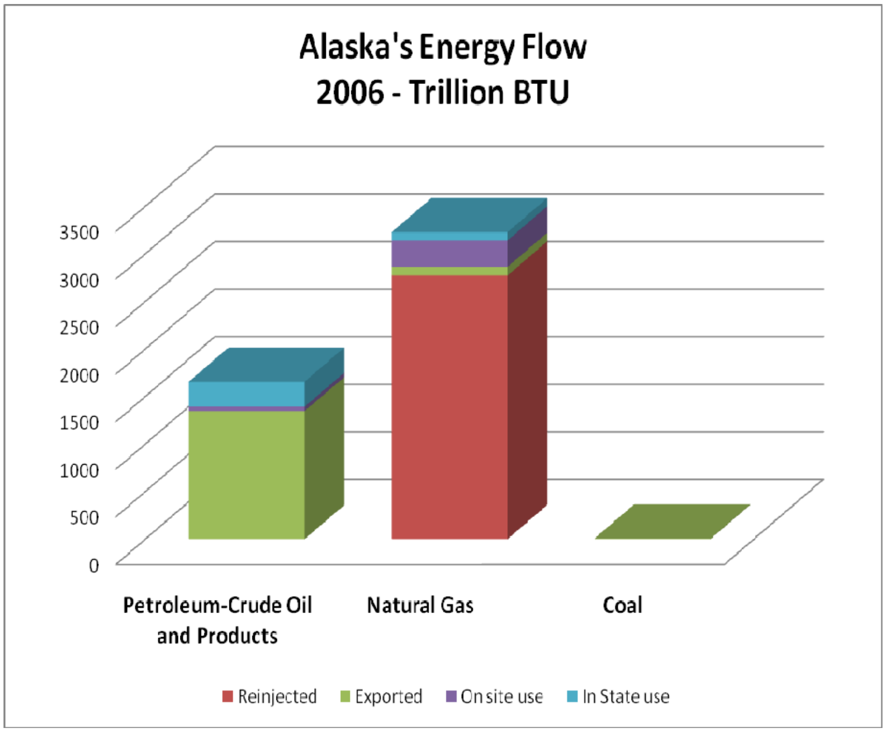
Exploration activity in the arctic regions (such as the National Petroleum Reserve-Alaska, the Beaufort and Chukchi Outer Continental Shelf, or the Nenana Basin or Bristol Bay) and future development of known resources were not considered or quantified in these deliberations. Consequently, the geographic focus of the MAG was directed toward the existing facilities and fields of the North Slope. Here, the cumulative production of oil and natural gas liquids is about 70% of EUR. The gas has not yet been brought to market, but is being used as fuel and for reinjection to maintain reservoir pressure. Impacts associated with a future natural gas pipeline were not included in the quantification, other than a presumed market value for North Slope gas starting in 2020.

It is important to understand that location and field life have significant economic impact on these technology-based options.

Alaska's emissions account for 0.7% of all U.S. emissions. Of the 52 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) emissions generated in Alaska, 15 $MMtCO_2e$ are related to the O&G industry. This represents a much higher percentage than the U.S. average, and reflects the fact that the vast majority of fuel produced in Alaska is shipped to consumers outside of Alaska (Figure 6-3).

[2] AOGCC December 31, 2008 Production Report, and 2004 DOE Report- South-Central Alaska Natural Gas Study http://www.netl.doe.gov/technologies/oil-gas/ReferenceShelf/RefShelf_archive.html #/reports04

Figure 6-3. Alaska energy flow (trillion Btu)



Source: Alaska Energy Authority energy diagram produced by the Alaska Center for Energy and Power, based on data from the University of Alaska–Anchorage Institute of Social and Economic Research, the Alaska Department of Natural Resources, the U.S. Army Corp of Engineers, and the U.S. Energy Information Administration.

Btu = British thermal units.

The MAG recommends that the information contained in this report be used by state officials to inform the federal climate change debate as to the impact on Alaska's O&G sector, from cap-and-trade program(s), carbon taxes, command-and-control programs, or combinations thereof. Care should be taken that state and federal policies do not inhibit current and future Alaska exploration and production.

The MAG emphasizes that the technical policies presented here are not intended or supported as recommendations ready for immediate implementation or justifications for specific state mandates at this time. Rather, they represent an important first step in understanding the issues, and require detailed technical and economic analysis before actual policies can be crafted.

Key Challenges and Opportunities

The MAG has made a high level analysis of eight technology options to reduce GHG emissions in Alaska's O&G sector. Most of these options will be expensive in today's current context. Alaska can improve their cost-effectiveness by providing and/or continuing leadership in several broad policy areas.

Adopting a Straightforward Carbon Regulatory Framework

The MAG believes that multiple layers of carbon regulation would hinder emission reductions and needlessly decrease the viability of Alaska's economy. The MAG recommends that Alaska remain an observer in the Western Climate Initiative process. The MAG also recommends the state participate in regulatory development at the federal level, and take actions necessary to efficiently implement a federal program, with strong emphasis on avoiding duplication of or conflict with state regulations, as well as understanding the efforts and resources that will be required for compliance with all programs.

The federal government will impose GHG regulations and requirements independent of Alaska. State actions in this regard would be redundant, impose regulatory confusion, and increase compliance costs (two separate GHG reporting regimes, two separate cap-and-trade tracking mechanisms, etc). Multiple regulatory programs will create a confusing environment in which to analyze and execute emission reductions projects, and will lead to increased uncertainty and cost of accomplishing reductions.

Any early emission reductions in the Alaska O&G sector must be creditable toward a federal program, because there are only a discrete number of such opportunities. Encouraging early action will help maximize emission reductions. A state- or regional-level program does not ensure this will occur.

There are existing regulatory impediments to reducing GHG emissions. Significant emission reductions could occur by building a large, high-efficiency central power plant that could service multiple fields on the North Slope. Existing barriers to centralized power include royalty payments for gas used to generate electricity that crosses unit boundaries; the prospect of increased regulations through creation of a public utility; and existing provisions of the Clean Air Act (CAA). (For example, the CAA provisions do not currently allow balancing increases in criteria pollutant emissions such as nitrogen oxides for carbon emissions.)

Also, technologies that limit GHGs can sometimes complicate or erode the effectiveness of technologies currently in place to limit emissions of other criteria pollutants. Several technology options (more energy-efficient turbines and fuel gas CO_2 removal) would likely require double investment in both carbon and criteria pollutant reduction systems. There may be ways to allow reasonable tradeoffs between carbon and criteria pollutants, provided the impacts on ambient air quality are acceptable.

Developing a Workforce Ready for a GHG-Constrained World

Alaska should consider how climate change regulation and the need for emission reductions will affect the state government workforce, and more broadly the statewide economy. A trained and experienced workforce, both for Alaska and industry, will be critical to the implementation of any large emission reductions efforts.

Of particular note, GHG reduction technologies will create significant additional workloads for state permitting and regulatory agencies. Current staffing levels and training of the staff at state regulatory agencies are likely unable to provide the required permits in a timely manner. Alaska should ensure that it has a trained and experienced workforce to implement the large permitting and regulatory changes for O&G operations within its agencies to help facilitate the implementation of the GHG reduction options.

Understanding Impacts to State Revenues and Investment in Alaska

The regulation of GHG emissions will forever change the landscape of energy production in Alaska. It is likely that Alaska's gas resources will become more valuable, while the value of petroleum resources will decrease, which in turn will profoundly change Alaska's economy. If GHG reduction requirements add economic burden to current and future Alaska production, existing field life could be shortened, and future development could be transferred outside the state, region, or country.

It is also critical for the state to understand the impact a GHG project with associated major capital expenditures and potential tax credits would have on its short- and long-term revenue streams.

Advocating the Importance of Alaska Oil and Gas to National Energy Security

Government policies to lower GHG emissions being debated at the state and federal levels could weaken Alaska's O&G sector, unless they recognize that GHG emission targets must take into account that until enough low-to-no-carbon emission fuels are available, Alaska's O&G resources are still critical to national energy security.

Alaska should participate in the federal legislative and rulemaking process by commenting and providing input to the U.S. Congress and U.S. Environmental Protection Agency on proposed reporting rules. Communicating the significance of Alaska O&G to national energy security should be an important part of a broader advocacy effort to help manage the potential impacts on state revenue and investment. Energy-exporting states, such as Alaska are in the minority, and the importance of maintaining a strong domestic conventional energy base should be a critical point in the federal debate. Heavy oil is likely the most significant proven O&G resource and source of state revenue, remaining to be developed after natural gas. Without appropriate balance between climate change and energy security issues, the major investments necessary to develop heavy oil are likely not to occur.

If GHG reduction costs make O&G production in Alaska not cost-effective, end users of Alaska petroleum energy would turn to other petroleum-producing regions to meet their energy demands. The GHGs associated with that energy production would simply be emitted in a different part of the world, negating the efforts to reduce GHG levels, and with an associated effect of reducing national energy security.

Analyzing Developments That Can Make Reductions More Viable

The MAG recognizes that an extensive amount of work has gone into understanding existing conditions and developing these policy recommendations. The MAG emphasizes that more efforts to address complex technological and economic issues are needed. The evaluations modeled a simple development case for each option to define boundaries sufficient to estimate costs. These development cases were intended to portray broadly how a technology might be deployed on a large scale. The real world is much more complex than these models; the unique boundaries established by individual projects will determine their viability.

The MAG recommends that an economic study be undertaken by the University of Alaska to integrate all aspects of Alaska's economic factors related to incentives. This study should model the economic impacts that GHG reduction policies will have on both the state and private industry. With the exception of ongoing conservation efforts discussed in policy option OG-1, none of the options modeled appears to be economically viable for private-sector investment at this time. The quantification model did not factor in state and federal tax policy or any cost for carbon. The MAG recommends further analysis of tax policy on investments in the eight options, and on any new government incentives that would improve the return on private-sector investment.

Further, technical studies should be undertaken to refine the current work in developing viable technology options, specifically the aspects of:

- Developing a centralized power production and distribution system for the O&G production areas on the North Slope of Alaska.
- Replacing the older combustion equipment in service on the North Slope with newer, more efficient equipment. The study should be used to determine any barriers associated with the upgrades, and provide recommendations on how to overcome these barriers.
- Using renewable wind energy to supplement electrical production on the North Slope. The study should identify any barriers associated with a centralized electricity production and distribution system and recommend how to overcome them.
- For carbon capture projects deriving value from enhanced oil recovery (EOR), conducting technical analysis to choose appropriate CO_2 capture technology and the best reservoir for CO_2 injection to maximize economics, especially relating to EOR benefits.
- For carbon capture projects away from known geologic traps, conducting technical analysis to include the size and type of facilities modifications, choice of appropriate combustion CO_2 capture technology, and either the search for nearby sequestration opportunities or the planning for a pipeline to known reservoirs with proven seals.

Finally, the studies should address the best mix and size of projects, viewed economically both short and long term. Whereas it may look more efficient in the short term to capture and inject carbon emissions, from a long-term perspective it is preferable to focus on energy efficiency options first. It takes energy to capture and inject carbon from exhaust streams—up to 30% more energy than is required in a non-capture scenario. It is far better resource management to first minimize the amount of carbon to be captured, and then treat a smaller volume of exhaust gases.

Overview of Policy Recommendations and Estimated Effects

The eight steps developed by MAG are predominantly “technology options” that require major capital investment to implement. This section provides a brief overview of each option recommended for further review. Appendix I. Oil and Gas Policy Recommendations contains the complete report for each O&G policy.

The GHG reductions estimated for each option are not additive. Based on high-level estimates, a reasonable combination of technologies could reduce emissions ~5 $MMtCO_2e$, at an average cost of $163 per metric ton (t). Alternative combinations could raise or lower the cost, as well as raise or lower the amount of reductions. Every combination of the eight technology options was not rigorously analyzed, but the MAG is unanimous in recommending that such analysis is necessary to evaluate the best mix of options.

The scenarios presented here can be grouped into categories of emissions avoided, conservation and energy efficiency, and emissions captured and stored [carbon capture and storage and/or reuse (CCSR)].

The MAG analyzed the eight options assuming 2008 O&G activity. Production of estimated O&G reserves in Alaska could create dramatic increases in production activity, with corresponding upward pressure on GHG emissions. If those predicted O&G reserves are not produced, the overall economics of the Trans Alaska Pipeline System would deteriorate, with a corresponding upward pressure on costs, but a downward trend for GHG emissions.

Quantification of options OG-2 through OG-8 for emission reduction potential, net present value (NPV), and cost-effectiveness is provided in Table 6-1. For OG-1, the broad nature of conservation measures precluded specificity that would allow economic quantification to be conducted. A unique situation exists on the North Slope, in that the natural gas used to power the operations has no "real" cost to the producers. Because of that, until that gas can be sold (i.e., a gas pipeline exists), there is no economic credit given to saving fuel. However, there are at least two significant values to natural gas on the North Slope:

- The gas is currently re-injected into the oil reservoir, maintaining pressure and increasing ultimate oil recovery.
- In the case of a gas pipeline, gas saved will eventually become gas sold.

Both these aspects were considered long term and difficult to quantify, and their value was not represented in the relatively short-term quantifications presented here.

Oil and Gas Policy Descriptions

The O&G sector includes emissions and mitigation opportunities related to O&G operations, including exploration, production, transport, and refining of O&G. In addition, geologic sequestration is included, regardless of the source of the emissions (as in OG-8.)

The O&G quantification followed all economic assumptions as directed by the MAG (including a 5% discount rate), with the exception of the amortization date. Due to the large and phased nature of the capital investments inherent in several of the options, the MAG chose to amortize out to 2035, instead of 2025, resulting in a reduced cost per ton estimate for GHG reductions.

Table 6.1. Summary List of Alaska Climate Change Mitigation Policy Recommendations

Policy No.	Policy Options	GHG Reductions ($MMtCO_2e$)				Net Present Value (million 2009$) 2010–2025	Cost-Effective-ness (2009$ /tCO_2e)	Level of Support
		2015	2020	2025	Total 2010-2025			
OG-1	Best Conservation Practices	*Not Quantified*						Unanimous
OG-2	Reductions in Fugitive Methane Emissions	0.2	0.2	0.2	3.2	$181.4	$57	Unanimous
OG-3	Electrification of North Slope Oil and Gas Operations, With Centralized Power Production and Distribution	—	3.0	4.4	26.6	$7,791.0	$293	Unanimous
OG-4	Improved Efficiency Upgrades for Oil and Gas Fuel-Burning Equipment	0.5	2.1	2.1	19.7	$1,600.1	$81	Unanimous
OG-5	Renewable Energy Sources in Oil and Gas Operations	0.7	0.7	0.7	8.0	$2,603.4	$327	Unanimous
OG-6	Carbon Capture (From North Slope High-CO_2 Fuel Gas) and Geologic Sequestration With Enhanced Oil Recovery	—	0.9	0.9	7.8	$1,368.8	$176	Unanimous
OG-7	Carbon Capture (From Exhaust Gas at a Centralized Facility) and Geologic Sequestration With Enhanced Oil Recovery	—	1.8	1.8	16.1	$3,094.1	$192	Unanimous
OG-8	Carbon Capture (From Exhaust Gas) and Geologic Sequestration Away From Known Geologic Traps	0.7	0.7	0.7	8.0	$7,937.7	$994	Unanimously not recommended at this time
	Sector Total Before Adjusting for Overlaps	**2.1**	**9.4**	**10.8**	**89.4**	**$24,576.5**		
	Sector Total After Adjusting for Different Implementation Strategies*	**0.2/ 0.8**	**6.7/ 4.8**	**10.0/ 4.8**	**62.9/ 46.2**	**$15,300/ $7,500**	**$243/ $163**	
	Reductions From Recent Actions (CAFE Standards)	**0**	**0**	**0**	**0**	**0**		

NOTES:

Policy options were modeled on generic, publicly available industry data from North Slope oil and gas operations. Thus, the results must only be used to help direct more precise modeling, which would include, for example, taxes, royalties, individual oil and gas facility data, and specific engineering studies.

"'Net Present Value" used in the summary table above would be regarded in the oil and gas industry as "Net Present Cost." Positive numbers in the two right-hand columns indicate that an investment in the policy would generate a financial loss.

"Net Present Value" and "Cost-Effectiveness" values do not apply in Cook Inlet or any other oil and gas basin, due to vastly different production life, geographic distribution, and physical constraints.

Due to the analytical methodology, "Cost Effectiveness" is likely lower than the break-even cost of carbon needed to make a project economically feasible.

None of the modeling included the impact of short-term production loss to implement the policies OG-2 though OG-7.

These policies are technology-based opportunities for reducing greenhouse gas emissions (GHG), not policies to be directly implemented by Alaska.

The GHG savings estimates presented here are not additive. Policies have significant, sometimes complete, overlap in targeted GHG emissions.

CAFE = corporate average fuel economy; CO_2 = carbon dioxide; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; OG = oil and gas.

*This range shows emissions reductions and costs if only the more cost-effective options were implemented, i.e., dropping sequestration away from geologic sources (OG-8) and keeping the rest (the first set of figures). The second set represents removal of the central electrification (OG-3) and sequestration away from geologic sources (OG-8).

OG-1. Best Conservation Practices

This option relates to companies' ongoing efforts to reduce GHG emissions using common-sense measures that minimize fuel consumption. Specific initiatives are already being developed to suit the needs of specific conservation opportunities.

The option is largely behavior-based and is achieved by continuing to encourage individuals to make good conservation choices and, through repetition, for those choices to become habits. Implementing this option does not require large capital projects. A specific model and set of assumptions were not developed from which economic quantification could be conducted, as indicated in the discussion above.

OG-2. Reductions in Fugitive Methane Emissions

This option relates to the technical and economic feasibility of reducing fugitive and wet-seal emissions by first determining where leaks occur, and then planning the optimal corrections. Steps for this determination are:

- Official refinements to fugitive methane inventories developed by the Alaska Department of Environmental Conservation and the Center for Climate Strategies in 2007 (current inventories dramatically overestimate the fugitive emissions).
- Assessment of potential reductions and associated costs to reduce fugitive and wet-seal methane emissions.

OG-3. Electrification of North Slope Oil and Gas Operations, With Centralized Power Production and Distribution

This option relates to the technical feasibility and economics of electrification of the largest North Slope O&G operations with centralized power production and distribution. The centralized power system could eventually be configured to serve Alaska's major O&G operations throughout the North Slope, and possibly to known expected expansion areas.

Electrifying the hydrocarbon recovery activities, while centralizing the power generation turbines and taking advantage of improved efficiencies, could significantly reduce the North Slope hydrocarbon recovery activity GHG emissions by up to 36%. This has some dependency on the scale of the electrification of the hydrocarbon recovery activities. Very few activities could not be converted from fuel-burning power to electrical power.

OG-4. Improved Efficiency Upgrades for Oil and Gas Fuel-Burning Equipment

This option relates to the technical feasibility and economics of improving the efficiency of fuel-burning equipment at North Slope O&G operations.

Upgrading any less efficient turbines to more efficient turbine technologies provides potential to significantly reduce the North Slope hydrocarbon recovery activity GHG emissions, by reducing the amount of fuel burned. The GHG savings has some dependency on the scale of the upgrades and the change in efficiency. Small changes in efficiency probably will not be economically viable. Some equipment is already at a high efficiency and would not be upgraded. Looking at this as a stand-alone option, analyses suggest a gross estimate of about 17.5% reduction in GHG emissions through the upgrading of fuel-burning equipment.

OG-5. Renewable Energy Sources in Oil and Gas Operations

This policy relates to the technical feasibility and economics of augmenting electrical power production at the Central Production Facility at Prudhoe Bay with wind power. Electrifying the hydrocarbon recovery activities, through the use of renewable energies to augment electric power production, has the potential to reduce North Slope hydrocarbon recovery activity GHG emissions relative to the amount of power that could be replaced. This option is dependent on OG-3, electrification of O&G facilities.

OG-6. Carbon Capture (From North Slope High-CO_2 Fuel Gas) and Geologic Sequestration With Enhanced Oil Recovery

This option relates to the technical feasibility and economics of CO_2 separation from produced gas, transport, and geologic sequestration from gas used for fuel in and around Prudhoe Bay. The technical goal is to remove and sequester the 10%–12% CO_2 from the natural gas produced at Prudhoe before that gas is burned in power generators. The geologic sequestration should utilize a reservoir where EOR can improve the economics.

OG-7. Carbon Capture (From Exhaust Gas at a Centralized Facility) and Geologic Sequestration With Enhanced Oil Recovery

This option relates to the technical feasibility and economics of post-combustion CO_2 capture, transport, and geologic sequestration in or near existing Alaska O&G fields, including the upside of initial EOR.

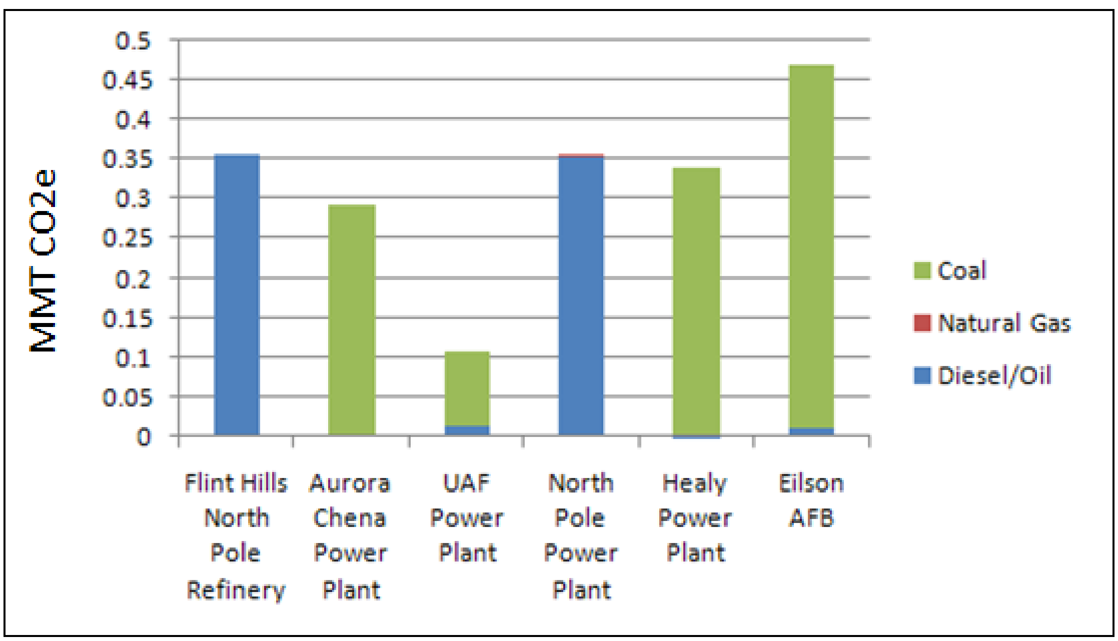
Quantification for this option is focused on the Central Gas Facility (CGF) at Prudhoe Bay, as preliminary studies have shown CCSR would have the highest possible efficiencies at this facility due to the concentration and sizes of the turbines. The CGF accounts for ~16% of all North Slope emissions.

OG-8. Carbon Capture (From Exhaust Gas) and Geologic Sequestration Away From Known Geologic Traps

This option relates to the technical and economic feasibility of CO_2 capture, transport, and geologic sequestration far from O&G infrastructure, in areas where a nearby storage reservoir is not proven. The capture and storage aspects, while similar in many aspects to those described in OG-7 for exhaust gas sources near existing Alaska O&G fields, differ in that there are no known reservoirs nearby. That means either a long pipeline needs to be built to either the North Slope or Cook Inlet, or an exploration program to prove up an appropriate storage reservoir needs to be executed.

This option also deals with emissions outside the O&G sector (Figure 6-4).

Figure 6-4. Interior Alaska CO_2e emissions sources, including non-O&G sources



AFB = Air Force Base; CO_2e = carbon dioxide equivalent; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; OG = oil and gas; UAF = University of Alaska-Fairbanks

Chapter 7
Transportation and Land Use Sectors

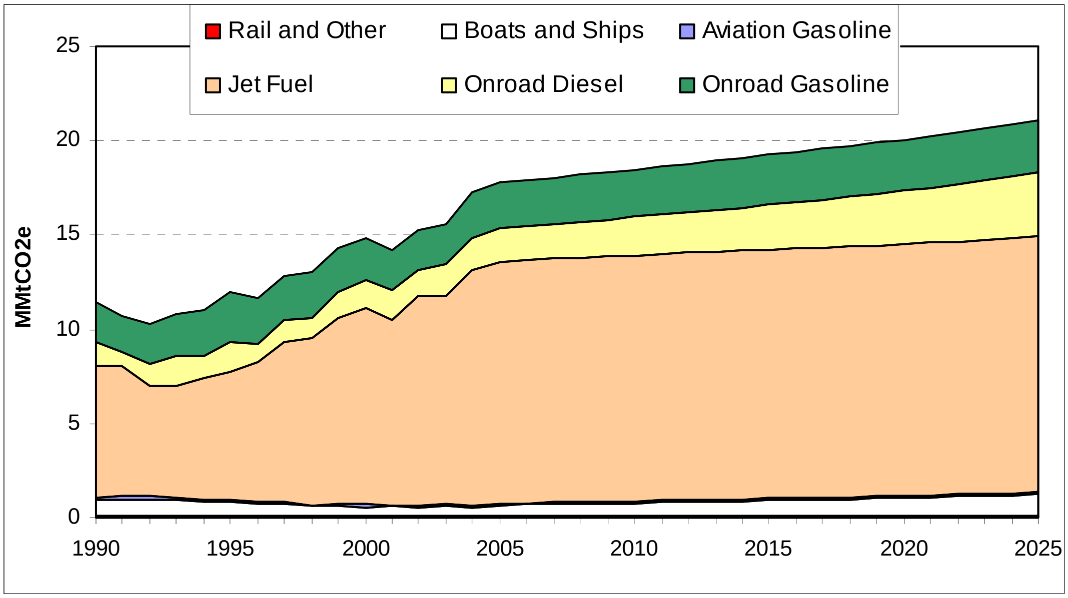
Overview of GHG Emissions

The transportation sector is a major source of greenhouse gas (GHG) emissions in Alaska, currently accounting for about 35% of the state's gross GHG emissions. The transportation technologies and fuels used are key determinants of those emissions, along with population, economic growth, and land-use policies that all affect the demand for transportation services. Alaska's GHG emissions from the transportation sector totaled about 18 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2005.

Figure 7-1 shows historical and projected transportation GHG emissions by fuel and source, and illustrates their rapid growth. Transportation emissions are expected to nearly double from 1990 to 2025. Jet fuel consumption accounts for the largest share of transportation GHG emissions by far, currently 72% of the transportation total. Emissions from jet fuel will continue to increase under reference case projections to 2025, although the rate of growth is projected to be smaller than that of on-road fuels. Aviation's large share of emissions reflects Alaska's dependence on air travel and role as a refueling stop for trans-Pacific flights.

Emissions from on-road vehicles (gasoline and diesel) currently make up 24% of total transportation GHG emissions. On-road GHG emissions will increase, as growth in vehicle miles traveled (VMT) is expected to outpace improvements in vehicle fuel efficiency. Emissions from marine vessels account for 4% of the transportation total, and are also expected to increase through 2025.

Figure 7-1. Historical and projected GHG emissions from the transportation sector, 1990–2025



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

Subsequent to the compilation of the inventory and projections, Congress enacted the 2007 Energy Independence and Security Act, which contained a provision for stricter Corporate Average Fuel Economy (CAFE) standards for cars and light trucks. This standard was classified as a "recent action" and was accounted for in the Transportation and Land Use (TLU) Technical Work Group analysis.

CCS performed an analysis of this new policy to determine the resulting reduction in the business-as-usual (BAU) projected transportation emissions in Alaska, represented in Figure 7-1. This analysis estimated the number of vehicles on the road that would be affected by the new standards, and then determined the amount of fuel saved by the efficiency improvements. Table 7-1 compares the BAU emissions from on-road vehicles to emissions under the new CAFE standard. By 2015, the new CAFE standard will result in a decrease in emissions of 0.01 MMtCO$_2$e in Alaska annually. By 2025, the fuel efficiency improvements will reduce transportation emissions by 0.73 MMtCO$_2$e annually, or 3.5% of total transportation GHG emissions in Alaska.

Table 7-1. Historic and projected emissions for the transportation sector (MMTCO$_2$e)—includes emission reductions estimated for recent actions

Emission Totals (MMtCO$_2$e)	1990	1995	2000	2005	2010	2015	2020	2025
On-road Gas and Diesel (BAU)	*3.41*	*4.24*	*3.71*	*4.19*	*4.55*	*5.01*	*5.57*	*6.20*
On-road Gas and Diesel (CAFE)	*3.41*	*4.24*	*3.71*	*4.19*	*4.54*	*4.79*	*5.04*	*5.47*
On-road Gas and Diesel Emission Reductions	0.00	0.00	0.00	0.00	0.01	0.22	0.53	0.73
Jet Fuel/Aviation Gas	7.15	6.94	10.59	12.94	13.14	13.31	13.44	13.65
Boats and Ships—Ports/Inshore	0.83	0.74	0.48	0.61	0.72	0.85	1.00	1.17
Boats and Ships—Offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.08	0.06	0.07	0.06	0.06	0.06	0.06	0.06
Total (BAU)	**11.47**	**11.99**	**14.86**	**17.80**	**18.47**	**19.23**	**20.07**	**21.09**
Total (CAFE)	**11.47**	**11.99**	**14.86**	**17.80**	**18.46**	**19.01**	**19.54**	**20.36**

BAU = business-as-usual; CAFE = Corporate Average Fuel Economy; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

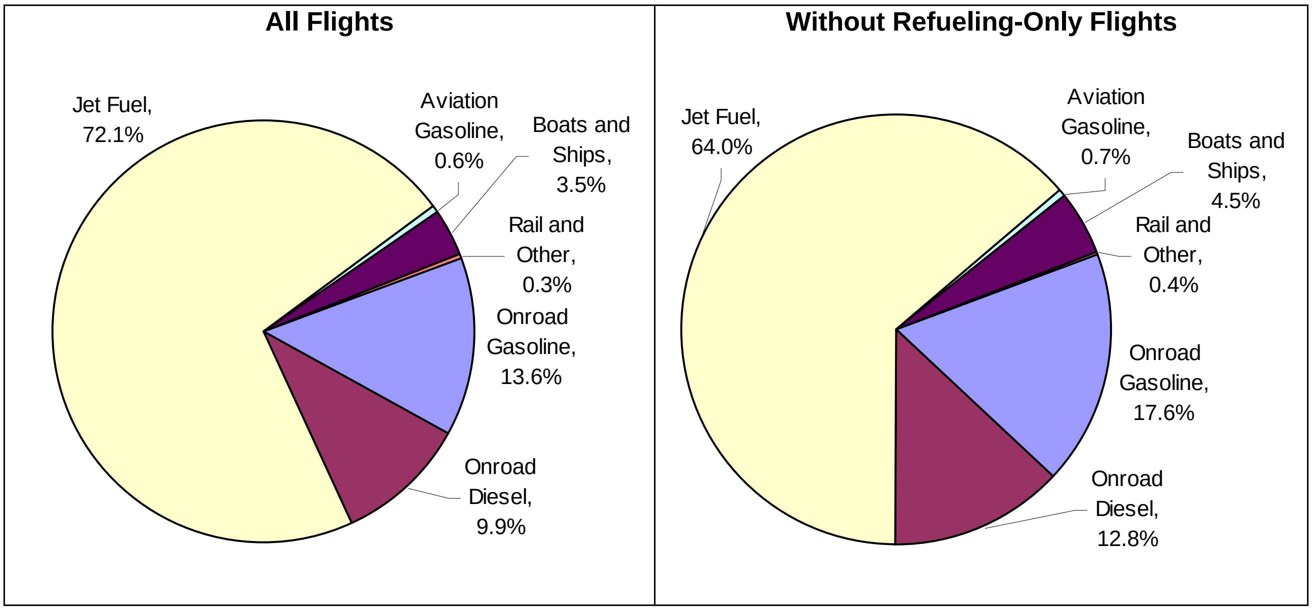
Key Challenges and Opportunities

Alaska is unique among U.S. states in that emissions from aircraft account for the majority of transportation GHG emissions. In most states, emissions from on-road vehicles make up two-thirds or more of transportation GHG emissions. Nationwide, on-road vehicles account for around 85% of transportation GHG emissions. Because Alaska is heavily dependent on air travel, aviation emissions dominate. Most travelers to and from the state use air transport, and air travel within the state is common. Alaska's geographical position also contributes to aviation activity; Alaskan airports are stopover points for some flights that cross the Pacific Ocean.

In accordance with the protocol for quantifying GHG emissions, aviation emissions are calculated based on fuel sales. Many flights stop in Alaska for refueling only. An estimated

75% of international cargo flights, in addition to a small number of international passenger flights, stop in Alaska for this purpose. The emissions from the fuel these aircraft purchase in Alaska is counted in Alaska's inventory, even though the associated movement of cargo and passengers is unrelated to Alaska's economy. Emissions from these refueling-only flights account for roughly 31% of the jet fuel GHG emissions attributed to Alaska. Figure 7-2 shows Alaska's 2005 transportation GHG inventory with and without refueling flight emissions.

Figure 7-2. 2005 Transportation GHG emissions with and without refueling-only flights



GHG = greenhouse gas.

In general, the State of Alaska has very limited control over aviation emissions. Most of the aviation GHG emissions associated with jet fuel sold in Alaska are emitted in flight, outside of Alaska's borders. Because aviation systems are national and global in nature, Alaska has little ability to affect the practices of the aviation industry. In the United States, the Federal Aviation Administration (FAA) sets regulations and manages air traffic control systems that determine much of aircrafts' in-air operations. Some specific options for reducing emissions for aircraft include using alternative fuels and operational measures to save fuel. But alternative fuels for aircraft are still in the very early stages of development. And while some airlines have already instituted operational measures to save fuel, there is little Alaska could do to increase the financial incentive that commercial operations already have to reduce fuel use. Alaska's best opportunity for reducing emissions associated with aviation is probably to change ground operations at airports, including changes to ground support equipment.

At the same time, the importance of aviation to Alaska positions the state to be a major partner in efforts to reduce aviation GHG emissions at the national level. Alaska may be able to partner with commercial operations and with the FAA and other organizations to promote more GHG-efficient aviation.

On-road transportation emissions can be reduced through a combination of policies that improve vehicle fuel efficiency, substitute gasoline and diesel with lower-emission fuels, and reduce vehicle travel. Using alternative fuels is more challenging in Alaska than in other states, because of Alaska's arctic climate and distance from the fuel production and distribution networks in the lower 48. Biofuels in particular present operational challenges in cold climates. More research is needed on appropriate alternative fuels for use in Alaska.

The reduction of per-capita VMT is a critical component of mitigating GHG emissions from the transportation sector. Expanded use of efficient land-use patterns can contribute substantially to this goal by reducing trip length and encouraging the use of transit, ridesharing, bicycling, and walking. A variety of pricing polices and incentive packages can also help to reduce VMT. The development of better planning methods and regulations and the increase of funding in support of alternative modes of transportation will be key mechanisms to achieve these goals. Reducing VMT is more feasible in urban areas than in rural areas.

Marine emissions are also relatively more important in Alaska than in many other U.S. states. The most straightforward way for the state to reduce marine emissions is by improving the fuel efficiency of marine vessels.

Overview of Policy Recommendations and Estimated Impacts

The Alaska Climate Change Mitigation Advisory Group (MAG) recommends a set of 10 policies for the TLU sectors that offer the potential for economic benefits and emission savings. These policy recommendations could lead to emission reductions from reference case projections of:

- 0.4 MMtCO_2e per year by 2025, and
- Cumulative savings of nearly 4 MMtCO_2e from 2010 through 2025.

The weighted-average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was $95 per metric ton of CO_2 equivalent (tCO_2e).

The estimated impacts of the individual policies are shown in Table 7-2. The MAG policy recommendations are described briefly here and in more detail in Appendix J of this report. The recommendations not only result in significant emissions savings, but offer a host of additional benefits as well.

These benefits include reduced local air pollution, more livable, healthy communities, and economic development and job growth. For the TLU policies recommended by the MAG to yield the levels of savings described here, the policies should be implemented in a timely, aggressive, and thorough manner.

Table 7-2. Summary list of Transportation and Land Use policy recommendations

Policy No.	Policy Recommendation	GHG Reductions (MMtCO$_2$e) 2015	2020	2025	Total 2010–2025	Net Present Value 2010–2025 (Million 2005$)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
TLU-1	Transit, Ridesharing, and Commuter Choice Programs	0.002	0.003	0.005	0.046	$29.9	$651	Unanimous
TLU-2	Heavy-Duty Vehicle Idling Regulations and/or Alternatives	0.004	0.009	0.009	0.095	$24.3	$255	Unanimous
TLU-3	Transportation System Management	0.006	0.006	0.006	0.092	–$9.7	–$105	Unanimous
TLU-4	Promote Efficient Development Patterns (Smart Growth)	0.019	0.043	0.066	0.501	Net Savings	NQ	Unanimous
TLU-5	Promotion of Alternative-Fuel Vehicles	0.026–0.084	0.054–0.173	0.09–0.288	0.669–2.139	$207.3–$494.8	$135–$740	Unanimous
TLU-6	VMT and GHG Reduction Goals in Planning	0.019	0.043	0.066	0.501	NQ	NQ	Unanimous
TLU-7	On-Road Heavy-Duty Vehicle Efficiency Improvements: a. SmartWay	0.050	0.075	0.084	0.930	–$52.3	–$56	Unanimous
	b. Phase Out	0.025	0.012	0.000	0.198	$20.9	$106	
	c. Public Fleets	0.016	0.033	0.037	0.364	NQ	NQ	
TLU-8	Marine Vessel Efficiency Improvements	0.012	0.022	0.032	0.269	$20.4	$76	Unanimous
TLU-9	Aviation Emission Reductions	NQ	NQ	NQ	NQ	NQ	NQ	Unanimous
TLU-10	Alternative Fuels Research and Development	NQ	NQ	NQ	NQ	NQ	NQ	Unanimous
	Sector Total Before Adjusting for Overlaps	**0.210**	**0.363**	**0.500**	**4.444**	**$364.3**	**$82**	
	Sector Total After Adjusting for Overlaps	**0.187**	**0.313**	**0.423**	**3.850**	**$364.3***	**$95***	
	Reductions From Recent Actions	**0.397**	**0.531**	**0.732**	**5.995**	**NQ**	**NQ**	
	Sector Total Plus Recent Actions	**0.412**	**0.844**	**1.155**	**9.845**	**NQ**	**NQ**	

*Does not include any cost for policies TLU-4, TLU-6, or TLU-7c, but does include emission reductions for those policies.

GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent; $/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; NQ = not quantified; TLU = transportation and land use; VMT = vehicle miles traveled.

Note: Negative numbers indicate cost savings.

Technology is an important component of the recommended policies. Promotion of Alternative-Fuel Vehicles (TLU-5) could provide the greatest emission reductions of the policies proposed, but the impact of the policy depends heavily on the propulsion technologies adopted. Electric vehicles could have around three times the impact on GHG emissions as vehicles powered by compressed natural gas. There is still some uncertainty about what alternative fuels and propulsion technologies are most appropriate for use in Alaska. Alternative Fuels Research and Development (TLU-10) would help to resolve this uncertainty and support the implementation of TLU-5.

While TLU-5 focuses on alternative fuels for light-duty vehicles, other proposed policies would promote technological improvements to heavy-duty vehicles. On-Road Heavy-Duty Vehicle Efficiency Improvements (TLU-7) proposes three mechanisms to improve the fuel economy of heavy-duty trucks and buses: retrofitting of existing vehicles with fuel-efficient technologies (SmartWay®); early replacement of older vehicles with newer, more fuel-efficient vehicles (Phase Out); and programs that promote improvements in fuel efficiency and use of alternative fuels specifically in public and private fleets. (Only public fleets were quantified in the analysis for this report.) An additional policy, Heavy Duty Vehicle Idling Regulations and/or Alternatives (TLU-2), could achieve modest reductions by decreasing unnecessary idling of heavy-duty vehicles. Less idling means less fuel consumed and fewer GHG emissions.

A number of policies would work together to reduce VMT by increasing the viability of alternative modes of travel and providing incentives to use alternative modes. These policies will require increased coordination between state government, local government, and businesses in many cases. Promote Efficient Development Patterns (Smart Growth) (TLU-4) presents the greatest institutional challenge. The promotion of more compact and mixed-use development patterns requires significant reform in local planning practices. Yet implementation of this policy is essential to make travel by walking, bicycling, and transit more feasible. In fact, transit use is on the rise nationwide and can be increased in many areas. TLU-1 (Transit, Ridesharing, and Commuter Choice Programs) is a policy package for the improvement, expansion, and promotion of public transit in Alaska's urban areas. VMT and GHG Reduction Goals in Planning (TLU-6) would support the implementation of both TLU-4 and TLU-1. TLU-6 would require both the state and municipal planning organizations (MPOs) to evaluate transportation GHG emissions and attempt to reduce per-capita VMT in areas where it is technically and economically appropriate.

One policy would reduce GHG emissions by improving the operations of existing roadways in Alaska, and by providing facilities for bicyclists and pedestrians as well. Transportation System Management (TLU-3) would promote the use of roundabouts, synchronization of traffic signals, light-emitting diode (LED) lights in traffic signals and street lamps, and reduced speed limits in some areas, among other measures.

Two policies target emissions from non-road transportation in Alaska. Marine Vessel Efficiency Improvements (TLU-8) would promote retrofitting existing marine vessels with more fuel-efficient engines. Aviation Emission Reductions (TLU-9) could be achieved by improving the operations of Alaska's airports, promoting the use of alternative fuels in aviation, and supporting improvements in federally managed aviation systems. While aviation is by far the largest source of transportation GHG emissions in Alaska, the state has a very limited ability to control the major factors that determine aviation GHG emissions. No emission reductions have been calculated for the short term.

There is overlap in the expected emission reductions among some of the policies within the TLU sectors; therefore, the GHG reductions resulting from individual stand-alone policies are not purely additive. In particular, policies that reduce VMT will erode the GHG benefits of policies that improve vehicle fuel economy or reduce fuel carbon intensity. Of policies that reduce light-duty VMT, TLU-4 and TLU-6 overlap entirely, having the same goal to reduce per-capita VMT. These goals also subsume the impact of TLU-1. To calculate the joint impact of policies on light-duty emissions, light-duty VMT and GHG emissions were calculated based on the combined impact of TLU-1, TLU-4, and TLU-6. The resulting emissions were reduced by the relative impacts of transportation system management (TLU-3) and use of alternative-fuel vehicles (TLU-5). Policies that affect emissions from heavy-duty vehicles primarily work by reducing the amount of fuel that vehicles consume, without changing the amount of travel by heavy-duty vehicles. It was assumed that there would be overlap between all of these policies (TLU-2, TLU-3, and TLU-7), as each subsequent measure would affect a more fuel-efficient baseline. Total fuel consumption and GHG emissions were estimated accounting for TLU-2, and the relative impacts of TLU-3 and TLU-7 were then applied. TLU-8 only affects marine vessels; therefore, it has no overlap with other policies. There is no overlap between TLU policies and those from the other sectors.

Transportation and Land Use Policy Descriptions

TLU-1. Transit, Ridesharing, and Commuter Choice Programs

The MAG recommends that Alaska provide the leadership and resources necessary to help expand the state's public transit and ridesharing system. To alter Alaskan driving habits to reduce GHG emissions, issues of convenience, choice, and finance must be major elements in expanded transit and ridesharing operations. Public education will also be paramount to success.

This policy would:

- Develop park-and-ride systems that are coupled to increased urban transit schedules. Estimates of new infrastructure will be needed in cold areas to keep car engines heated.
- Develop outlying collector routes with buses or vans to high-employment destinations—i.e., university campuses, oil industry offices, and state offices. A daytime shuttle or van offer to provide for personal lunchtime trips has been demonstrated in the private workplace.
- Provide funding support to expand the current transit systems' operations to increase the frequency of in-town schedules.
- Develop rail tie-in along existing track. Diesel multiple-unit cars from Wasilla to Anchorage and North Pole–University of Alaska Fairbanks campus through Fairbanks would be leased on an initial winter basis. Funding would be provided to invest in these cars and a program operator—a possible statewide or Regional Transportation Authority.

The Alaska Department of Transportation and Public Facilities (ADOT&PF) will help achieve an expansion of transit services in Alaskan communities, including coordinated transit solutions, and will seek additional funds to support this expansion.

The State of Alaska should also support the development of a Regional Transportation Authority in Anchorage and Fairbanks to integrate all alternatives into one coordinated regional system. This system would eventually include rail, bus transit, paratransit, and ferries, where appropriate.

Specific goals of the policy include:

- Double transit ridership in Alaska by 2025, compared to 2007 levels.
- Double vanpooling in Alaska by 2025, compared to 2007 levels.
- Increase the carpool mode share in Alaska by 2025.

This policy was unanimously approved by the MAG.

TLU-2. Heavy-Duty Vehicle Idling Regulations and/or Alternatives

The MAG recommends that the Alaska focus on reducing idling times for diesel and gasoline heavy-duty vehicles, buses, and other vehicles through a combination of statewide anti-idling regulations and by promoting and expanding the use of technologies that reduce heavy-duty vehicle idling. Through this policy, the state would:

- Develop and implement a statewide regulation banning extended idling by heavy-duty vehicles given accommodations for below-zero arctic and subarctic winter conditions, and provide local governmental units with model language for adoption of local anti-idling ordinances.
- Encourage and promote reduced idling through programs aimed at increasing voluntary adoption of idle-reduction technologies.
- Provide additional incentives to fleet or individual heavy-duty truck owners to purchase and install idle-reduction technologies on their vehicles. These incentives may come in the form of full grants, matching grants, tax credits, and low- or no-interest loans.

Alaska may also provide incentives to assist the private fleets to convert some of their vehicles to hybrid operation. Such engine technology is or soon will become available in the marketplace.

Alaska DOT&PF will lead by example with the installation of idle-reduction technology and/or idle-reduction policies/procedures for its fleet of heavy-duty vehicles. This goal will be phased to accomplish installation of these technologies or adoption of policies: 20% will be so equipped by 2012, with the remaining 80% equipped by 2020, with exception for vehicles used only seasonally.

This policy was unanimously approved by the MAG.

TLU-3. Transportation System Management

The MAG recommends that the Alaska seek to reduce GHG emissions from the transportation sector through improvements to transportation system management. These efforts would focus on the improvement, management, and operation of the transportation infrastructure, with a focus on the road and highway systems.

Specific policies include:

- ADOT&PF will encourage the installation of roundabouts. Roundabouts can reduce traffic queuing and delay, thus saving fuel and reducing GHG emissions; they also have safety benefits.
- To improve fuel economy and reduce GHG emissions per mile traveled, the state will reduce maximum speed limits on state highways to 60 miles per hour, or lower where appropriate.
- ADOT&PF will continue its commitment to providing a multimodal transportation system by continuing to invest in transit, bike, and pedestrian facilities.
- All urban areas (i.e., >5,000 population) will continue to include consideration of bike and pedestrian facilities in their urban transportation plans.
- ADOT&PF, in partnership with urban communities, will work to improve traffic signal synchronization on all state-managed routes (mostly arterials) in urban areas (i.e., >5,000 population) by 2012.
- ADOT&PF will complete conversion of all traffic lights to LED bulbs by 2010, and will work with cities to convert roadway luminary lighting under city jurisdiction.
- All urban transportation plans will be updated by 2012, with an emphasis on operations and safety. The operations elements in urban transportation plans will improve traffic flow and reduce conflict points, and can result in turn lanes, reconfiguration of intersections, or access control.
- Congestion management plans for all high-traffic-volume construction projects will be considered by ADOT&PF.
- Access management will continue to be pursued consistent with Alaska statutes and ADOT&PF policies. Access management is intended to reduce the number of street and driveway access points to major roads and highways, in order to reduce conflict points.
- The state will install traffic management technologies and provide public information of travel conditions on high-volume commuter routes, especially those lacking practical bypasses. ADOT&PF, along with partner communities, will complete by 2010 a comprehensive ITS Plan for the Glenn Highway corridor between Anchorage and the Mat-Su valley.
- The state will improve the manner in which incidents and accidents on high-volume routes are processed, and will require drivers involved in crashes to pull away from travel lanes.

This policy was unanimously approved by the MAG.

TLU-4. Promote Efficient Development Patterns (Smart Growth)

The MAG recommends that Alaska promote efficient, sustainable (i.e., smart growth) land development patterns to complement transit improvements, and sustained implementation of multimodal links to facilitate biking, walking, and winter trail use in residential and urban areas.

This policy will focus on promoting land-use changes that result in higher densities in developed, urban areas. It will also focus on incorporating retail zones and small limited commercial nodes in residential developments, with a goal of reducing driving needs by facilitating walking or bicycling, and also reducing the length of driving trips.

The Alaska Department of Education will require school boards in selecting new school sites to favor sites that can be reached by walking and biking for the majority of the population the school will serve.

Additional issues and items to be developed would include:

- State policy issues detailing funding parameters and funders' policies distributing state and federal dollars.
- Changes to state laws and regulations.
- Local development plans—e.g., *Anchorage 2020*,[1] Fairbanks North Star Borough Regional Comprehensive Plan.
- Local zoning code changes.
- Increased urban/residential density factors.
- Land "disposal" sales and auctions, including the University of Alaska and the Alaska Mental Health Land Trust.
- Subdivision codes and standards to set aside people-friendly open spaces and greenbelt reserves.
- Tax credits/incentives to developers.
- Must be combined with infrastructure planning—roads and utilities.
- Public buy-in is a must. There must be strong incentives to have people accept programs.

This policy was unanimously approved by the MAG.

TLU-5. Promotion of Alternative-Fuel Vehicles

The MAG recommends that Alaska promote the use of alternative-fuel vehicles (AFVs) in the light-duty fleet, including vehicles powered by natural gas, propane, biodiesel, electricity, ethanol, hydrogen, and fuel cells, and hybrid vehicles that use more than one power source.

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[1] See: http://www.muni.org/Planning/prj_Anch2020.cfm..

This mitigation policy consists of two parts: (1) working toward the replacement of existing light-duty vehicle fleets with AFVs, and (2) better informing the public of the benefits of purchasing AFVs and providing incentives as well. The policy's specific goals are:

- Increase the use of light-duty AFVs by public-sector agencies and private-sector firms to 25% of on-road fuel consumption by 2020 and 35% by 2030.
- Increase the use of AFVs by consumers to 10% of on-road fuel consumption by 2020 and 25% by 2030.
- Ensure that the AFV technologies chosen produce a minimum 15% life-cycle reduction in GHG emissions per mile, compared to conventional fuels.

This policy was unanimously approved by the MAG.

TLU-6. VMT and GHG Reduction Goals in Planning

The MAG recommends that Alaska require all significant transportation system plans developed at the state and MPO levels, and all actions that would change or provide a new mode of transportation or enlarge capacity, to have an evaluation of their contributions to GHG emissions. Currently, traffic models to assist in such evaluations exist only at the metropolitan level in Alaska; thus, time may be needed to develop tools for non-metropolitan areas.

The goal of the policy is to reduce the per-capita light-duty VMT in communities that offer transit services by 1% by 2015 and 3% by 2025. To implement this policy:

- The two MPOs—the Fairbanks Metropolitan Area Transportation Study (FMATS) and Anchorage Metropolitan Area Transportation Solutions (AMATS)—would work with ADOT&PF to develop consistent methods to evaluate GHGs from transportation system plans and relevant projects by the end of 2010.
- The state legislature would enact a policy that requires per-capita reductions in VMT in communities that offer transit services.

This policy would support and promote public and private planning and development practices, including smart growth planning (see TLU-4) and infrastructure provisions, such as expanded opportunities for non-vehicular travel that reduce the number and/or length of trips made in Alaska.

This policy was unanimously approved by the MAG.

TLU-7. On-Road Heavy-Duty Vehicle Efficiency Improvements

The MAG recommends that Alaska create new services and provide additional support to existing voluntary and incentive-based programs that help public and private on-road heavy-duty diesel-powered fleets reduce GHG emissions.

This policy employs a combination of three primary strategies to achieve GHG emission reductions:

- Develop incentives to encourage public and private on-road diesel fleets to participate in the EPA Smart Way® Transport Partnership Program.
  - Goal: Achieve the following public and private fleet participation in Smart Way®: 30% of total trucks in Alaska by 2012, and 50% by 2020.

- Provide incentives to phase out "old" (1988 and older) high-GHG-emitting on-road heavy-duty diesel engines, and replace them with modern lower-GHG-emitting diesel engines if appropriate. Vehicles replaced by the program must be permanently scrapped in order to achieve a net emission reduction. They may not be sold into the used truck market.
  - Goal: Phase out 50% of "old" (1988 and older) high-GHG-emitting on-road heavy-duty diesel engines by 2015.

- Develop incentives for state, borough, and municipal government-managed vehicle fleets to develop and implement plans to reduce GHG emissions from their public transit, school bus, and maintenance vehicles. Examples could include idle-reduction strategies, alternatively powered engines—liquefied natural gas, natural gas, electric, hybrid, resource sharing etc.
  - Goal: Achieve a minimum 20% GHG emission reduction from the 2008 benchmark by 2020.

This policy was unanimously approved by the MAG.

TLU-8. Marine Vessel Efficiency Improvements

The MAG recommends that Alaska promote efficiencies and conservation options for commercial fishing, recreational fishing, marine tourism, and other forms of marine transportation.

- Provide financial incentives, such as low-cost loans, that would encourage vessel owners to implement changes without unduly compromising industry economics.
- Encourage federal and state agencies that regulate commercial fishing to consider GHG emissions when making policy decisions. Efficiency improvements relating to conduct of a given commercial, commercial sport (charter), recreational, personal use, or subsistence fishery are regulatory in nature and would require action by the Alaska Board of Fisheries.

This policy was unanimously approved by the MAG.

TLU-9. Aviation Emission Reductions

The MAG recommends that Alaska support measures to reduce GHG emissions from operation of airports and aircraft in the state.

This mitigation option includes three components:

- Support the FAA in the redesign and improvement of the existing, outdated, air traffic management system through the implementation of the Next Generation Air Transportation System (NextGen) project.
- Identify existing and new operational best practices for maximizing fuel efficiency in the aviation sector, facilitate (including through financial incentives) voluntary implementation of such practices where practical, and evaluate resulting emission benefits where possible.
- Adopt a clear statement that it is the policy of the State of Alaska to facilitate the rapid introduction of alternative fuels for aviation that both are economically viable and have a reduced emissions profile on a life-cycle basis.

In addressing GHG emissions from the aviation sector, Alaska must take into account its unique interests in the sector, the policies and practices of other states and territories, and other national and international laws and policies affecting aviation and environmental goals.

This policy was unanimously approved by the MAG.

TLU-10. Alternative Fuels Research and Development

The MAG recommends that Alaska support research and development of alternative transportation fuels that are feasible in the Alaska climate, result in significant life-cycle GHG reductions when used in Alaska, and can benefit Alaska's economy. Research should focus on existing alternative propulsion technologies and methods to make existing technologies more viable in Alaska, rather than on development of new propulsion technologies.

Specifically, the state of Alaska and research partners should:

- Determine the market potential, cost, and GHG impacts of existing alternative fuel and vehicle types in Alaska.
- Determine methods to encourage the in-state production and use of alternative fuels.

This policy was unanimously approved by the MAG.