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.

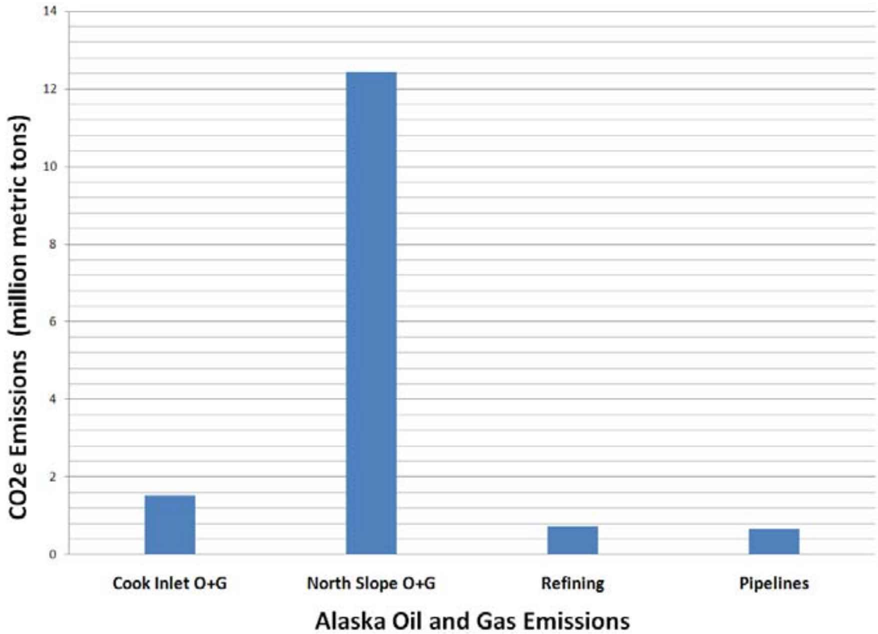
Overview of GHG Emissions

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.

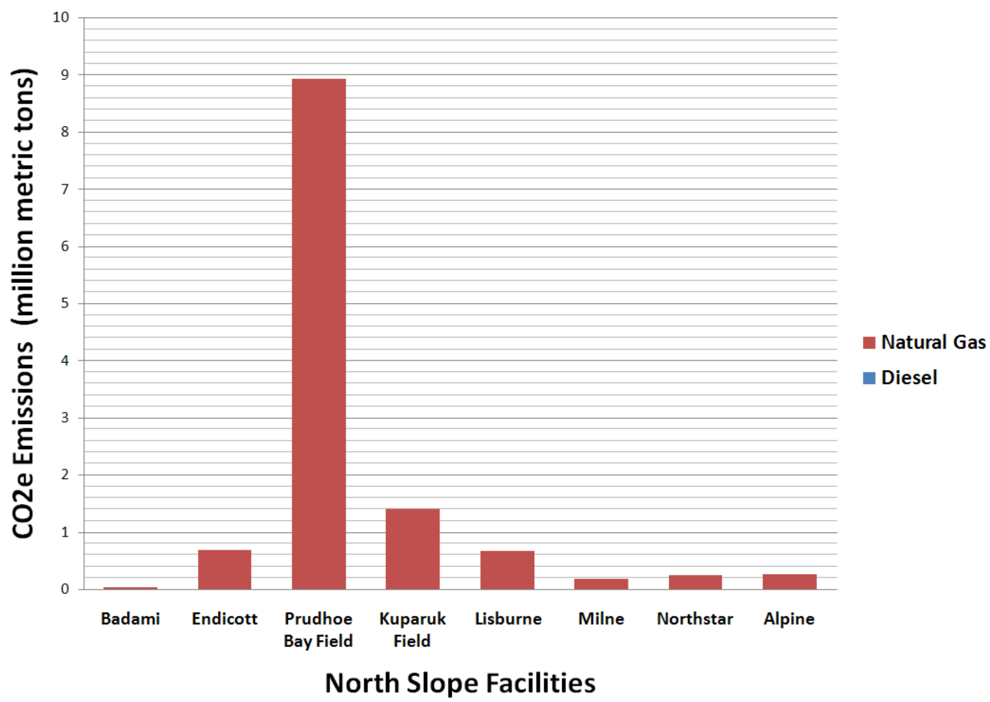
[1] DRAFT Alaska Department of Environmental Conservation , "Report of Improvements to the Alaska Greenhouse Gas Emission Inventory" (includes Final Alaska GHG Inventory and Reference Case Projection), January 2008. Available at: http://www.climatechange.alaska.gov/docs/ghg_ei_rpt.pdf.

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.

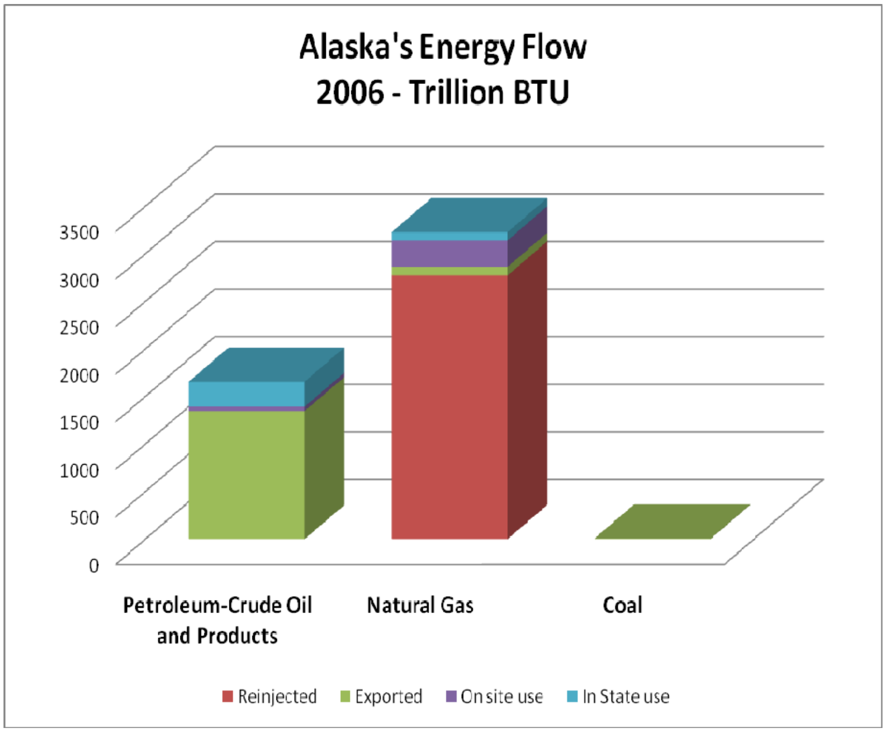
Exploration activity in the arctic regions (such as the National Petroleum Reserve-Alaska, the Beaufort and Chukchi Outer Continental Shelf, or the Nenana Basin or Bristol Bay) and future development of known resources were not considered or quantified in these deliberations. Consequently, the geographic 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.

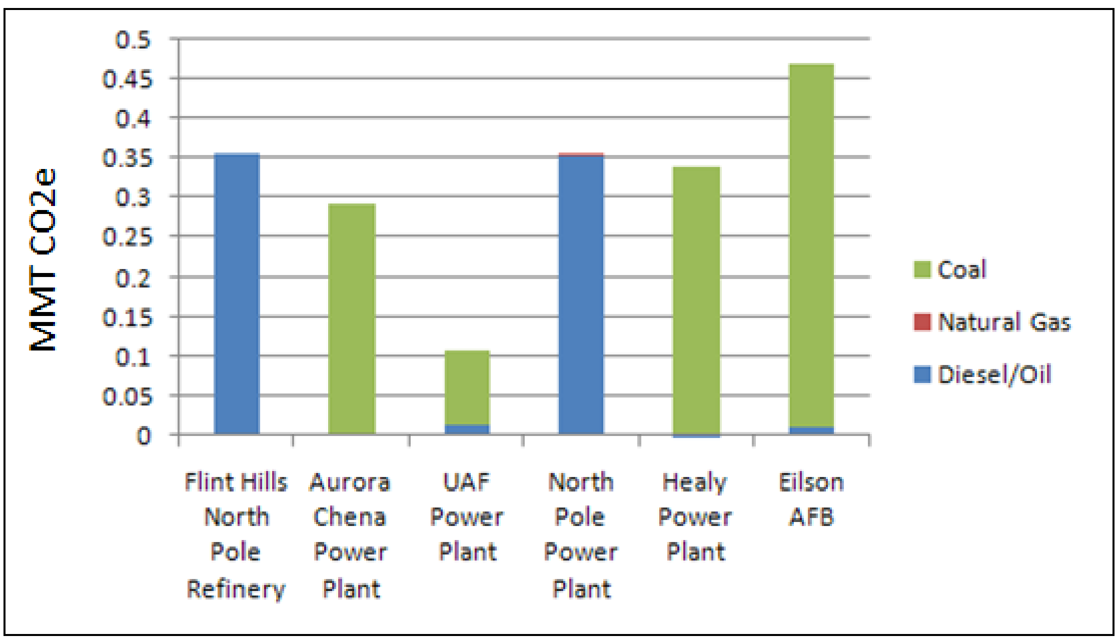
Quantification for this option is focused on the Central Gas Facility (CGF) at Prudhoe Bay, as preliminary studies have shown CCSR would have the highest possible efficiencies at this facility due to the concentration and sizes of the turbines. The CGF accounts for ~16% of all North Slope emissions.

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