DRAFT Alaska Greenhouse Gas Inventory and Reference Case Projections, 1990-2025

Center for Climate Strategies
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Executive Summary

The Center for Climate Strategies (CCS) prepared the first draft of this report for the Alaska Department of Environment Conservation (ADEC) under an agreement with the Western Governors' Association. The report presented an assessment of the State's greenhouse gas (GHG) emissions and anthropogenic sinks (carbon storage) from 1990 to 2020. The preliminary draft inventory and forecast estimates served as a starting point to assist the State, as well as the Alaska Climate Change Mitigation Advisory Group (CCMAG) and Technical Work Groups (TWGs), with an initial comprehensive understanding of Alaska's current and possible future GHG emissions, and thereby informed the identification and analysis of policy options for mitigating GHG emissions.[1] The CCMAG 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. The inventory and forecast as well as this report have been revised to address the comments provided and approved by the CCMAG

Emissions and Reference Case Projections (Business-as-Usual)

Alaska's anthropogenic GHG emissions and sinks (carbon storage) were estimated for the period from 1990 to 2025. Historical GHG emission estimates (1990 through 2005)[2] were developed using a set of generally accepted principles and guidelines for state GHG emission estimates, with adjustments by CCS to provide Alaska-specific data and inputs when it was possible to do so. The reference case emission projections (2006-2025) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities for Alaska, along with a set of transparent assumptions described in the appendices of this report.

The inventory and projections cover the six types of gases included in the US Greenhouse Gas 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 (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis.[3]

Table ES-1 provides a summary of historical (1990, 2000 and 2005) and reference case projection (2010, 2020, and 2025) GHG emissions for Alaska. Activities in Alaska accounted for approximately 50.6 million metric tons (MMt) of *gross*[4] carbon dioxide equivalent (CO_2e)

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[1] "Alaska Greenhouse Gas Inventory and Reference Case Projections, 1990-2020," prepared by the Center for Climate Strategies for the Alaska Department of Environmental Conservation, July 2007.

[2] The last year of available historical data varies by sector; ranging from 2000 to 2005.

[3] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the 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 (IPCC, 2001). Holding everything 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 Change Cambridge University Press. Cambridge, United Kingdon. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

[4] Excluding GHG emissions removed (e.g., CO_2 sequestered) in forestry and other land uses.

emissions in 2005, an amount equal to about 0.7% of total U.S. gross GHG emissions. Alaska's gross GHG emissions grew at a faster rate than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Alaska's gross GHG emissions increased 30% from 1990 to 2005, while national emissions rose by 16% during this period. The growth in Alaska's emissions from 1990 to 2005 is primarily associated with the transporation and the residential, commercial, and industrial (RCI) fuel consumption sectors.

Estimates of carbon sinks within Alaska's forests have also been included in this report. Estimates of carbon dioxide sequestered in Alaska's managed forests are -1.4 MMtCO_2/yr ("managed forests" consist of the coastal maritime forests in Alaska; see Appendix H). This leads to *net* emissions of 49.2 MMtCO_2e in Alaska in 2005.

Figure ES-1 illustrates the State's emissions per capita and per unit of economic output. On a per capita basis, Alaskans emitted about 79 metric tons (Mt) of CO_2e in 2005, higher than the national average of 24 MtCO_2e in 2005. 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. Per capita emissions in Alaska have increased somewhat from 1990 to 2005, while economic growth exceeded emissions growth throughout the 1990-2005 period (leading to declining estimates of GHG emissions per unit of state product). From 1990 to 2005, emissions per unit of gross product dropped by 26% nationally, and by 17% in Alaska.

The principal source of Alaska's GHG emissions is RCI fuel use, accounting for 43% of total State gross GHG emissions in 2005. Nearly 85% of the RCI fuel use sector emissions are contributed by the industrial fuel use subsector. The next largest contributor to total gross GHG emissions is the transportation sector, which accounted for 35% of the total State gross GHG emissions in 2005.

As illustrated in Figure ES-2 and shown numerically in Table ES-1, under the reference case projections, Alaska's gross GHG emissions continue to grow, and are projected to climb to 62.8 MMtCO_2e per year by 2025, 61% above 1990 levels. As shown in Figure ES-3, emissions associated with RCI fuel use are projected to be the largest contributor to future emissions growth, followed by emissions from the transportation sector.

Emissions of aerosols, particularly "black carbon" (BC) from fossil fuel combustion, could have significant climate impacts through their effects on radiative forcing. Estimates of these aerosol emissions on a CO_2e basis were developed for Alaska based on 2002 data and 2018 projected data from the Western Regional Air Partnership (WRAP). Estimated BC emissions for the year 2002 were a total of 3.0 $MMtCO_2$e, which is the mid-point of a range of estimated emissions (1.9 – 4.0 $MMtCO_2$e). Based on an assessment of the primary contributors, it is estimated that BC emissions will decrease by 2018 after new engine and fuel standards take effect in the onroad and nonroad diesel engine sectors. Details of this analysis are presented in Appendix I to this report. These estimates are not incorporated into the totals shown in Table ES-1 below because a global warming potential for BC has not yet been assigned by the Intergovernmental Panel on Climate Change (IPCC).

Some data gaps exist in this analysis, particularly for the reference case projections. Key tasks for future GHG inventory work in Alaska include review and revision of key emissions drivers. These include electricity, fossil fuel production, and transportation fuel use growth rates and future electricity generation source mix, which will be major determinants of Alaska's future GHG emissions. Appendices A through H provide the detailed methods, data sources, and assumptions for each GHG sector. Also included are descriptions of significant uncertainties in emission estimates or methods and suggested next steps for refinement of the inventory. Appendix J provides background information on GHGs and climate-forcing aerosols.

GHG Reductions from Recent Actions[5]

The federal Energy Independence and Security Act (EISA) of 2007 was signed into law in December 2007. This federal law contains several requirements that will reduce GHG emissions as they are implemented over the next few years. During the CCMAG process, sufficient information was identified (e.g., implementation schedules) to estimate GHG emission reductions associated with implementing the Corporate Average Fuel Economy (CAFE) requirements in Alaska. The CCMAG also identified recent actions that Alaska has undertaken to control GHG emissions while at the same time conserving energy. One recent action related to weatherization bonding was identified for which data were available to estimate the emission reductions of the action relative to the business-as-usual reference case projections. The GHG emission reductions projected to be achieved by these recent State and Federal actions are summarized in Table ES-2. This table shows a total reduction of about X.X $MMtCO_2$e in 2025 from the business-as-usual reference case emissions, or a Y.Y% reduction from the business-as-usual emissions in 2025 for all sectors combined.

[5] Note that actions recently adopted by the state of Alaska have also been referred to as "existing" actions.

Table ES-1. Alaska Historical and Reference Case GHG Emissions, by Sector ($MMtCO_2e$)[a]

$MMtCO_2e$	1990	2000	2005	2010	2020	2025	Explanatory Notes for Projections
Energy Use (CO_2, CH_4, N_2O)	**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	See electric sector assumptions
Coal	0.40	0.42	0.48	0.50	0.79	0.79	in appendix A.
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	
Net 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	Based on US DOE regional projections
Natural Gas	1.79	2.22	1.87	1.91	2.09	2.13	Based on US DOE regional projections
Oil	1.21	1.30	1.29	1.29	1.34	1.26	Based on US DOE regional projections
Wood (CH4 and N2O)	0.012	0.013	0.023	0.023	0.023	0.023	Based on US DOE regional projections
Industrial Fuel Use	**15.7**	**19.6**	**21.6**	**23.5**	**28.5**	**29.8**	
Coal	0.000	0.001	0.001	0.001	0.001	0.001	Based on US DOE regional projections
Natural Gas	13.2	17.3	18.5	19.9	24.4	25.5	Based on US DOE regional projections
Oil	2.44	2.35	3.08	3.56	4.06	4.33	Based on US DOE regional projections
Wood (CH4 and N2O)	0.012	0.000	0.000	0.000	0.000	0.000	Based on US DOE regional projections
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	FAA aircraft operations forecasts
Marine Vessels	0.83	0.48	0.61	0.72	1.00	1.17	DEC commercial marine growth factors
Onroad Vehicles	3.41	3.71	4.19	4.55	5.57	6.20	WRAP inventory VMT projections
Rail and Other	0.082	0.075	0.056	0.057	0.062	0.063	Historical trends and USDOE regional projections
Fossil Fuel Industry	**4.87**	**3.28**	**3.12**	**3.04**	**2.35**	**1.93**	
Natural Gas Industry	0.20	0.43	0.62	0.61	0.62	0.65	Historical trends and DNR natural gas production forecasts
Oil Industry	4.67	2.83	2.49	2.42	1.72	1.27	Historical trends and DNR oil production forecasts
Coal Mining	0.009	0.008	0.008	0.008	0.009	0.009	Historical trend
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	Alaska manufacturing employment growth
Soda Ash (CO_2)	0.006	0.006	0.006	0.006	0.007	0.007	National projections for 2004-2009 (USGS)
ODS Substitutes (HFC, PFC)	0.001	0.17	0.30	0.42	0.72	0.94	EPA 2004 ODS cost study report
Electric Power T&D (SF_6)	0.044	0.025	0.024	0.017	0.010	0.008	Based on national projections (USEPA)
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	Projected based on 1995-2005 trend
Wastewater Management	0.057	0.067	0.068	0.071	0.076	0.079	Projected based on population
Agriculture	**0.053**	**0.054**	**0.053**	**0.056**	**0.066**	**0.073**	
Manure Management	0.001	0.002	0.004	0.005	0.009	0.012	USDA livestock projections
Enteric Fermentation	0.013	0.015	0.020	0.023	0.029	0.034	USDA livestock projections
Agricultural Soils	0.039	0.037	0.030	0.029	0.028	0.028	Projected based on historical trend
Total Gross Emissions	**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	Projections held constant at 2000 level
Net Emissions (incl. forestry)	**38.7**	**44.7**	**49.2**	**52.1**	**58.9**	**61.4**	
increase relative to 1990		*15%*	*27%*	*35%*	*52%*	*59%*	

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

Figure ES-1. Historical Alaska and U.S. GHG Emissions, Per Capita and Per Unit Gross Product

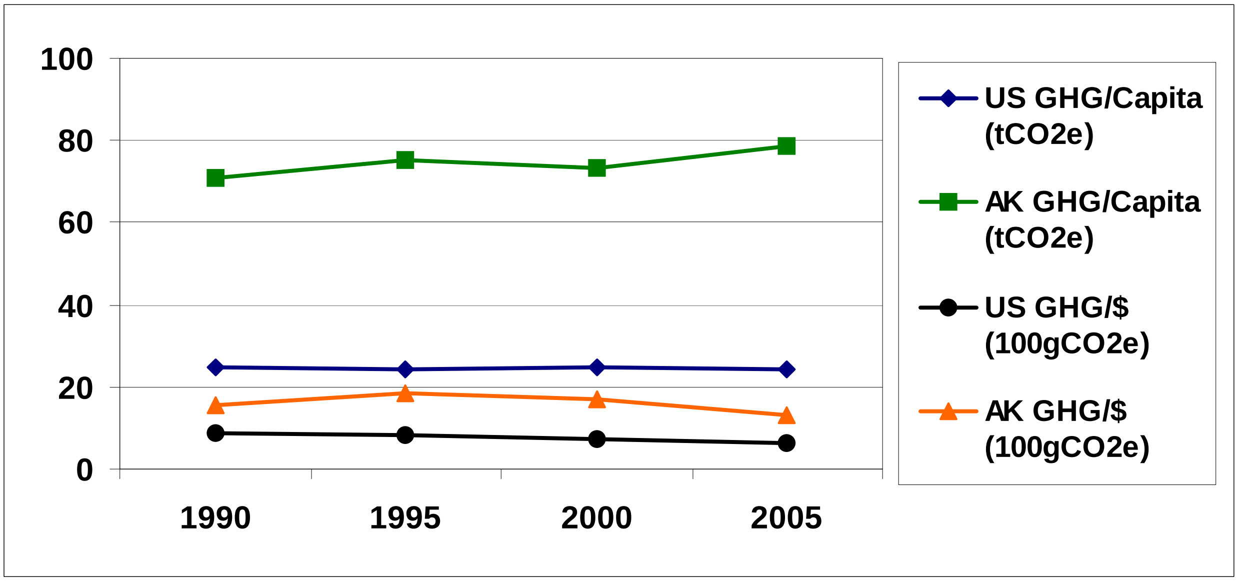
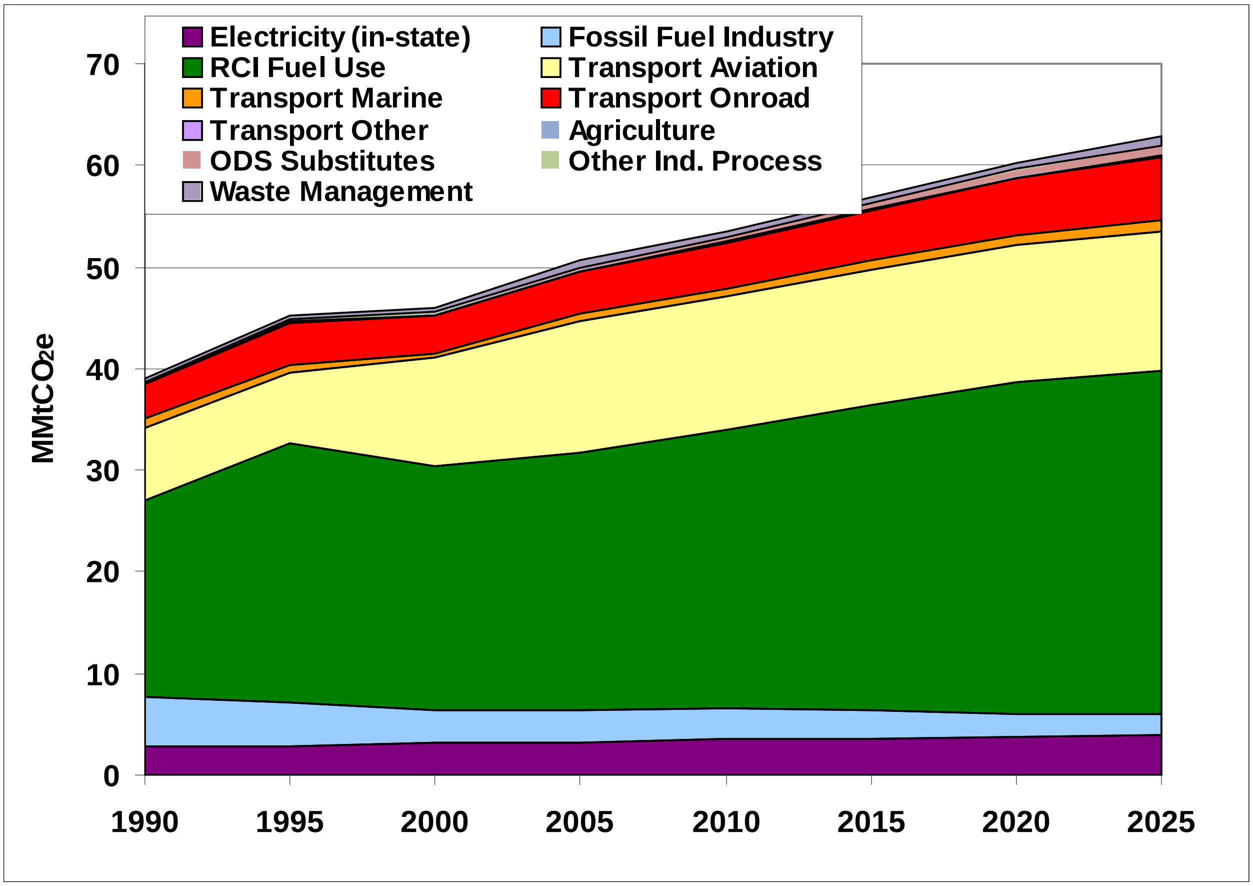


Figure ES-2. Alaska Gross GHG Emissions by Sector, 1990-2025: Historical and Projected



Notes: Fossil Fuel Industry emissions include emissions not associated with fuel combustion (fugitive CH_4). Fossil fuel combustion emissions are included in the RCI Fuel Use sector. RCI – direct fuel use in residential, commercial and industrial sectors. ODS – ozone depleting substance.

Figure ES-3. Sector Contributions to Emissions Growth in Alaska, 1990-2025: Reference Case Projections

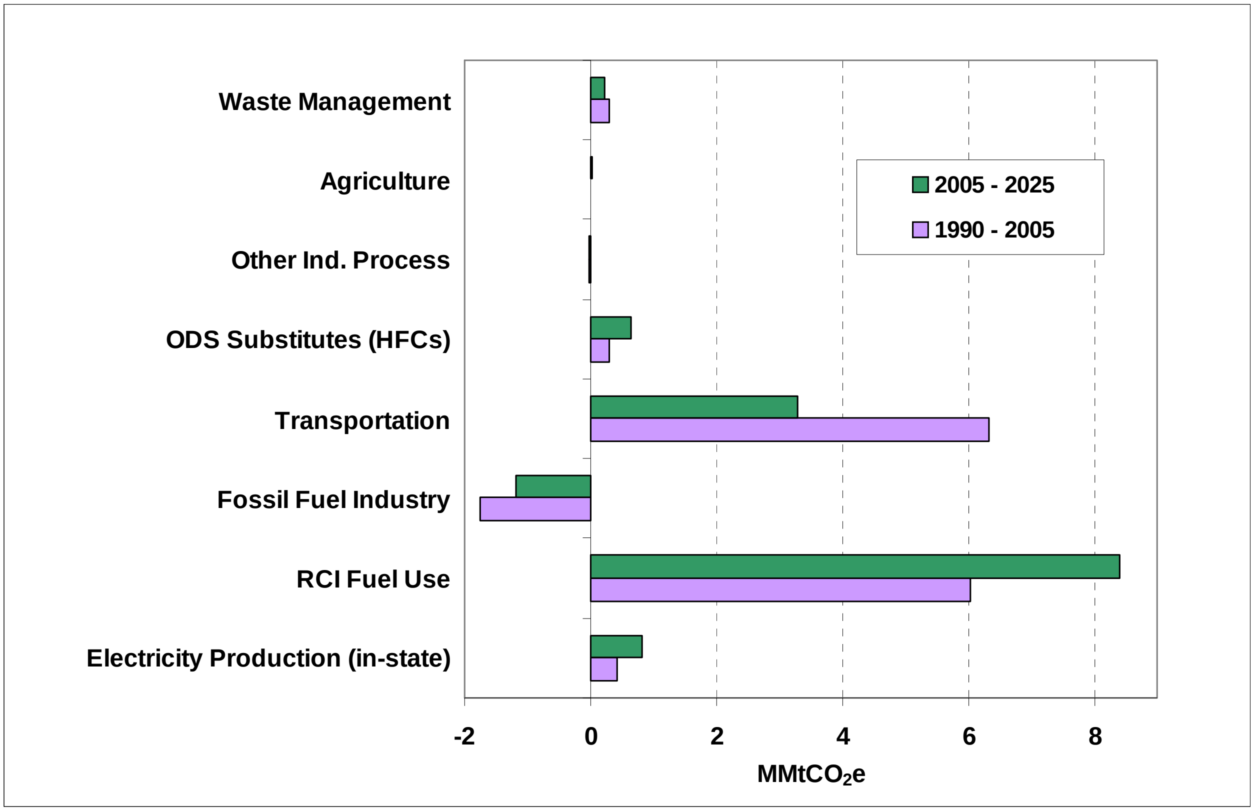


Table ES-2. Emission Reduction Estimates Associated with the Effect of Recent Actions in Alaska (Consumption-Basis, Gross Emissions)

Sector / Recent Action	GHG Reductions ($MMtCO_2e$) 2015	GHG Reductions ($MMtCO_2e$) 2025	GHG Emissions (MMtCO2e) Business as Usual 2025	GHG Emissions (MMtCO2e) With Recent Actions 2025
Residential/Commercial/Industrial (RCI) Fuel Use				
Weatherization Bonding			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)			55.0	
Total (All Sectors)			62.8	

Table of Contents

Acronyms and Key Terms

AEO – *Annual Energy Outlook*

Ag – Agriculture

ADEC – Alaska Department of Environmental Conservation

bbls – Barrels

BC – Black Carbon

Bcf – Billion cubic feet

BLM – United States Bureau of Land Management

BOC – Bureau of Census

BTU – British thermal unit

C – Carbon

$CaCO_3$ – Calcium Carbonate

CBM – Coal Bed Methane

CCS – Center for Climate Strategies

CFCs – chlorofluorocarbons

CH_4 – Methane*

CO_2 – Carbon Dioxide*

CO_2e – Carbon Dioxide equivalent*

CRP – Federal Conservation Reserve Program

EC – Elemental Carbon

eGRID – U.S. EPA's Emissions & Generation Resource Integrated Database

EIA – U.S. DOE Energy Information Administration

EIIP – Emissions Inventory Improvement Project (US EPA)

FIA – Forest Inventory Analysis

GHG – Greenhouse Gases*

GSP – Gross State Product

GWh – Gigawatt-hour

GWP - Global Warming Potential*

HFCs – Hydrofluorocarbons*

HNO_3 – Nitric acid

HWP – Harvested Wood Products

IPCC – Intergovernmental Panel on Climate Change* kWh – Kilowatt-hour

LFGTE – Landfill Gas Collection System and Landfill-Gas-to-Energy

LMOP – Landfill Methane Outreach Program

LNG – Liquefied Natural Gas

LPG – Liquefied Petroleum Gas

Mg – Megagrams (equivalent to one metric ton)

Mt - Metric ton (equivalent to 1.102 short tons)

MMt – Million Metric tons

MPO – Metropolitan Planning Organization

MSW – Municipal solid waste

MW – Megawatt

N – Nitrogen

N_2O – Nitrous Oxide*

NO_2 – nitrogen dioxide*

NAICS – North American Industry Classification System

NASS – National Agricultural Statistics Service

NO_x – Nitrogen oxides

NSCR – Non-selective catalytic reduction

ODS – Ozone-Depleting Substances

OM – Organic Matter

PADD – Petroleum Administration for Defense Districts

PFCs – Perfluorocarbons*

PM – Particulate Matter

ppb – parts per billion

ppm – parts per million

ppt – parts per trillion

PV – Photovoltaic

RCI – Residential, Commercial, and Industrial

RPA – Resources Planning Act Assessment

RPS – Renewable Portfolio Standard

SAR – Second Assessment Report

SCR- Selective catalytic reduction

SED – State Energy Data

SF_6 – Sulfur Hexafluoride*

SGIT – State Greenhouse Gas Inventory Tool

Sinks – Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.

TAR – Third Assessment Report

T&D – Transmission and Distribution

TWh – Terawatt-hours

UNFCCC – United Nations Framework Convention on Climate Change

U.S. EPA – United States Environmental Protection Agency

U.S. DOE – United States Department of Energy

USDA – United States Department of Agriculture

USFS – United States Forest Service

USGS – United States Geological Survey

VMT – Vehicle-Miles Traveled

WAPA – Western Area Power Administration

WECC – Western Electricity Coordinating Council

W/m^2 – Watts per Square Meter

WMO – World Meteorological Organization*

WRAP – Western Regional Air Partnership

* - See Appendix J for more information.

Acknowledgements

CCS appreciates all of the time and assistance provided by numerous contacts throughout Alaska, as well as in other western states and at federal agencies. Thanks go to the many staff at several Alaska state agencies and universities for their inputs, and in particular to: Alice Edwards and Tom Chapple of the Alaska Department of Environment Quality, Division of Air Quality who provided key guidance and review for this analytical effort; Peter Crimp of the Alaska Energy Authority, Scott Goldsmith of the Institute of Social and Economic Research, and Mark Foster of MAFA Consulting for information in the electricity sector; and David McGuire and Michael Balshi of the University of Fairbanks, Alaska for their information and review of the forestry sector inventory.

The authors would also like to express their appreciation to the additional CCS reviewers: Katie Bickel, Michael Lazarus, Lewison Lem, and David Von Hippel.

Summary of Findings

Introduction

The Center for Climate Strategies (CCS) prepared the first draft of this report for the Alaska Department of Environment Conservation (ADEC) under an agreement with the Western Governors' Association. The report presented an assessment of the State's greenhouse gas (GHG) emissions and anthropogenic sinks (carbon storage) from 1990 to 2020. The preliminary draft inventory and forecast estimates served as a starting point to assist the State, as well as the Alaska Climate Change Mitigation Advisory Group (CCMAG) and Technical Work Groups (TWGs), with an initial comprehensive understanding of Alaska's current and possible future GHG emissions, and thereby informed the identification and analysis of policy options for mitigating GHG emissions.[6] The CCMAG 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. The inventory and forecast as well as this report have been revised to address the comments provided and approved by the CCMAG

Emissions and Reference Case Projections (Business-as-Usual)

Historical GHG emissions estimates (1990 through 2005)[7] were developed using a set of generally accepted principles and guidelines for state GHG emissions inventories, as described in the "Approach" section below, relying to the extent possible on Alaska-specific data and inputs. The initial 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 appendices of this report.

This report covers the six gases included in the U.S. Greenhouse Gas 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 (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential- (GWP-) weighted basis.[8] The final appendix to this report provides a more complete discussion of GHGs and GWPs. Emissions of black carbon were also estimated. Black carbon (BC) is an aerosol species with a positive climate forcing potential (that is, the potential to warm the atmosphere, as GHGs do); however, black carbon currently does not have a GWP defined by the IPCC due to uncertainties in both the

[6] "Alaska Greenhouse Gas Inventory and Reference Case Projections, 1990-2020," prepared by the Center for Climate Strategies for the Alaska Department of Environmental Conservation, July 2007.
[7] The last year of available historical data varies by sector; ranging from 2000 to 2005.
[8] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the 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 (IPCC, 1996). Holding everything 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), http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm.

direct and indirect effects of BC on atmospheric processes (see Appendices I and J for more details). Therefore, except for Appendix I, all of the summary tables and graphs in this report cover emissions of just the six GHGs noted above.

It is important to note that the emission estimates for the electricity sector reflect the *GHG emissions associated with the electricity sources used to meet Alaska's demands,* corresponding to a *consumption-based* approach to emissions accounting (see "Approach" section below). Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the State.* 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. CCS introduces this concept of consumption- versus production-based emissions, since in other states, electricity imports and exports are an important issue.

Alaska Greenhouse Gas Emissions: Sources and Trends

Table 1 provides a summary of GHG emissions estimated for Alaska by sector for the years 1990, 2000, 2005, 2010, 2020, and 2025. Details on the methods and data sources used to construct these estimates are provided in the appendices to this report**.** In the sections below, we discuss GHG emission sources (positive, or *gross*, emissions) and sinks (negative emissions) separately in order to identify trends, projections and uncertainties for each.

The next section of the report provides a summary of the historical emissions (1990 through 2005) followed by a summary of the reference case projection year emissions (2006 through 2025), key uncertainties, and suggested next steps. We also provide an overview of the general methodology, principles, and guidelines followed for preparing the inventories. Appendices A through H provide the detailed methods, data sources, and assumptions for each GHG sector.

Appendix I provides information on 2002 and 2018 BC estimates for Alaska. CCS estimated that BC emissions in 2002 ranged from 1.9 – 4.0 $MMtCO_2e$ with a mid-point estimate of 3.0 $MMtCO_2e$. A range is estimated based on the uncertainty in the global modeling analyses that serve as the basis for converting BC mass emissions into their carbon dioxide equivalents (see Appendix I for more details). Since the IPCC has not yet assigned a global warming potential for BC, CCS has excluded these estimates from the GHG summary shown in Table 1 below. Based on an assessment of 2018 forecasted emissions for the primary BC contributors from the Western Regional Air Partnership (WRAP), it is estimated that BC emissions will decrease by 2018 after new engine and fuel standards take effect in the onroad and nonroad diesel engine sectors. Appendix I contains a detailed breakdown of emissions contribution by source sector.

Appendix J provides background information on GHGs and climate-forcing aerosols.

Table 1. Alaska Historical and Reference Case GHG Emissions, by Sector ($MMtCO_2e$)[a]

$MMtCO_2e$	1990	2000	2005	2010	2020	2025	Explanatory Notes for Projections
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Oil Industry	4.67	2.83	2.49	2.42	1.72	1.27	Historical trends and DNR oil production forecasts
Coal Mining	0.009	0.008	0.008	0.008	0.009	0.009	Historical trend
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	Alaska manufacturing employment growth
Soda Ash (CO_2)	0.006	0.006	0.006	0.006	0.007	0.007	National projections for 2004-2009 (USGS)
ODS Substitutes (HFC, PFC)	0.001	0.17	0.30	0.42	0.72	0.94	EPA 2004 ODS cost study report
Electric Power T&D (SF_6)	0.044	0.025	0.024	0.017	0.010	0.008	Based on national projections (USEPA)
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	Projected based on 1995-2005 trend
Wastewater Management	0.057	0.067	0.068	0.071	0.076	0.079	Projected based on population
Agriculture	**0.053**	**0.054**	**0.053**	**0.056**	**0.066**	**0.073**	
Manure Management	0.001	0.002	0.004	0.005	0.009	0.012	USDA livestock projections
Enteric Fermentation	0.013	0.015	0.020	0.023	0.029	0.034	USDA livestock projections
Agricultural Soils	0.039	0.037	0.030	0.029	0.028	0.028	Projected based on historical trend
Total Gross Emissions	**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	Projections held constant at 2000 level
Net Emissions (incl. forestry)	**38.7**	**44.7**	**49.2**	**52.1**	**58.9**	**61.4**	
increase relative to 1990		*15%*	*27%*	*35%*	*52%*	*59%*	

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

Historical Emissions

Overview

In 2005, activities in Alaska accounted for approximately 50.6 million metric tons (MMt) of *gross*[9] CO_2e emissions, an amount equal to 0.7% of total U.S. gross GHG emissions. Alaska's gross GHG emissions grew at a faster rate than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Alaska's gross GHG emissions increased 30% from 1990 to 2005, while national emissions rose by 16% during this period. 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.

Figure 1 illustrates the State's emissions (metric tons) per capita and per dollar of economic output. On a per capita basis in 2005, Alaska activities emitted about 79 metric tons (Mt) of CO_2e annually; significantly higher the national average of 24 MtCO_2e. 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. Figure 1 also shows that per capita emissions have increased somewhat in Alaska through the 1995-2005 period. Like the nation as a whole, Alaska's economic growth exceeded emissions growth throughout the 1990-2005 period (leading to declining estimates of GHG emissions per unit of state product). From 1990 to 2005, emissions per unit of gross product dropped by 26% nationally, and by 17% in Alaska.[10] .

[9] Excluding GHG emissions removed due to forestry and other land uses and excluding GHG emissions associated with exported electricity.
[10] Based on real gross domestic product (millions of chained 2000 dollars) that excludes the effects of inflation, available from the US Bureau of Economic Analysis (http://www.bea.gov/regional/gsp/). The national emissions used for these comparisons are based on 2005 emissions from the 2008 version of EPA's GHG inventory report. (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

Figure 1. Alaska and US Gross GHG Emissions, Per Capita and Per Unit Gross Product

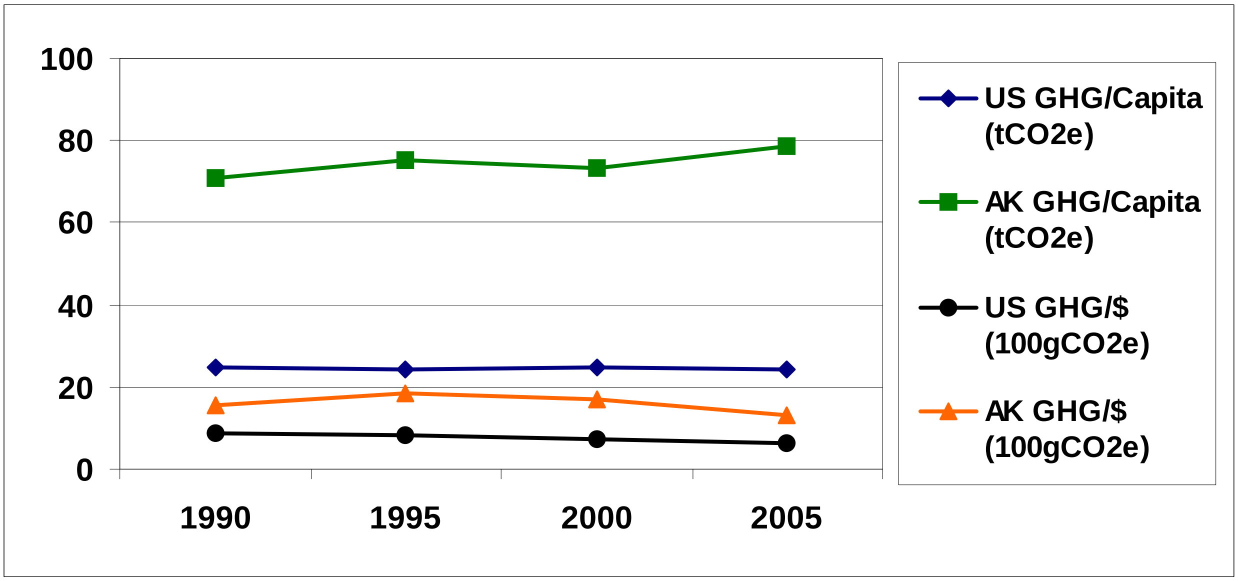
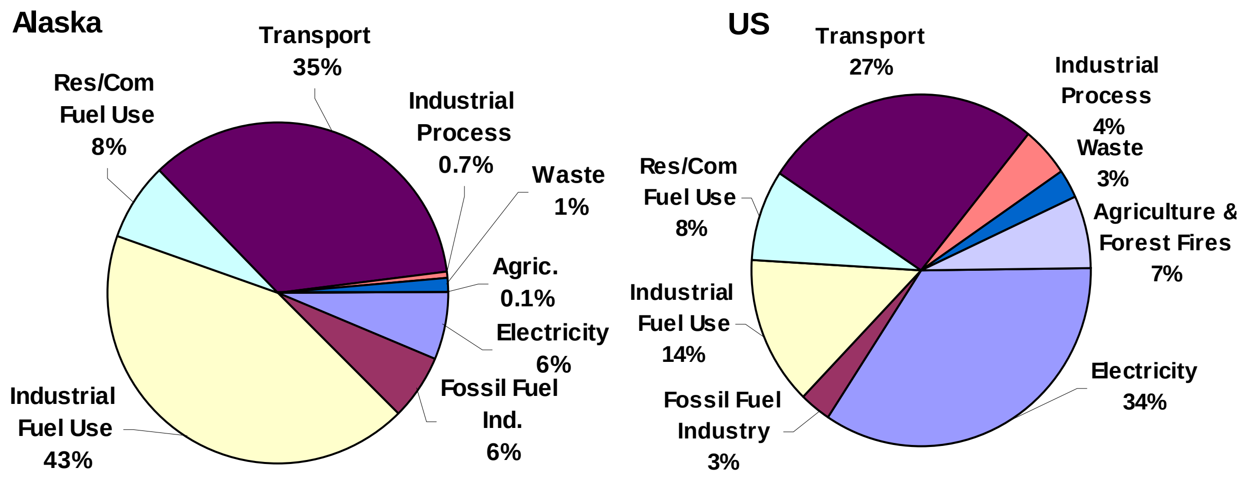


Figure 2 compares the contribution of gross GHG emissions by sector estimated for Alaska to emissions for the U.S. for year 2005. Industrial fossil fuel combustion and transportation are the State's principal GHG emissions sources. Industrial fossil fuel combustion accounted for 43% of Alaska's *gross* GHG emissions in 2005, as shown in Figure 2. The transportation sector accounted for 35% of gross GHG emissions in 2005. Fossil fuel combustion by the residential and commercial sectors accounted for 8% of gross GHG emissions. Electricity production and the fossil fuel industry each accounted for 7% of gross GHG emissions. The fossil fuel industry sector includes GHG emissions associated with natural gas production, processing, T&D, flaring, and pipeline fuel use, as well as with oil production and refining and coal mining emission releases. 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 HFC as substitutes for ozone-depleting chlorofluorocarbons.[11] 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 transmission and distribution (T&D) equipment.

Forestry activities in Alaska are estimated to be net sinks for GHG emissions. Forested lands are a net sink of about 1.4 $MMtCO_2e$ in 2005.

[11] Chlorofluorocarbons (CFCs) are also potent GHGs; they are not, however, included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix J.

Figure 2. Gross GHG Emissions by Sector, Alaska and US – 2005 Data



Notes: Res/Com = Residential and commercial fuel use sectors. Emissions for the residential, commercial, and industrial 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 processes sector accounts for emissions associated with manufacturing and excludes emissions included in the industrial fuel use 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. Emissions associated with forest wildfires were not calculated for Alaska due to a lack of data on acreage burned. Electricity = Electricity generation sector emissions on a consumption basis.

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

Industrial Fuel Use Sector

Activities in the industrial[12] fuel use sector produce GHG emissions when fuels are combusted to provide space heating, process heating, and other applications. In 2005, combustion of oil, natural gas, coal, and wood in the industrial sector contributed about 43% of Alaska's gross GHG emissions, much higher than the industrial fuel use sector contribution for the nation (14%).

By 2005, the industrial fuel use sector emissions were at 21.6 MMtCO_2e of gross GHG emissions. A majority of these emissions resulted from the use of natural gas (18.5 MMtCO_2e). Industrial oil combustion contributed 3.1 MMtCO_2e of GHG emissions in 2005. An insignificant amount of the industrial fuel use sector emissions were contributed by coal use. GHG emissions for the industrial fuel use sector (excluding those associated with electricity consumption) are expected to increase by 38% between 2005 and 2025, reaching 29.8 MMtCO_2e by 2025.[13]

[12] The industrial sector includes emissions associated with agricultural energy use and fuel used by the fossil fuel production industry.
[13] See Appendix B for more details. Given the forecasted decline in non-combustion emissions for the fossil fuel industry; the increase in the industrial fossil fuel consumption seems odd; however, ADEC contacts indicate that

Transportation Sector

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 1990-2005 to account for 72% of total transportation emissions in 2005. Emissions from onroad gasoline grew by 15% between 1990 and 2005 and onroad diesel grew by 37% during this period. In 2005, onroad gasoline and diesel accounted for 14% and 10% of total transportation emissions, respectively. GHG emissions from marine fuel consumption decreased by 44% 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 LPG, and oxidation of lubricants) contributed slightly over 0.3% of total transportation emissions in 2005.

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

It is important to note that the jet fuel emissions include fuel that is purchased in-state 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 3 reflects the importance of this industry in Alaska.

Reference Case Projections (Business as Usual)

Relying on a variety of sources for projections, as noted below and in the appendices, we developed a simple reference case projection of GHG emissions through 2025. Figure 3 provides both the historical and projected gross emission estimates for all source sectors. Figure 4 is a chart showing the contribution for each sector to emissions growth both historically (1990-2005) and for the reference case forecast (2005-2025). As illustrated in Figure 3 and shown numerically in Table 1, under the reference case projections, Alaska gross GHG emissions continue to grow steadily, climbing to 62.8 MMTCO_2e by 2025, 61% above 1990 levels. This equates to an annual growth rate of 1.1% per year from 2005 to 2025. Relative to 2005, the share of emissions associated with industrial fuel consumption, industrial processes, and waste management all increase slightly to 47%, 1.5%, and 1.4%, respectively, in 2025. The share of emissions from the transportation, fossil fuel industries, and residential and commercial fuel use sectors all decrease slightly by 2025, relative to 2005, to 34%, 3%, and 6%, respectively. The

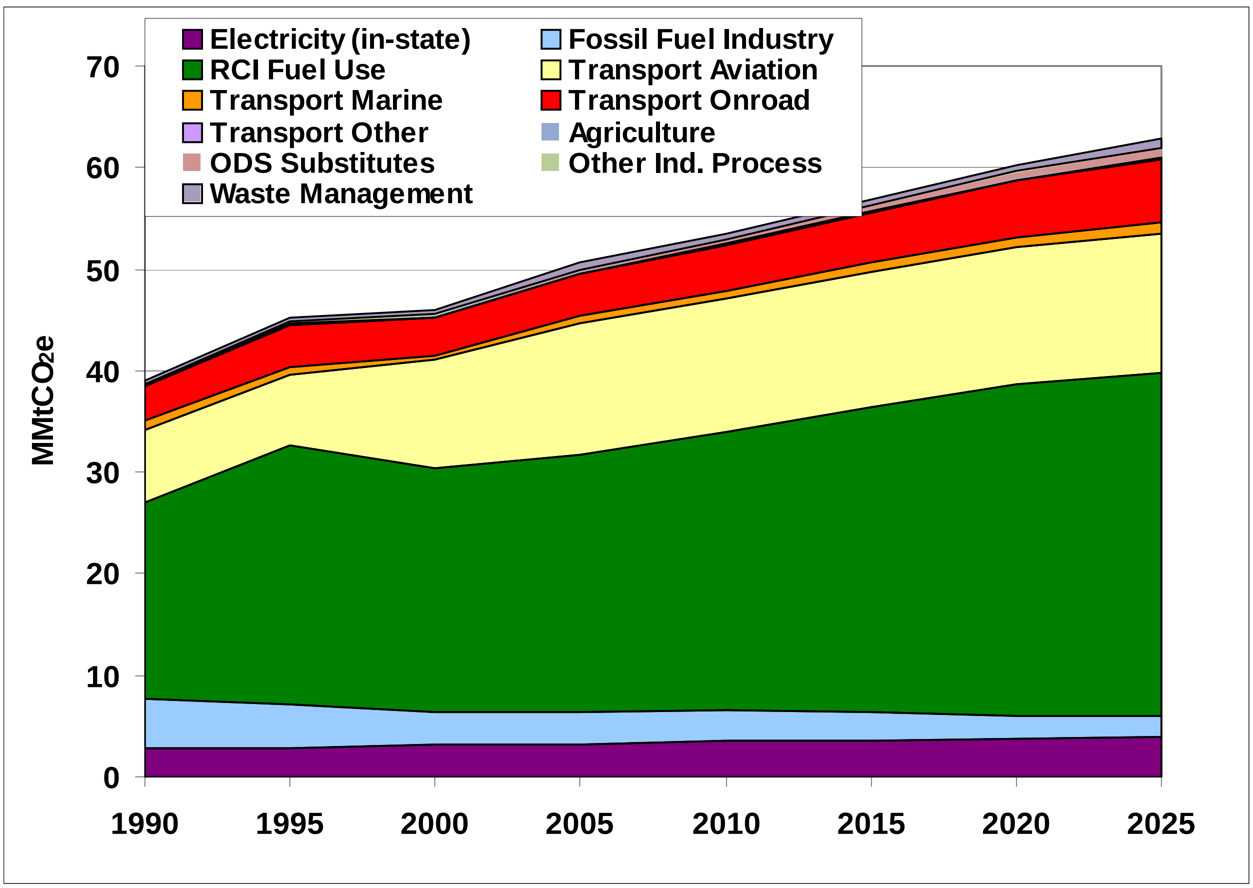
natural gas combustion is expected to increase significantly in future years since more fuel is consumed to extract oil and gas as the production in existing fields declines. This is an area that should be investigated further during future work. The industrial fossil fuel consumption projections are based on the regional EIA AEO forecast data for the Pacific Region.

share of emissions from the electricity and the agricultural sectors both remain the same in 2025 as their shares in 2005.

As shown in Figure 4, both the RCI fuel combustion and transportation sectors are important contributors to emissions growth, both historically and in the future projected emissions, with the industrial subsector being the key contributor to the RCI sector growth. Non-combustion emissions for the fossil fuel industry show declining growth both historically and in the future as existing oil and gas production fields are expected to decline. As described in Appendix E, the reference case forecast does not assume significant new oil and gas leases coming into production before 2025 (an important area for future assessment for GHG implications). Additional details on the assumptions used to estimate future GHG emissions are provided in the applicable technical appendices to this report.

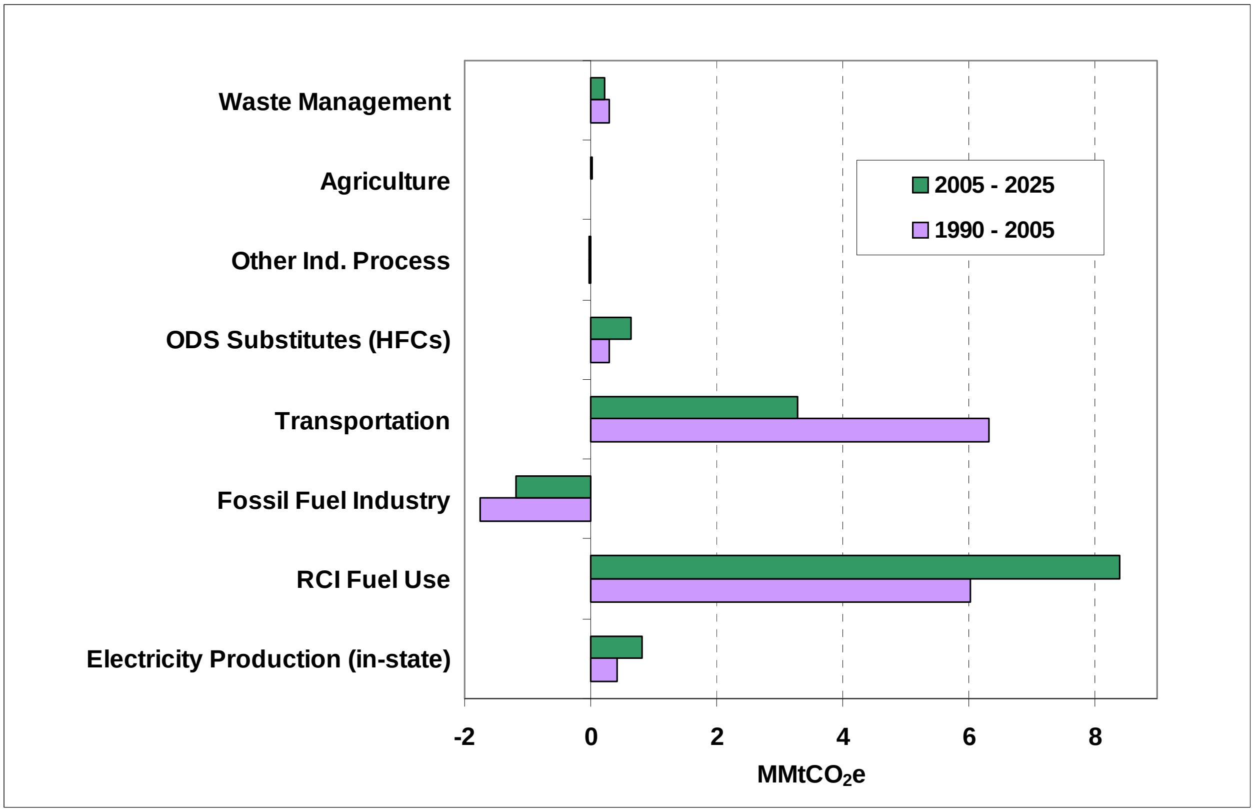
Table 2 summarizes the growth rates that drive the growth in the Alaska reference case projections as well as the sources of these data.

Figure 3. Alaska Gross GHG Emissions by Sector, 1990-2020: Historical and Projected



Notes: Fossil Fuel Industry emissions include emissions not associated with fuel combustion (fugitive CH_4). Fossil fuel combustion emissions are included in the RCI Fuel Use sector.
RCI – direct fuel use in residential, commercial and industrial sectors. ODS – ozone depleting substance.

Figure 4. Sector Contributions to Emissions Growth in Alaska, 1990-2020: Historic and Reference Case Projections



*RCI – direct fuel use in residential, commercial and industrial sectors; ODS – ozone depleting substance.

Table 2. Key Annual Growth Rates for Alaska, Historical and Projected

Key Parameter	1990-2005	2005-2025	Sources
Population	1.0%	0.6%	Alaska Department of Labor and Workforce Development
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 from EIA data, projections are CCS assumptions as described in Appendix A.
Vehicle Miles Traveled	1.7%	1.3%	Alaska Department of Transportation and Public Facilities, Western Region Air Partnership (WRAP) Mobile Source Inventory

* Population and employment projections for Alaska were used together with US DOE's Annual Energy Outlook 2006 projections of changes in fuel use on a per capita and per employee, as relevant for each sector. 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.

Reference Case Projections with Recent Actions[14]

The federal Energy Independence and Security Act (EISA) of 2007 was signed into law in December 2007. This federal law contains several requirements that will reduce GHG emissions as they are implemented over the next few years. During the CCMAG process, sufficient information was identified (e.g., implementation schedules) to estimate GHG emission reductions associated with implementing the Corporate Average Fuel Economy (CAFE) requirements in Alaska.

The CCMAG also identified recent actions that Alaska has undertaken to control GHG emissions while at the same time conserving energy. One recent action related to weatherization bonding was identified for which data were available to estimate the emission reductions of the action relative to the business-as-usual reference case projections.

The GHG emission reductions projected to be achieved by these recent State and Federal actions are summarized in Table 3. This table shows a total reduction of about X.X $MMtCO_2e$ in 2025 from the business-as-usual reference case emissions, or a Y.Y% reduction from the business-as-usual emissions in 2025 for all sectors combined.

The following provides a brief summary of the component of the EISA that was analyzed as a recent federal action.

Federal Corporate Average Fuel Economy Requirements: Subtitle A of Title I of EISA imposes new CAFE standards beginning with the 2011 model year vehicles. The average combined fuel economy of automobiles will be at least 35 mpg by 2020, with separate standards applying to passenger and non-passenger automobiles. The standard will be phased in, starting

[14] Note that actions recently adopted by the state of Alaska have also been referred to as "existing" actions.

with the 2011 model year, so that the CAFE increases each year until the average fuel economy of 35 mpg is reached by 2020.

The following provides a brief summary of the Alaska recent action.

Weatherization Bonding: xxxxx.

Table 3. Emission Reduction Estimates Associated with the Effect of Recent Actions in Alaska (Consumption-Basis, Gross Emissions)

Sector / Recent Action	GHG Reductions ($MMtCO_2e$)		GHG Emissions (MMtCO2e)	
			Business as Usual	With Recent Actions
	2015	2025	2025	2025
Residential/Commercial/Industrial (RCI) Fuel Use				
Weatherization Bonding			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)			55.0	
Total (All Sectors)			62.8	

Key Uncertainties and Next Steps

Some data gaps exist in this inventory, and particularly in the reference case projections. Key tasks that should be performed in future updates 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). These growth rates are driven by uncertain economic, industrial, 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 on air travel and industrial sector growth. Finally, uncertainty remains regarding the estimates for historic GHG sinks from forestry, and projections for these emissions may affect the net GHG emissions in Alaska.

Emissions of aerosols, particularly black carbon from fossil fuel combustion, could have significant impacts in terms of radiative forcing (that is, climate impacts). Methodologies for conversion of black carbon mass estimates and projections to global warming potential involve significant uncertainty at present, but CCS has developed and used a recommended approach for estimating black carbon emissions based on methods used in other States. Current estimates suggest a 6% CO_2e contribution overall from BC emissions, as compared to the CO_2e contributed from the gases (see Appendix I).

Approach

The principal goal of compiling the inventories and reference case projections presented in this document is to provide the State, with a general understanding of Alaska's historical, current, and projected (expected) GHG emissions. The following explains the general methodology and the general principles and guidelines followed during development of these GHG inventories for Alaska.

General Methodology

CCS prepared this analysis in close consultation with Alaska agencies, in particular, with the ADEC staff. The overall goal of this effort is to provide simple and straightforward estimates, with an emphasis on robustness, consistency and transparency. As a result, we rely on reference forecasts from best available state and regional sources where possible. Where reliable forecasts are lacking, we use straightforward spreadsheet analysis and linear extrapolations of historical trends rather than complex modeling.

In most cases, we follow the same approach to emissions accounting for historical inventories used by the US EPA in its national GHG emissions inventory[15] and its guidelines for States.[16]

[15] *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2006*, April 15, 2008, US EPA #430-R-08-005, (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
[16] http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateInventoryGuidance.html.

These inventory guidelines were developed based on the guidelines from the Intergovernmental Panel on Climate Change, the international organization responsible for developing coordinated methods for national GHG inventories.[17] The inventory methods provide flexibility to account for local conditions. The key sources of activity and projection data are shown in Table 4. Table 4 also provides the descriptions of the data provided by each source and the uses of each data set in this analysis.

General Principles and Guidelines

A key part of this effort involves the establishment and use of a set of generally accepted accounting principles for evaluation of historical and projected GHG emissions, as follows:

- **Transparency:** We report data sources, methods, and key assumptions to allow open review and opportunities for additional revisions later based on input from others. In addition, we will report key uncertainties where they exist.

- **Consistency:** To the extent possible, the inventory and projections were designed to be externally consistent with current or likely future systems for state and national GHG emission reporting. We have used the EPA tools for state inventories and projections as a starting point. These initial estimates were then augmented and/or revised as needed to conform with state-based inventory and base-case projection needs. For consistency in making reference case projections[18], we define reference case actions for the purposes of projections as those *currently in place or reasonably expected over the time period of analysis*.

- **Priority of Existing State and Local Data Sources:** In gathering data and in cases where data sources conflicted, we placed highest priority on local and state data and analyses, followed by regional sources, with national data or simplified assumptions such as constant linear extrapolation of trends used as defaults where necessary.

- **Priority of Significant Emissions Sources:** In general, activities with relatively small emissions levels may not be reported with the same level of detail as other activities.

- **Comprehensive Coverage of Gases, Sectors, State Activities, and Time Periods.** This analysis aims to comprehensively cover GHG emissions associated with activities in Alaska. It covers all six GHGs covered by U.S. and other national inventories: CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs and black carbon. The inventory estimates are for the year 1990, with subsequent years included up to most recently available data (typically 2002 to 2005), with projections to 2010, 2020, and 2025.

- **Use of Consumption-Based Emissions Estimates:** To the extent possible, we estimated emissions that are caused by activities that occur in Alaska. For example, we reported emissions associated with the electricity consumed in Alaska. The rationale for this

[17] http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm.
[18] "Reference case" refers to a projection of the current or "base year" inventory to one or more future years under business-as-usual forecast conditions (for example, existing control programs and economic growth).

method of reporting is that it can more accurately reflect the impact of State-based policy strategies such as energy efficiency on overall GHG emissions, and it resolves double counting and exclusion problems with multi-emissions issues. This approach can differ from how inventories are compiled, for example, on an in-state production basis, in particular for electricity. *As mentioned previously, since there are no significant electricity imports to or exports from Alaska, the production-based estimates are the same as the consumption-based estimates.*

Table 4. Key Sources for Alaska Data, Inventory Methods, and Growth Rates

Source	Information provided	Use of Information in this Analysis
US EPA State Greenhouse Gas Inventory Tool (SIT)	US EPA SIT is a collection of linked spreadsheets designed to help users develop State GHG inventories. US EPA SIT contains default data for each State for most of the information required for an inventory. The SIT methods are based on the methods provided in the Volume 8 document series published by the Emissions Inventory Improvement Program (http://www.epa.gov/ttn/chief/eiip/techreport/volume08/index.html)	Where not indicated otherwise, SIT is used to calculate emissions from residential/commercial/industrial fuel combustion, industrial processes, transportation, agriculture and forestry, and waste. We use SIT emission factors (CO_2, CH_4 and N_2O per British thermal unit (Btu) consumed) to calculate energy use emissions.
US DOE Energy Information Administration (EIA) State Energy Data (SED)	EIA SED source provides energy use data in each State, annually to 2001.	EIA SED is the source for most energy use data. We also use the more recent data for electricity and natural gas consumption (including natural gas for vehicle fuel) from the EIA website for years after 2001. Emission factors from US EPA SIT are used to calculate energy-related emissions.
US DOE Energy Information Administration Annual Energy Outlook 2006 (AEO2006)	EIA AEO2006 projects energy supply and demand for the US from 2005 to 2030. Energy consumption is estimated on a regional basis. Alaska is included in the Pacific Census region (AK, CA, HI, OR, and WA)	EIA AEO2006 is used to project changes in per capita (residential) and per employee (commercial/industrial) energy consumption
American Gas Association – Gas Facts	Natural gas transmission and distribution pipeline mileage.	Pipeline mileage from Gas Facts used with SGIT to estimate natural gas transmission and distribution emissions.
US EPA Landfill Methane Outreach Program (LMOP)	LMOP provides landfill waste-in-place data.	Waste-in-place data used to estimate annual disposal rate, which was used with SGIT to estimate emissions from solid waste, with additional data from ADEC staff.
US Forest Service	Data on forest carbon stocks for multiple years.	Data are used to calculate CO_2 flux over time (terrestrial CO_2 sequestration in forested areas).
USDS National Agricultural Statistics Service (NASS)	USDA NASS provides data on crops and livestock.	Crop production data used to estimate agricultural residue and agricultural soils emissions; livestock population data used to estimate manure and enteric fermentation emissions

If ADEC decides to refine this analysis, they may also consider estimating other sectoral emissions on a consumption basis, such as accounting for emissions from combustion of transportation fuel used in Alaska, but purchased out-of-state. In some cases this can require venturing into the relatively complex terrain of life-cycle analysis. In general, CCS recommends considering a consumption-based approach where it will significantly improve the estimation of the emissions impact of potential mitigation strategies. [For example re-use, recycling, and source reduction can lead to emission reductions resulting from lower energy requirements for material production (such as paper, cardboard, and aluminum), even though production of those materials, and emissions associated with materials production, may not occur within the State.]

Details on the methods and data sources used to construct the inventories and forecasts for each source sector are provided in the following appendices:

- Appendix A. Electricity Use and Supply.
- Appendix B. Residential, Commercial, and Industrial (RCI) Fossil Fuel Combustion.
- Appendix C. Transportation Energy Use.
- Appendix D. Industrial Processes.
- Appendix E. Fossil Fuel Industries.
- Appendix F. Agriculture.
- Appendix G. Waste Management.
- Appendix H. Forestry.

Appendix I contains a discussion of the inventory and forecast for black carbon. Appendix J provides additional background information from the US EPA on greenhouse gases and global warming potential values