Cost Assessment for Diesel Fuel Transition in Western and Northern Alaska Communities

Prepared for the

Alaska Department of Environmental Conservation, Division of Air Quality

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Prepared by

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Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEA	Alaska Energy Authority
AEB	Aleutians East Borough
AIDEA	Alaska Industrial Development and Export Authority
AMHS	Alaska Marine Highway System
ARECA	Alaska Rural Electric Cooperative
ARRC	Alaska Railroad Corporation
ASTM	American Society for Testing and Materials
AVEC	Alaska Village Electric Cooperative
BTU	British thermal unit
CAGR	Compound Annual Growth Rate
CFEC	Alaska Commercial Fisheries Entry Commission
DCCED	Department of Commerce, Community and Economic Development
DMV	Alaska Division of Motor Vehicles
DOE	Department of Energy
EIA	US Energy Information Agency
EPA	Federal Environmental Protection Agency
FHWA	Federal Highway Administration
HS	High Sulphur
ISER	Institute of Social and Economic Research
ISO	International Standards Organization
kWh	Kilowatt-hour
LPG	Liquefied Petroleum Gas
MAFA	Mark A. Foster and Associates
NEI	Northern Economics, Inc.
NPV	Net Present Value
NSB	North Slope Borough
OPIS	Oil Price Information Service
PCE	Power Cost Equalization

ppm	Parts per million
PV	Present Value
RCA	Regulatory Commission of Alaska
RFP	Request for Proposals
SAIC	Science Applications International Corporation
ULS	Ultra Low Sulphur
ULSD	Ultra Low Sulfur Diesel
USDOT	Federal Department of Transportation
WAFG	Western Alaska Fuel Group

Executive Summary

In July 2007, the Alaska Department of Environmental Conservation (ADEC) contracted with Northern Economics, Inc. and its team of experts to develop economic and financial information about the impacts and costs that would accrue to rural Alaska communities and households as they make the required transition to ultra low-sulfur diesel (ULSD).

Air Quality

In response to health concerns related to chemical and particulate matter in diesel exhaust, the Environmental Protection Agency (EPA) enacted stringent standards for new diesel engines and fuels.

EPA rules currently mandate the use of ultra-low sulfur diesel (ULSD) in on-highway mobile sources with diesel engines such as automobiles, which will reduce harmful emissions by 90 percent or more (EPA 2007). Similar rules will take effect for construction equipment, locomotive, boats and ships, and similar off-highway equipment in 2010. The rule for stationary engines applies to new, modified, or reconstructed internal combustion engines used for power generation and industrial pumps starting with model year 2011 (EPA 2007). Rules are summarized in Table ES-1 below.

Table ES-1. Summary of EPA Fuel Rules on Mobile Source engines for Urban and Rural Alaska

Region	Engine Type	2006	2007 to 2009	2010 to 2011	2012
		Parts per Million			
Rural Alaska	Highway	> 500	> 500	15	15
	Non-road	> 500	> 500	15	15
	Locomotive and Marine	> 500	> 500	15	15
Urban Alaska	Highway	15	15	15	15
	Non-road	> 500	500	15	15
	Locomotive and Marine	> 500	500	500	15

Source: Alaska Department of Environmental Conservation (ADEC).

Western and Northern Alaska

Approximately 61,000 people live in western and northern Alaska (an area about the size of Texas) spread across 151 communities that range in size from 2 residents to approximately 6,000 people. Approximately 15 percent of these residents live in 100 villages with fewer than 400 residents. Neither roads nor power lines connect these communities in almost all cases. The survival of rural Alaska residents and communities depends on their continued ability to generate electricity and heat from hundreds of continuously operating diesel engines and burners. Figure ES-1 illustrates western and northern Alaska.

Figure ES-1. Northern and Western Alaska Rural Communities

Source: Map developed by Alaska Map Company with data from USGS and Alaska DNR.

The EPA acknowledged the difficulties of implementing new standards in western and northern Alaska because of the area's unique "geographical, metrological, air quality, and economic characteristics." Unlike other parts of the country, the majority of fuel consumption in the study area is for stationary sources rather than mobile uses. None of the 151 project area communities connects to the Federal Aid Highway System in Alaska.

EPA Transition Plan for Alaska

In May 2006, the EPA finalized an alternative low sulfur-diesel fuel transition plan for Alaska. Under the EPA rules for Alaska, rural areas can continue to use uncontrolled sulfur content diesel for all uses and are not required to carry multiple grades of fuel until 2010.

However, as of June 1, 2010 all areas of Alaska, rural and urban, will begin the transition of both highway and non-road, locomotive, and marine diesel fuel to 15 parts per million (ppm) sulfur content diesel fuel with ULSD available in retail facilities by December 1, 2010.

The transition is likely to be more costly and challenging in rural Alaska because of the logistics of distributing and storing multiple petroleum products. ADEC wants to know what the transition to ultra-low sulfur is going to cost and who will bear those costs.

Rural residents currently pay some of the highest diesel prices nationwide—recently over $7 per gallon. Electricity generated from diesel can cost as much as 50 cents per kilowatt hour (kWh).

Household Cost Impacts

Table ES-2 summarizes estimated annual household cost increases, by category. Electrical cost increases are projected at $61 per year, with fuel transportation and storage system costs estimated at $99 per year. ULSD costs more to refine than competing fuels, such as Jet A, and that cost, delivered and paid at rural households, is estimated at $49 per year.

Table ES-2. Estimated Annual Household Incremental Costs, by Category

Cost Category	$/Year	Percent
Cost of modifications to electric utility diesel generating systems	$61	29.2%
ULSD refinery premium over Jet A	$49	23.4%
Cost of modifications to fuel transportation and storage systems	$99	47.4%
Total	$209	100.0%

Source: Northern Economics, MAFA

Results in Brief

Results are listed below as a series of bulleted comments:

- The project area, consisting of northern and western Alaska that is not connected to the road or ferry system has 151 communities categorized as hubs, subregional hubs, towns, and villages. The number of communities in these categories and their population statistics are shown in Table ES-3.

Table ES-3. Project Area Population, Growth, and Size, 2000 and 2006

Community, Type	2000 Population	2006 Population	2000-2006 CAGR (%)	Community Count	% of Total 2000 Population	% of Total 2006 Population
Hubs	19,105	18,918	-0.16	5	31.42	31.04
Sub-regional Hubs	4,975	5,028	0.18	9	8.18	8.25
Towns	20,620	21,642	0.81	37	33.91	35.51
Villages	16,105	15,357	-0.79	100	26.49	25.20
Total	**60,805**	**60,945**	**0.04**	**151**	**100.00**	**100.00**

Source: Northern Economics, Census 2000, Department of Community, Commerce and Economic Development, 2007. Note: CAGR refers to compound annual growth rate.

- There are six refineries in Alaska and one, at Nikiski, produces ULSD. Other sources of fuel include some of the 35 refineries in the State of Washington.
- Typical fuels consumed in the project area are Jet A (both as a heating fuel and for certain aircraft), diesel No. 1 and No. 2 (sometime with additives for the Arctic), aviation gasoline, and unleaded gasoline.

- Communities in the area have increased their bulk fuel capacity since the Denali Commission and Alaska Energy Authority began a rural bulk fuel program in the late 1990s and early 2000. Of the total 186 projects statewide, 58 completed or near-complete projects within the project area provided current cost data for the project.
- Statewide fuel demand is estimated at 1.7 billion gallons (in 2006) with 1.1 billion of that amount consumed as Jet A fuel. Gasoline and associated fuels were approximately 0.3 billion gallons and regulated distillates were about the same, at 0.3 billion gallons. Distillates are liquid by-products generated from crude oil refining including gasoline, kerosene and diesel.
- Estimated fuel demand in the project area is shown in Table ES-4.

Table ES-4. Estimated Fuel Consumption by Use in Study Area Communities, 2006

Storage Use	Hubs	Sub-regional Hubs	Village and Towns	Totals
	(Millions of Gallons)			
Total Petroleum Products	34.6	6.8	29.8	71.2
Motor Gasoline	6.6	1.3	5.7	13.6
Electricity	9.9	1.9	7.2	19.1
Residential Heating	4.9	1.1	8.2	14.1
Marine	3.4	0.7	0.0	4.1
Aviation	6.6	1.0	0.0	7.6
Off-Road	1.0	0.2	1.0	2.1
Other	3.3	0.8	6.5	10.5
All Distillates, excl. Jet	21.2	4.5	24.4	50.0
Regulated Distillates	13.8	2.8	11.3	27.9

Source: Estimates by Northern Economics, Inc.

Notes: The volumes shown for all distillates, excluding jet fuel, represent the maximum amount of ULSD that might be required in the study area if all uses except those needing jet fuel switched to ULSD. Regulated distillates are a portion of total distillates and indicate the volumes of ULSD that might be required if only regulated sources, including all power generation equipment, switched to ULSD.

- Cost differences between ULSD and Jet A (the main fuel consumed in the project area) are estimated at 1.32 percent in Anchorage, 3.3 percent in Fairbanks, and 1.4 percent at Anacortes, Washington, which is representative of the refineries located in northern Puget Sound that supply fuel to Alaska. Cost differences between these fuels are getting smaller as ULSD volumes increase.
- Anchorage cost differences per gallon ranged from a low of 0.6 cents to a high of 13.2 cents, averaging 9.1 cents for the period from mid-2006 to the present. These costs are for the fuel only and do not reflect additives for pour point adjustment or lubricity.
- Anacortes price differences were approximately 2.7 cents for the same period, on the same basis.

- Storage and distribution costs will vary with community size and location. The least cost option appears to be a blend-down approach with ULSD shipped in 2008, 2009, and 2010, with the final tank filling achieving a 15 parts per million sulfur level (or less).
- Electric power costs in the 151 communities range from less than $0.20 per kWh to near $1.00 per kWh, excluding any household cost adjustments for the Power Cost Equalization program.
- Three scenarios were used to analyze two main cost centers (storage and distribution, and heat and electrical power). Scenario 1 was labeled the Warranty scenario, reflecting just enough shipment of ULSD to meet 2007 and newer engine requirements. Scenario 2 was termed the Compliance scenario with more consumption of ULSD to meet EPA-mandated timelines. Scenario 3 was labeled the Full Conversion scenario, with ULSD shipped for all purposes (heating, engines, and power plants) except aircraft Jet A needs. Table ES-5 summarizes results by household costs, in the year 2010, by Scenario. Note that a rapid transition is less expensive than a gradual process.

Table ES-5. Estimated Incremental Cost of ULSD compared to Jet A for rural Alaska households – Selected Scenarios

	Units	**Scenario 2A:** Gradual Transition to ULSD (excluding heating oil)	**Scenario 2B:** Rapid Transition (excluding heating oil) with blend down	**Scenario 3:** Rapid Transition (including heating oil) with blend down
Household Cost 2010	$/household/year	$300	$278	$189
Household Cost (2008-2030)	$/household (NPV 2006$)	$2,902	$2,361	$2,091
Households	Number of households in Study Area	14,700	14,700	14,700

Source: ULSD Economic Model. The household costs represent an aggregate weighted average of coastal hub and upriver community costs.

- Environmental justice factors are an issue in the project area. Demographic data suggest the area's population is 84 percent minority, exceeding the 50 percent threshold level set by the federal government. An estimated 19.6 percent of the area's population is low-income, using Census 2000 figures, while Alaska as a state had a poverty rate of 9.4 percent (in 2000).
- The analysis suggests that the household costs of transitioning to ULSD fuel are highest for the regions of the state with the highest concentrations of minority and low-income populations. This disproportionate impact is due to the greater reliance of project area communities on diesel for heating and power generation in comparison to the rest of Alaska. The analysis further indicates that several characteristics of project area communities would exacerbate this disproportionate adverse economic effect.

Blend-down Transition Process

Thus, at least over the next several years, the primary driver to import ULSD into rural Alaskan villages will likely be the desire to responsibly transition to the new fuel and not the growth in the number of new diesel engines. By starting to burn ULSD in 2008, villages could benefit from a process called "blend-down", where average sulfur concentrations decline, over three years, to less than the mandated 15 ppm. Subsequent report sections address each of these factors and suggest the blend-down approach is a low-cost alternative to new tanks, cleaning and waste disposal, or temporary drum use.

1 Introduction

The regulation of diesel fuel has become a major environmental policy issue in the United States because of health concerns related to the particulate matter in diesel exhaust. Until recently, diesel fueled engines faced less stringent emission standards than gasoline engines. As the greatest source of mobile source pollution, the U.S. government targeted gasoline engines first. However, as emissions from gasoline engines grew cleaner, the federal government, through the Environmental Protection Agency (EPA) increased its focus on removing emissions from diesel engines, especially through the use of ultra low sulfur diesel (ULSD) fuels.

In January 2001 and June 2004, the U.S. Environmental Protection Agency (EPA) finalized the *Highway Diesel* and *Nonroad Diesel Rules,* respectively, which implemented stringent standards for new diesel engines and fuels. The rules mandated the use of ultra low-sulfur fuels (less than 15 parts per million) in diesel engines beginning in 2006 for highway diesel fuel and in 2007 for nonroad diesel fuel.

Alaska Rule Adoption

Alaska adopted EPA regulations for urban parts of the state, however, the state requested and the EPA granted the state's request for more lead time to implement the use of ULSD fuel in rural Alaska because of the area's unique geographical, meteorological, air quality, and economic characteristics.

In May 2006, the EPA finalized an alternative ULSD fuel transition program for Alaska—modifying the diesel fuel regulations "to apply an effective date of June 1, 2010 for implementation of the 15 parts per million (ppm) sulfur requirements for highway, non-road, locomotive, and marine diesel fuel produced or imported for, distributed to, or used in the rural areas of Alaska." A copy of this regulation is attached as Appendix A. Beginning with the 2011 model year, new diesel engines at stationary sources (for example, diesel engines that power electrical generation equipment), will also be required to use ULSD. The EPA regulations do not apply to kerosene or jet fuel used to power aircraft or fuels used for heating or use in industrial boilers.

Implementation of the EPA rules in rural Alaska requires the cooperation of a wide variety of stakeholders and will impact residents, businesses, and government agencies in northern and western parts of the state.

The rest of this chapter discusses the purpose of the study and provides background information for the reader. This report is a synthesis and compilation of technical reports from numerous experts in economics, finance, and energy issues.

The goal of this report is to provide information in an accessible format for decision makers and other stakeholders on the complex issues related to transitioning to ULSD. The questions addressed are, "What are the costs of the transition to ULSD and who will bear these costs?"

The goal of this first chapter is to introduce the purpose of the study, define and describe the rural project area in western and northern Alaska, and provide contextual information needed to understand the analysis that occurs in the report. The project team assumed early on in the study that impacts to local communities would vary by community based on several factors. The following factors are discussed in this report:

- Community location
- Population and demographic characteristics
- Local fuel requirements, including substitutability
- Existing fuel storage and transfer infrastructure
- Refinery location and transportation corridors

1.1 Purpose of the Study: Develop Economic Costs for Implementation of New Federal Fuel Requirements

The purpose of the study is to develop economic information that will help affected communities and the state plan to efficiently and effectively convert to ULSD by 2010.

The geographic focus of this cost assessment is western and northern Alaska, particularly those locations without road, ferry, or rail systems. Specification of the study area is an important component of this report because the results of this study will be used to inform ADEC's final recommendation for the transition to ULSD of diesel burning stationary internal combustion engines, such as rural power utilities. The state will submit recommendations to EPA in early 2008.

Communities in the study area are considered rural for the purposes of complying with federal fuel rules.

1.2 Project Area Description

*Alaska's Transition Plan to Ultra Low Sulfur Diese*l (see Appendix B) was submitted to the EPA on April 1, 2002 and differentiated between urban and rural communities. One of the major distinctions defined in the state's plan is the way fuel is distributed.

As noted in the request for proposal (RFP) that initiated this project, the fuel distribution system for rural communities is simple and efficient, but at the same time poses an obstacle to transitioning to ULSD.

Urban communities were categorized as communities that are serviced directly from the road system connected to Canada (and the rest of the U.S.) and communities serviced by the Alaska Marine Highway. In contrast, rural communities were defined as communities not on the contiguous road system or with periodic and minimal ferry service. As a result of this differentiation, the scope of this study provides for analysis of the most remote and logistically challenging areas in Alaska—northern and western Alaskan communities that are not served by the road, railroad, or ferry systems (Figure 1).

Figure 1. Northern and Western Alaska Rural Communities

Source: Map developed by Alaska Map Company with data from USGS and Alaska DNR.

Project staff identified 151 communities within the project area, based on the Alaska Department of Commerce, Community, and Economic Development's Division of Community Advocacy Community Database (DCCED, 2007a). Team members added additional information to the study database for analytic purposes including:

- Denali Commission bulk fuel projects (Denali Commission, 2007a)
- Power Cost Equalization information (Alaska Energy Authority, 2007)
- Climatic data related to degree days. (University of Alaska, Anchorage, 2007)

In 2006, the population within the 151 communities was estimated at 60,945 residents. These communities were grouped into four categories using the following criteria:

- **Hubs.** There are five communities considered as regional hubs. These places range in size from 1,000 to 6,000 residents. Hubs have larger bulk fuel tank farms and may serve local communities as a fuel source for almost all types of fuel, from diesel to jet fuel (commonly referred to as Jet A) to gasoline and lubricants. All of these hubs have tidewater access and are supplied by ocean-going fuel barges. Hub population is estimated in 2006 as 18,918 residents and accounts for 31 percent of total project area population.
- **Sub-regional Hubs and Towns.** These two categories have population estimates between 400 and 1,000 residents. Of these 46 places, 9 are considered as sub-regional

hubs that have an ongoing demand for Jet A as aviation fuel. The other 37 towns may use Jet A for heating, but there are no known uses that mandate Jet A or separate Jet A fuel tanks. Population of the sub-region hubs is estimated at 5,028 residents (8 percent of the project area) and towns have 21,642residents (36 percent of the project area).

- **Villages.** There are 100 villages with populations that range from 2 to 400 residents. Most of these villages are accessible only by air or water, depending on weather and ice conditions. Population is estimated at 15,357 residents or 25 percent of the project area.

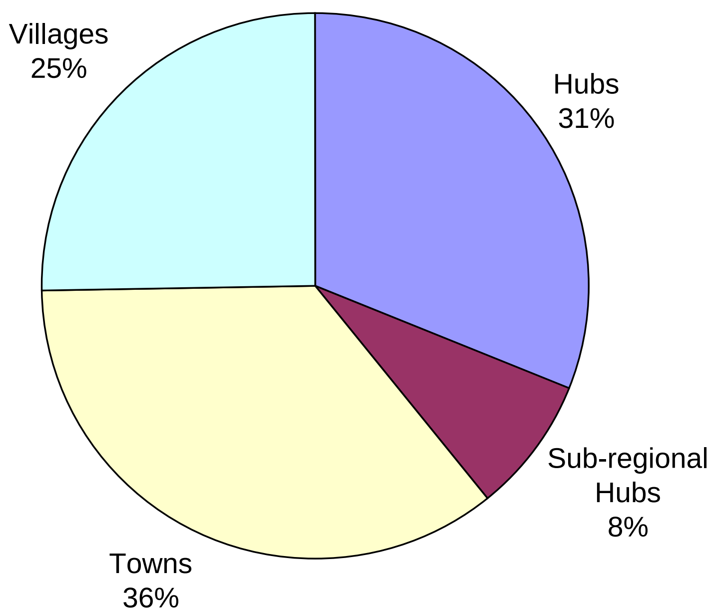
Table 1 illustrates population in the project area, in 2000 and 2006, while Figure 2 shows relative size of each segment.

Table 1. Project Area Population, Growth, and Size, 2000 and 2006.

Community, Type	2000 Population	2006 Population	2000-2006 CAGR (%)	Community Count	% of Total 2000 Population	% of Total 2006 Population
Hubs	19,105	18,918	-0.16	5	31.42	31.04
Sub-regional Hubs	4,975	5,028	0.18	9	8.18	8.25
Towns	20,620	21,642	0.81	37	33.91	35.51
Villages	16,105	15,357	-0.79	100	26.49	25.20
Total	60,805	60,945	0.04	151	100.00	100.00

Source: Northern Economics, Census 2000, Department of Community, Commerce and Economic Development, 2007.
Note: CAGR refers to compound annual growth rate.

Figure 2. Percent of Project Area Population by Community Type, 2006.



Source: Northern Economics, from Alaska Department of Community, Commerce and Economic Development, 2007.

1.3 EPA Rules for Rural Alaska

Alaska's unique geographic circumstances have created a rural fuel supply chain that is more complex than those experienced by Alaska's urban centers such as Anchorage, Fairbanks, and Juneau. For example, ULSD fuel from Tesoro's Nikiski refinery flows via pipeline to Anchorage where it is stored in terminals near Ship Creek. Fuel is distributed via truck to many retail and wholesale users, while rail tanker cars are loaded at Ship Creek and hauled north to Fairbanks. The supply chain is short, simple, and direct.

Fuel transported to the project area, by contrast, may be stored in tanks at Nikiski, pumped into fuel barges, and hauled to hubs over seas that can be difficult to navigate. Barged fuel is then pumped into regional storage tanks where it is held until weather and ice permits transport to villages. It is once again pumped into transport vessels and hauled to village sites, weather and water conditions permitting. Finally, fuel is pumped from storage tanks into day tanks and hauled via pumper trucks to end-users, where it is once again pumped and stored in home-based fuel tanks, or retail tanks. The supply chain to the project area is long, involves several transfers, each to a smaller storage area, and involves more time and more companies, when compared to southcentral Alaska's fuel situation.

As a result of these challenges, implementation of EPA's rules for transition to ULSD is different for rural Alaska when compared to urban Alaska and the rest of the United States. The schedule for transitioning to ULSD in rural Alaska was designed to reflect a simplified distribution process by allowing all fuels to transition or convert to ULSD at the same time in 2010.

Cost impacts of the EPA rules on fuel use will depend on factors such as the number of engines that will be impacted by the rules over the years, potential changes in fuel prices, the demand response to these price changes, and also the flexibility or lack thereof in the fuel distribution system and storage infrastructure in certain rural communities. One of the major challenges as noted throughout this document is related to the current ability of local rural communities to readily and easily substitute one type of distillate fuel for another without significant consequences.

1.3.1 Rules for Mobile Sources

Table 2 summarizes the EPA fuel rules for mobile sources by both of Alaska's regions and by engine type. Mobile engines include highway vehicles, all terrain vehicles with diesel engines, and non-road diesel engines that move or are portable but not certified for highway use. These can include construction, farm, and mining equipment as well as portable generators.

Table 2. Summary of EPA Fuel Rules on Mobile Source engines for Urban and Rural Alaska

		2006	2007 to 2009	2010 to 2011	2012
Region	**Engine Type**	**Parts per Million**			
Rural Alaska	Highway	> 500	> 500	15	15
	Non-road	> 500	> 500	15	15
	Locomotive and Marine	> 500	> 500	15	15
Urban Alaska	Highway	15	15	15	15
	Non-road	> 500	500	15	15
	Locomotive and Marine	> 500	500	500	15

Source: Alaska Department of Environmental Conservation (ADEC).
Highway engine type specifically refers to heavy duty on-highway diesel engines.
Non-road engines are diesels that move or are portable, but are not certified for highway use. Non-road engines include construction, farm, and mining equipment, as well as portable generators.
Low sulfur diesel has no more than 500 ppm.
Ultra low sulfur diesel has no more than 15 ppm sulfur.

1.3.2 Rules for Stationary Sources

The EPA fuel rules for stationary sources are different from mobile source rules. They apply to internal combustion engines for power generation and industrial pumps—the rule only applies to new engines, or engines that have been modified, constructed or reconstructed. Model year 2011 and later engines in this category must use ultra low sulfur diesel.

A modification is defined as any change to a source which increases the emission rate of any pollutant to which a standard applies. The term reconstruction applies to the replacement of source parts to such an extent that the cost of the new parts exceeds 50 percent of the cost to construct an entirely new source.

Currently, the majority of fuel consumption in the study area is for stationary sources, such as power generation and uses such as home heating, based on consumption estimates. Electricity is generated by small local "systems" (generation and distribution) using diesel fuel at a cost that is three to five times higher than urban costs. In many rural communities, the tribal government, the city government, the electric utility, the store, the school, or the Alaska Native village corporation operate their own generators to produce electricity and heat.

1.3.3 Potential Changes in Fuel Demand Due to New EPA Rules

With the requirements for most new diesel engines to burn ULSD, there is a need to provide rural Alaska communities with ULSD in order to meet diesel engine manufacturer fuel specifications and environmental regulations.[1] Due to their small size and remote location off road networks, many rural Alaska villages may not have a new diesel engine that requires ULSD until a few years in the future. There is no need for ULSD in communities that will have no model year 2007 or

[1] New engines that are designed for ULSD have or will have additional pollution control devices that could fail if higher sulfur fuel is used. If the pollution control device fails and creates excessive backpressure in the exhaust system, the engine itself could suffer significant damage resulting in the need to replace the entire engine. (AEA, 2007b). Thus, ULSD must be segregated from other distillate fuels to avoid potential engine failures.

later diesel vehicles or engines, and therefore there will be no need for infrastructure changes in these communities until 2010.

Communities that have new model year engines will need to ship ULSD to consumers. ULSD can be shipped in 55-gallon drums or larger portable tanks built to the specifications of the International Standards Organization (ISO) and commonly referred to as ISO tanks. Depending on the volumes required. If the community's fuel storage and transfer infrastructure is flexible enough to handle another grade of fuel, there will be no significant cost impacts to the community; dedicating tankage for ULSD will just be a matter of flushing or cleaning existing tanks. In these villages, current environmental regulations will drive the need for ULSD for highway, non-road equipment, stationary diesel power, locomotive and marine engine types by 2010.[2]

In larger rural communities and regional hubs, new diesel engines that require ULSD in order to function correctly are expected to arrive over the next few years. However, the rate at which engine stock is turned over, even in the regional hubs, tends to be low because modest rural cash resources favor keeping old equipment running rather than buying expensive new equipment.

1.4 Current Fuel Supply Chain and Future Challenges in Rural Alaska

This section briefly describes fuel distribution to rural Alaska and introduces some of the challenges facing the transition to ULSD. The current fuel supply chain, which starts when crude oil is delivered to refineries in Nikiski, Alaska or Anacortes, Washington, ends when fuel is converted to electricity or heat for a village household.

In the study area, almost all fuel is delivered by barge, except for some small amounts that are delivered by air or moved overland on ice roads. Fuel is typically supplied to these communities once a year via ocean or river fuel barges as weather and river water levels permit.[3]

To be in compliance, some communities will need ULSD for new diesel power generators (engine model year 2011 or later) and all other mobile source engines, but they will not necessarily need it for older power generators or for home heating. If there is a substantial price differential between unregulated diesel fuel (assuming this will still be available for sale to communities) and ULSD, communities are likely to continue using unregulated diesel fuel (greater than 15 ppm sulfur content) for older power generators and for home heating.

Bulk fuel tank farms are a major component of the basic infrastructure of rural communities and are necessary for their survival. Fuel stored in these tanks is used to heat homes and other buildings and to generate electricity for local use. Of the 151 rural communities in the study area, approximately half are served by cooperatives or another form of utility that has a well-established organization. Others are served by very small entities, many of which experience

[2] Alaska ULSD Transition Plan (Appendix B)

[3] Exceptions include delivery via truck to villages on or near the road system and delivery via air for more remote villages.

technical and administrative problems due to lack of economies of scale, the lack of specialized skills in the community, or both.

In the early 1990s, many rural communities faced the very real threat that they would no longer be allowed to take delivery of fuel in bulk quantities because of the condition of their bulk fuel storage tank farms. The State of Alaska, relying heavily on federal funds, has conducted a program over the past several years to replace and consolidate these tank farms with new or refurbished facilities that meet all applicable safety and environmental codes. The Alaska Energy Authority's best estimate of the total cost to upgrade and replace tank farms throughout rural Alaska is $450 million (AEA, 2007).

1.5 Technical Reports, Report Organization

This report is a synthesis and analysis of 11 individual technical reports (or memos) prepared by project team members to address a wide range of questions and concerns as specified by ADEC related to the transition to ULSD in the project area.

The study design includes both quantitative and qualitative methods including an extensive literature review, development of a database for communities in the study area, interviews with key informants on a variety of topics, and creation of several demand and cost models.

The next eight chapters present project results and continue our efforts to define the fundamental issues, identify alternative courses of action, and forecast and systematically compare the consequences in terms of costs and impacts of the alternatives for stakeholders.

Chapter 2 identifies current and potential future suppliers of ULSD for the study area. The chapter begins with a diagram that introduces the process used for refining crude oil followed by identification of the types of fuel typically refined from a barrel of crude oil. A discussion and analysis of refinery capacity in Alaska, Washington and across the West Coast is next, along with a description of the fuel transportation and distribution system used to transport fuel from the refinery to the study area. The chapter concludes with a discussion of the volume and price benefits of aggregated fuel purchasing and a list of cooperatives and other organizations in the study area that consolidate fuel purchases.

Chapter 3 presents estimates of current statewide and project area sales and demand for distillate and kerosene fuels. Changes in statewide fuel sales between 2000 and 2005 are identified for distillates and kerosene fuel by major end-use categories. Estimates for current use include total petroleum products fuel demand for hubs, sub-regional hubs, villages and towns, and industry within the study area including per capita tank farm capacity usage and tank farm capacity in the study area for various petroleum products. The chapter concludes with estimates of future demand for distillate fuels in the both the State of Alaska and the study area and identifies anticipated changes in demand due to technological improvements and the response of customers to price changes.

Chapter 4 assesses the price differentials between various types of distillate fuels and describes the effects of changes in fuel costs on electric power generation. The chapter begins with a review of current pricing based on data for Anacortes, Washington and Fairbanks and Anchorage, Alaska. Price differentials between ULSD and high sulfur fuels are identified. The second half of the chapter addresses cost issues related to generation of power in rural Alaska focusing on communities served by the Power Cost Equalization program, which subsidized power costs in 85 of the communities in the study area in 2006. The chapter concludes with discussion of the average price of fuel per gallon and total fuel usage in PCE communities.

Chapter 5 discusses various issues and costs related to storage and distribution of fuels in the study area. The chapter includes capital and operating costs for communities that may require new steel fuel tanks and ISO containers in order to accommodate ULSD. The chapter uses a spreadsheet cost model based on 58 Denali Commission bulk fuel projects in the study area to determine potential capital, operating, and maintenance costs for storage and distribution by various shipping methods.

Chapter 6 introduces the characteristics and basic assumptions of three fuel transition scenarios developed by project staff in consultation with ADEC that reflect alternative ways of implementing rural Alaska's transition to ULSD. Delivery of small amounts of ULSD to rural communities on an as-needed basis occurs under Scenario 1. Delivery of enough ULSD to comply with EPA rules for the 2010 switch for affected engines occurs in Scenario 2. Scenario 3 covers a full conversion of all distillate fuels to ULSD except Jet A.

Chapter 7 discusses the capital and operational costs associated with ULSD transition in a typical village under the three scenarios developed in Chapter 6. The cost review includes end-user and fuel supply chain considerations and changes to infrastructure required under each scenario.

Chapter 8 specifies incremental household costs for fuel and power through information on cost flows and the incremental costs differences for ULSD fuels. The model developed for this chapter estimates the economic impacts of the transition to ULSD and incremental costs in the fuel supply chain for rural Alaska. The chapter concludes with a sensitivity analysis of specific cost variables such as Jet A fuel, incremental costs of ULSD, gallons of fuel consumer per household, and the cost of a new bulk fuel tank system.

Chapter 9 addresses the potential environmental justice effects of the transition to ULSD in the study area. Affected populations in the study area are identified along with potential adverse effects on individual households and local community characteristics that could amplify any adverse effects. The chapter concludes with a discussion of possible mitigation measures.

2 Refining, Fuel, and Fuel Transportation

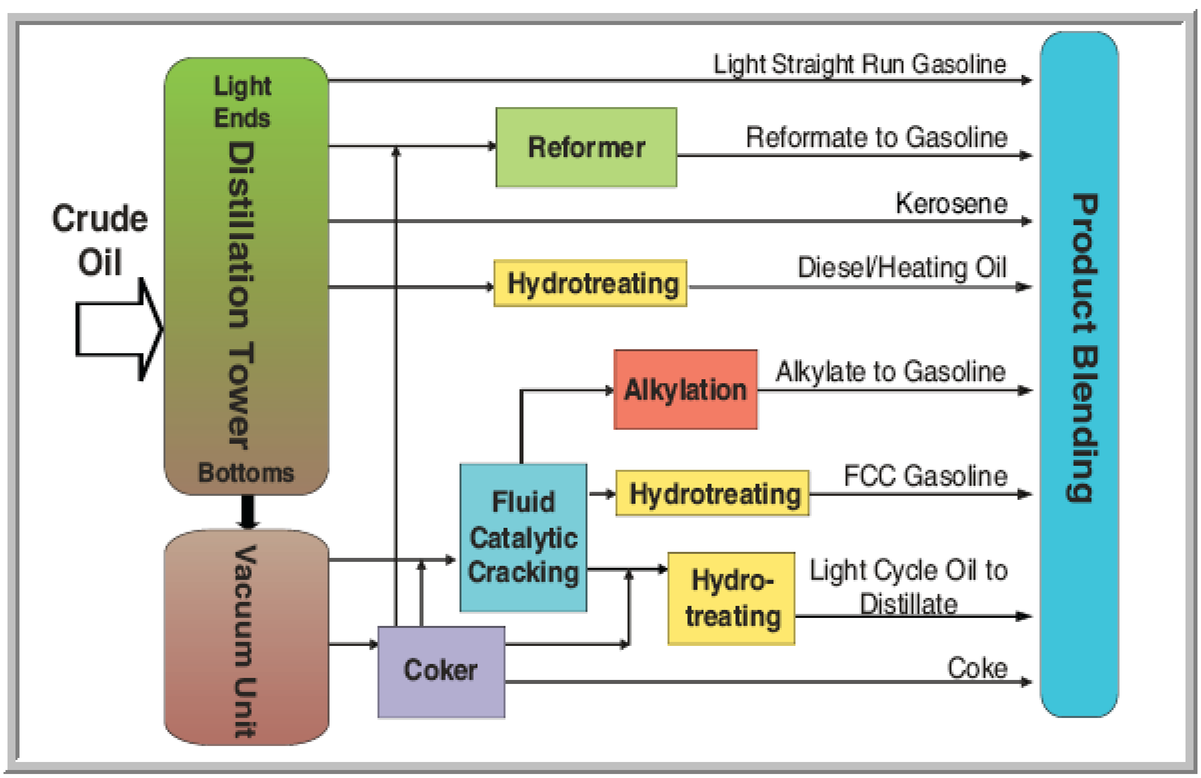
This chapter identifies the current and potential future suppliers of ULSD for western and northern Alaska. First, the concept of refining crude oil is briefly discussed to illustrate the number of products that can be generated from a barrel of crude oil. Second, a discussion of refinery capacity in Alaska, Washington, and across the West Coast provides background on where Alaska's fuels are refined and how they are transported to Alaska.

The purpose of this chapter is to inform the reader about how and where Alaska gets its distillate products and the implications of these systems on implementation of the EPA rules. Of note is that in Alaska only one refinery, Tesoro's refinery in Nikiski on the Kenai Peninsula, currently produces ULSD.

2.1 Refining Process

Figure 3 illustrates the crude oil refining process. Gasoline, kerosene, and diesel (and heating oil) are distillates; note that product blending is a part of the refining process. Alaska's six refineries have the potential to generate all of these products, but not all refineries generate all products, as some are specialized and lack the equipment to process certain products.

Figure 3. Crude Oil Refining Process

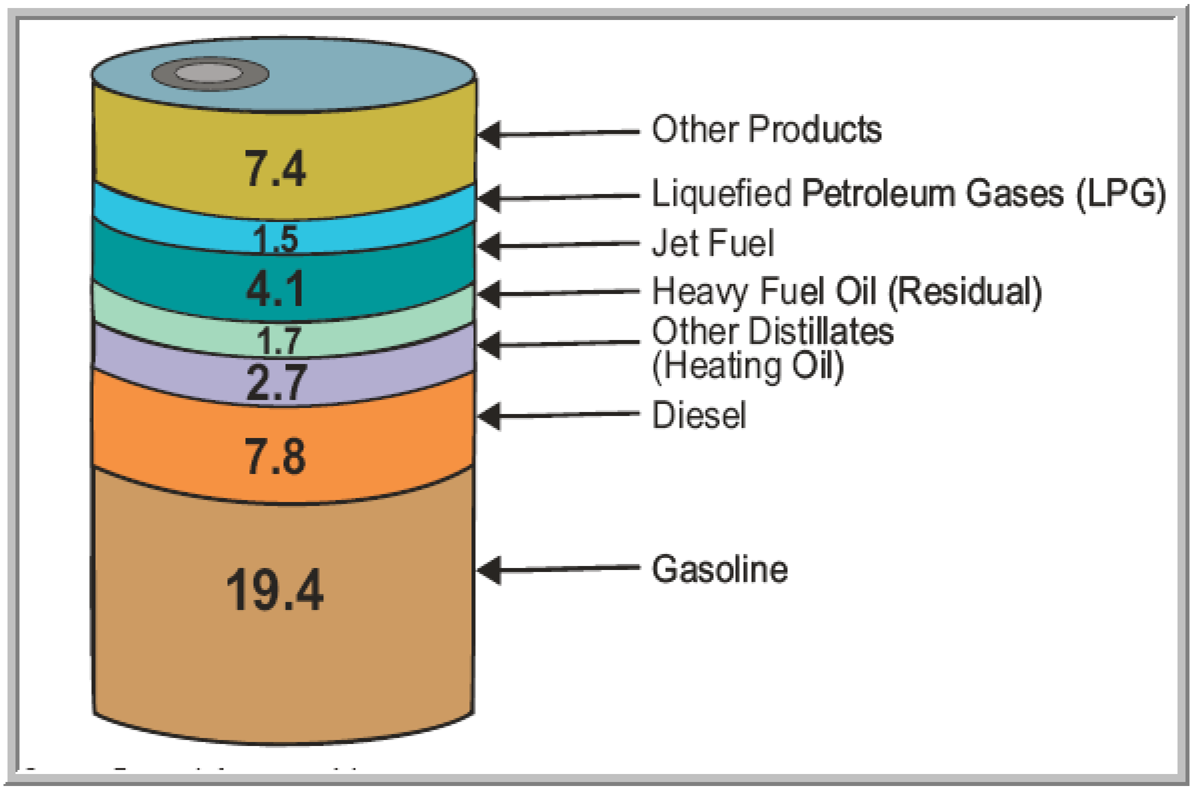


Source: DOE/EIA-X063, April 2007.

2.2 Fuel Types

There are a number of fuels used in the project area for home heating, ranging from Diesel No. 1 and Diesel No. 2 to kerosene and Jet A fuel. As shown in Figure 4 there are many products that are refined from a barrel of crude oil. Diesel fuel is one of a group of fuels known as distillates. Other distillates include kerosene, jet fuel, and fuel oil (heating oil). Each has its own American Society for Testing and Materials (ASTM) specification.

Figure 4. Products Made from a Barrel of Crude Oil, in Gallons.



Source: Energy Information Administration, EIA-X063, April 2007.
Note: Gallons round to greater than 42 gallons due to gains in the refining process.

2.2.1 Gasoline

Gasoline is consumed in the project area in two forms: aviation gasoline and unleaded gasoline. Aviation fuel, in particular, must be stored and used without contamination due to potential problems with aircraft engines. Unleaded gasoline is used in the project area for outboard motors, all terrain vehicles, trucks and cars (in those areas with roads), chain saws, and smaller generator sets (home sized).

2.2.2 Diesel

Petroleum diesel is the common name for the fuel oil used in compression ignition engines. Diesel is generally cheaper to refine than gasoline and often costs less than gasoline. However, due to its high level of impurities diesel fuel must undergo additional filtration, which sometimes contributes to higher costs. Generally, diesel-powered automobiles have better fuel economy than a comparative gasoline powered automobile because of the higher energy content of diesel fuel and the inherent efficiencies of the diesel engine.

Diesel fuel quality in the United States is regulated at the state level and most states have adopted the latest version of ASTM D 975 *Standard Specification for Diesel Fuel* as their standard. This standard essentially divides diesel fuel into grades No. 1 and No. 2.

Each diesel fuel grade is split into three sulfur levels, S5000, S500, and S15. The "S" stands for sulfur and the number refers to the maximum amount of sulfur allowed in parts per million (ppm). The highest level, 5,000 ppm, is equivalent to 0.5 percent by mass while S5000 is known as high sulfur (HS); S500 is low sulfur (LS) and S15 is ultra-low sulfur (ULS). These three fuel grades are summarized as shown in Table 3.

Table 3. Diesel Fuel, Sulfur Parts Per Million, and Percentage by Mass.

Name	Parts per Million	Percentage
S5000	5,000	0.5
S500	500	0.05
S15	15	0.0015

Source: Northern Economics

A refinery can produce No. 2 and No. 1 fuels at various levels and it is common for one refined product to be sold as multiple retail products provided the applicable American Society for Testing and Materials specs are met. However, in order to meet a particular specification, special testing or additives may be required. For example, a low sulfur No. 1 fuel may be sold from a single tank as Jet A, K-1 Kerosene, diesel and fuel oil, but this doesn't mean that they are interchangeable. Kerosene and jet fuel require certification testing and some fuels require additives before use.[4]

2.2.3 Heating Oil

Diesel No. 1 fuels are similar but less dense than No. 2 fuels, and they have lower Btu's per gallon of product. They also have lower viscosity, lower boiling points, lower flash points and typically have better cold-flow properties. No. 1 fuels are typically used in cold climates and are widely used in rural Alaska, especially during the arctic winter. No. 1 fuels tend to cost more and have lower heating value per gallon than No. 2 fuels.

Most of the remote rural Alaska electric utilities in the study area appear to use a No. 1 fuel, commonly Jet A, marketed as a diesel "arctic blend" for winter operations. In general, No. 1 fuels tend to have less smoke, noise, and vibration. It is also common to blend a No. 1 fuel and a No. 2 fuel in order to get adequate flow in winter conditions without losing as much fuel economy from use of 100 percent No. 1 fuel.

[4] For example, indoor space heaters require ASTM D 3699 K-1 kerosene to limit exposure to undesirable indoor emissions.

Some rural Alaska electric utilities use waste heat from their diesel engines to heat fuel systems in order to maintain sufficient viscosity in No. 2 fuels to be able to use them year round or to at least extend the season over which the No. 2 fuels can be effectively used.

2.2.4 Jet Fuel

Jet fuel is refined in much the same process as diesel and ULSD; however, when directed towards aircraft use, it must be clean and not contaminated with additives, water, or dirt. Jet A is used in many project area households for home heating. Costs are addressed in more detail in section 8 of this report.

2.2.5 Liquefied Petroleum Gas (LPG)

LPG is not refined in the same manner as liquid fuels, but it is consumed in the project area. It is most often used for cooking and, occasionally, for clothes driers. The conventional delivery method is a 100-pound bottle (steel) that is usually consumed in pairs, with one bottle serving as a reserve while the primary bottle is being used.

LPG is a competing fuel for certain types of liquid fuel in the project area but is not available in the same quantity that home heating fuels are.

2.2.6 Other Energy Fuels and Sources

Heavy fuel oils from the refining process, often called residual fuel oil, have limited markets in Alaska. These fuels can be used to make asphalt and are used in very large diesel engines in ocean going vessels and power plants. Asphalt is the primary use of these fuels in Alaska. Very few ocean-going vessels take on residual fuel oil in Alaska, and air quality issues restrict their use in power plants in the state. Much of the product is exported to customers in the lower 48 states or exported internationally.

Other power and heating fuels in the project area include wood and other biomass fuels where they can be gathered, cut, and stored. The main river systems, in particular, provide firewood during spring break-up. At Tanana in September 2007, approximately 30 tree-length stems were observed on the banks of the Yukon River. Most were tied to wire, cable, and earth anchors along the shore; they were cut into four-foot lengths on an as-needed basis.

Wind power is another competing energy source in those areas with sufficient market and sufficient wind. Kotzebue is a good example of an area with plentiful wind and 22 wind generators. Local power staff suggested, in the spring of 2007, fuel oil savings of approximately 90,000 gallons per year or $270,000 at an estimated $3.00 per gallon.

As fuel oil costs have risen in rural Alaska, residents have investigated the use of energy alternatives, including wood (if available), propane, and in a very few cases, coal. There is increasing interest in wood pellet production at Fairbanks, Delta Junction, and on the Kenai Peninsula, as well as wood chips for fuel.

Table 4 illustrates unit fuel costs based on alternative fuels, units, heat or energy value per unit and average efficiency; it is adapted from a University of Alaska, Cooperative Extension, publication originally developed in 1977 by Axel Carlson, engineer. Average plant efficiencies range from 45 percent for low-efficiency wood stoves to near 88 percent for the very efficient Toyo and Monitor oil stoves.

Table 4. Unit Fuel Costs, Per Dollar, 2007.

Net Heat, BTU/Dollar	Fuel oil, $/gallon	Nat Gas $/CCF	Propane, $/gallon	Coal $/ton	Spruce $/cord	Wood pellets $/bag	Wood chips $/ton
242,052	$0.50	$0.36	$0.35	$38.63	$31.81	$1.02	$21.27
121,026	$1.00	$0.72	$0.71	$77.26	$63.62	$2.04	$42.54
80,684	$1.50	$1.08	$1.06	$115.88	$95.43	$3.05	$63.80
60,513	$2.00	$1.45	$1.41	$154.51	$127.25	$4.07	$85.07
48,410	$2.50	$1.81	$1.76	$193.14	$159.06	$5.09	$106.34
40,342	$3.00	$2.17	$2.12	$231.77	$190.87	$6.11	$127.61
34,579	$3.50	$2.53	$2.47	$270.40	$222.68	$7.13	$148.88
30,257	$4.00	$2.89	$2.82	$309.02	$254.49	$8.14	$170.15
26,895	$4.50	$3.25	$3.17	$347.65	$286.30	$9.16	$191.41
24,205	$5.00	$3.61	$3.53	$386.28	$318.11	$10.18	$212.68
22,005	$5.50	$3.98	$3.88	$424.91	$349.92	$11.20	$233.95
20,171	$6.00	$4.34	$4.23	$463.54	$381.74	$12.22	$255.22
18,619	$6.50	$4.70	$4.59	$502.16	$413.55	$13.23	$276.49
17,289	$7.00	$5.06	$4.94	$540.79	$445.36	$14.25	$297.75
16,137	$7.50	$5.42	$5.29	$579.42	$477.17	$15.27	$319.02
15,128	$8.00	$5.78	$5.64	$618.05	$508.98	$16.29	$340.29
14,238	$8.50	$6.15	$6.00	$656.68	$540.79	$17.31	$361.56

Source: Northern Economics, adapted from U of Alaska Cooperative Extension, Unit Fuel Costs, 1977, Axel Carlson. Re-issued as Cooperative Extension, Comparative Unit Fuel Costs for Equivalent Dollar Net Heat Output, EEM-01152, April 2007.

As an example, fuel oil at $5.00 per gallon generates about 24,205 net BTUs per dollar and is approximately the same heat value as natural gas at $3.61 per CCF (hundred cubic feet), propane at $3.53 per gallon, or a cord of spruce firewood at $318. Wood moisture contents are assumed at 45 percent on an original (delivered) weight basis.

In project-area communities, fuel oil can cost $5.00 or more per gallon at retail and there are generally few alternative fuels, with firewood considered the most common. Firewood costs vary depending on supply, distance, moisture content, size, and species and demand. Wood cost in Tanana was cited at $200 per cord in November 2007 at the Alaska Wood Energy Conference, 2007, as an example, and at that price, it is approximately equal to fuel oil at $3.25 per gallon.

Toyo fuel oil stoves are very efficient and can generate more net heat per dollar than older fuel oil systems. Also, wood combustion efficiencies are tied to capital costs; a 55-gallon barrel conversion kit has a lower efficiency than a $2,000 "airtight" wood stove.

2.3 Alaska Refineries

Alaska's six refineries, their location, and daily capacity in barrels, as well as their percentage of Alaska's daily production, are shown in Table 5. While Alaska has six refineries, at the present time, distillate products for western and northern Alaska communities are supplied by both Alaska and Washington state sources: refineries located in northern Puget Sound, Washington, the Tesoro refinery in Nikiski, fuel storage facilities in Anchorage, and the Flint Hills refinery in North Pole.

Table 5. Alaska Oil Refineries by Name, Location, Daily Capacity in Barrels and Percent of Alaska's Daily Capacity, 2007.

Refinery	Location	Capacity	Percent
ConocoPhillips	Kuparuk	15,000	4.0
BP	Prudhoe Bay	12,500	3.3
Petro Star	North Pole	17,500	4.7
Petro Star	Valdez	48,000	12.8
Tesoro	Nikiski	72,000	19.2
Flint Hills	North Pole	210,000	56.0
Total		375,000	100.0

Source: U.S. EIA, Refinery Capacity Report, January 2007. URL: http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/refinery_capacity_data/current/table3.pdf, accessed October 2007.

As shown in Table 5 the two largest refineries in Alaska are Flint Hills, located at North Pole, and Tesoro, at Nikiski. Their combined capacity is approximately 75 percent of Alaska's refining capacity. Petro Star Inc. operates two refineries in Alaska in North Pole and Valdez. The North Pole refinery has been in operation since 1958, while the Valdez refinery was built in 1993 (Petro Star, Inc. 2007). Petro Star has indicated that its two refineries in the state will not produce ULSD.

Flint Hills made a business arrangement with Tesoro to centralize in-state ULSD at the Nikiski refinery. ULSD capital investments at Nikiski were approximately $45 million and Flint Hills paid $15 million of that amount, in exchange for priority on the first 6,000 barrels per day of production. In addition, Flint Hills spent another $8 million to upgrade its terminal and shipping facilities (Petroleum News, November 27 2005).

ULSD is shipped via pipeline from Nikiski to Flint Hills' terminal in Anchorage. Storage tanks hold the fuels until dedicated rail cars are available and the product is shipped north to Flint Hills' terminals at North Pole. Tesoro designed the facility for potential expansion to 14,000 barrels per day of ULSD (Petroleum News, July 15, 2007).

The Tesoro refinery at Nikiski produces ULSD No. 1 and has sold ULSD 1 and ULSD 2 since 2006. Tesoro has said it does not plan to use additives to depress the pour point of ULSD, leaving that option up to down-stream transporters and retailers.

ConocoPhillips' refinery at Kuparuk was scheduled to produce ULSD but a decision in December 2007 indicated ULSD fuel would be trucked, not refined.[5]

2.4 Washington Refineries

Four refineries in Washington State produce ULSD. The Shell Oil Company refinery in Anacortes Washington has a capacity of 44,000 barrels per day of ULSD, followed by BP's refinery at Cherry Point (31,000 bpd), ConocoPhillips (25,000 bpd) in Ferndale (EIA, 2007a), and Tesoro's refinery in Anacortes (25,000 bpd). The more limited number of refineries producing ULSD does raise a concern about the competitiveness of ULSD production.

Based on correspondence with the Shell refinery in Anacortes (Sibley, 2007) and the BP refinery at Cherry Point (Fridrich, 2007), neither refinery markets No. 1 diesel (for extremely cold conditions) in Alaska.

The Shell refinery produces No. 1 diesel, but only markets it for Canada, and the BP refinery does not produce or have any plans to produce No. 1 diesel. The BP refinery indicated that they believe some of their diesel production (perhaps their No. 2 ULSD) sold at the Seattle Terminal is used in Alaska, but there is no marketing of the diesel product for Alaska. Information for the other two refineries was not available.

2.5 Canadian Refineries

Canadian refineries have the capacity to support Alaska markets. Northern Transportation Company Ltd., based in Hay River in the Northwest Territories, can deliver ULSD to the North Slope. The fuel moves from Edmonton refineries to Hay River via rail car and then is barged down the Mackenzie River to the Beaufort Sea and then to Alaska. However, fuel delivered in the past has had jelling problems and has failed to meet arctic grade specifications (Olemaun, 2007). This issue can be addressed with additives, careful product specification, and quality control. In any case, Canadian suppliers have not established any market presence in the project area and, therefore, this analysis is primarily concerned with domestic refineries as potential fuel sources.

2.6 West Coast Refining Capacity

Since the mid-1990s, West Coast refining capacity has increased as a result of growing demand for petroleum products. Utilization was at a record level in 1998, eased somewhat at the turn of the century, and has risen slightly in recent years. Utilization is the percent of the total industry capacity of petroleum refineries that is in use. For example, if utilization is 100%, then all refineries are operating at full capacity to meet the demand for petroleum products. In response to the growing demand and higher utilization, total capacity of the industry has risen, and the average size and sophistication of West Coast refineries has increased.

Table 6 shows the number of refineries declined from a high of forty-two in 1995 to a low of thirty-five since 2003. On the other hand, the total capacity of the industry had risen by nearly

[5] Alaska Journal of Commerce: *Plant death means more trucks on roads.* December 2, 2007.

0.35 million barrels from 1995 to 2003. This suggests that the additions of industry capacity have occurred at existing refineries, not through the construction of new refineries. Utilization on the West Coast has been stable since the year 2000 but has risen slightly in recent years (EIA 2007d). The decline in the number of refineries and the recent rise in utilization suggest that refineries represent a potential bottleneck in the process of bringing fuels, including ULSD, to the pump. Nonetheless, the steady rise in the total capacity of the industry continues to ease that bottleneck.

Table 6. Number of Operable Refineries, Total Capacity, Average Capacity and Utilization on the West Coast

Year	Number	Total Capacity (Million Barrels per Day)	Average Capacity (Thousand Barrels per Day)	Utilization (%)
1995	42	2.83	65.81	88.6
1996	NA	2.84	NA	89.2
1997	40	2.87	70.00	90.4
1998	NA	2.89	NA	92.6
1999	39	2.99	74.75	87.0
2000	39	3.01	75.25	87.4
2001	38	3.03	77.69	89.0
2002	37	3.09	81.32	89.9
2003	35	3.10	86.11	91.2
2004	35	3.10	86.11	90.4
2005	35	3.11	86.39	91.6
2006	35	3.14	87.22	90.5
2007	35	3.17	87.78	85.1

Source: EIA, Petroleum Supply Annual, 1995-2007.

Note: The west coast is represented by the Petroleum Area Defense District (PADD) V that comprises the states of Alaska, Washington, Oregon, California, Hawaii, and Nevada. Year 2007 estimates are from January 1, 2007 data.

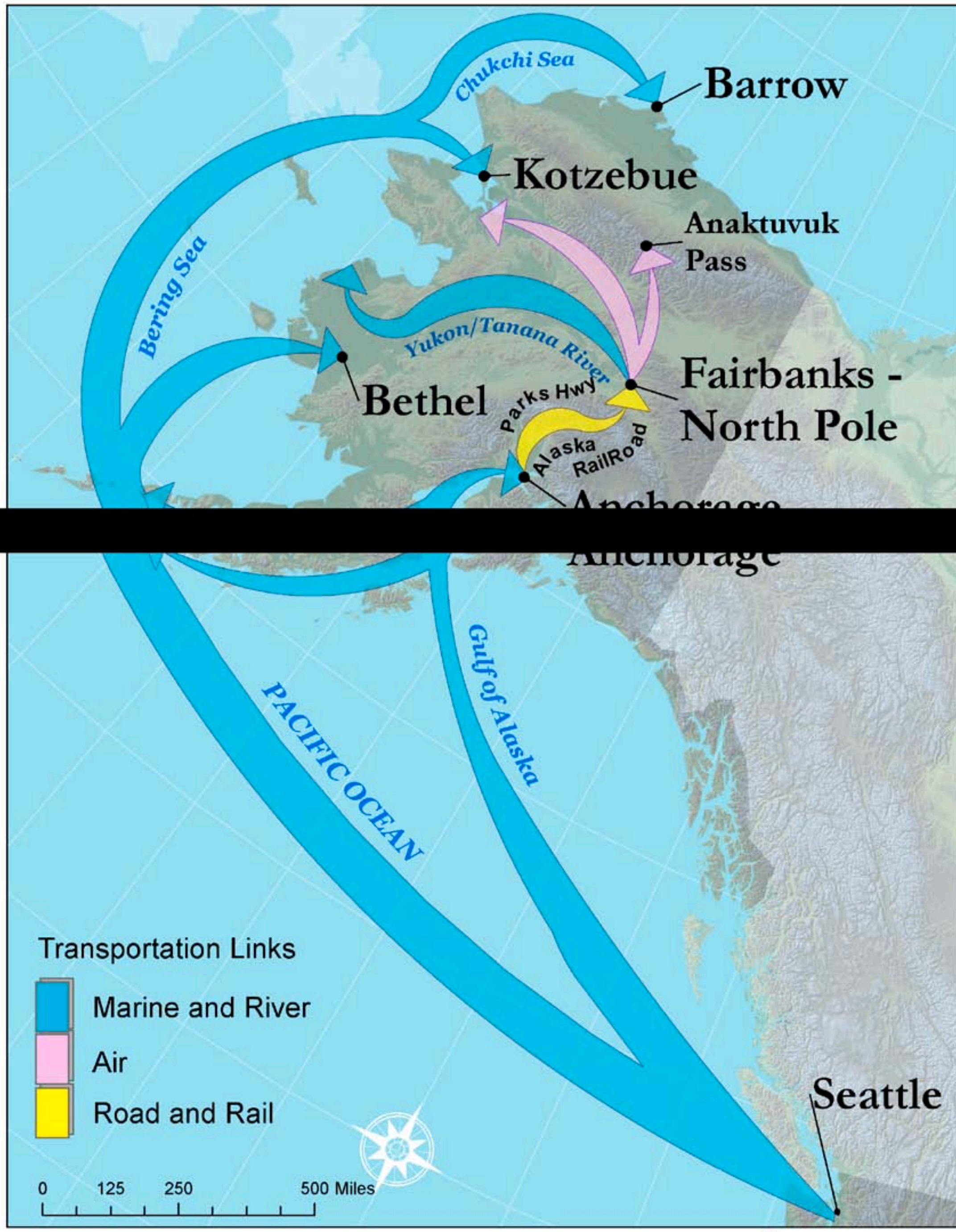
2.7 Fuel Transportation and Distribution

Transportation of diesel from refineries to communities in western and northern Alaska primarily takes place via ocean and river barges. However, communities that are not accessible by barge receive fuel by air or (in isolated instances) by vehicles approved for tundra travel in the winter.

As noted in prior sections, ULSD supplied by Flint Hills comes from the Tesoro refinery at Nikiski and is moved via pipeline to Anchorage and from there to North Pole in dedicated rail tank cars. Communities that receive ULSD from Flint Hills will incur additional rail transportation costs.

The subsections below discuss transport of fuel in Alaska and the general transportation routes used during delivery. Figure 5 shows the illustrative transportation routes used to service western and northern Alaska. Barge routes are shown to some of the major hubs and down the Yukon River, while air transport is shown to Anaktuvuk Pass, which is only accessible by air, and to other communities that may only be accessible by air during periods of low water conditions. There are other communities in the state that are only accessible by air that are not shown on this map.

Figure 5. Illustrative Diesel and Ultra Low-Sulfur Diesel Transportation Routes



Projection: North America Equidistant Conic
August 2007

Source: Alaska Map Company LLC.

2.7.1 Transportation Routes and Terminals

Most fuel delivered to northern and western Alaska comes from the Tesoro refinery in Nikiski or refineries in the Puget Sound area. Much of the fuel destined for communities on the upper Yukon River is supplied by Flint Hills, with delivery in Nenana for barge haul along the Yukon, Tanana, and Nenana river systems. There are two main fuel distributors in the project area: Crowley Marine and Delta Western. At Nenana, Ruby Marine provides barge service, including delivery of liquid fuels and propane (LPG).

Crowley Marine

Crowley sells and delivers heating fuel, diesel fuel, unleaded gasoline, jet fuel, aviation gasoline, propane, packaged petroleum products, lubricants and oil spill cleanup products from the north Arctic Slope to Southcentral Alaska, coastal communities, and inland communities, including those along the Kuskokwim and Yukon rivers. Crowley Maritime Corporation and its subsidiaries are the primary fuel suppliers to western and northern Alaska.

The Crowley tank farm in Bethel serves the Bethel, Kuskokwim River and Bristol Bay regions. Shallow draft combination fuel and freight lighterage barges are loaded at the terminal for delivery to other locations. From Bethel, barges go as far up the river as McGrath and Nikolai. The amount delivered varies from year to year, depending on weather, river and water conditions, and fuel prices.

The Crowley facility in Nenana is the primary terminal and tank farm serving the upper Yukon River. The marine/fuel terminal receives bulk petroleum products, packaged petroleum products, and general cargo via truck, barge, and rail, and consolidates the cargo for delivery through the Yukon River basin. Crowley's Fort Yukon terminal and tank farm provides petroleum products to Fort Yukon and further up the Yukon River toward Canada's Yukon Territory.

In Kotzebue, Crowley's tank farm serves the people of Kotzebue and Kotzebue Sound, selling and delivering petroleum products locally through their Kotzebue facility. The marine/fuel terminal serves as a logistics center for bulk petroleum products, packaged petroleum products, and general cargo.

In Nome, Crowley's tank farm serves the Nome and the Norton Sound region with petroleum products. Like Kotzebue, the Nome marine/fuel terminal serves as a regional logistic center where bulk and packaged petroleum products and general cargo are consolidated and loaded for shipments to remote sites and villages in the region.

Other Crowley marine/fuel terminals are located in Aniak, St. Mary's, Galena, Hooper Bay, Kenai, McGrath, Iliamna, and St. Michael.

In 2005 Crowley purchased Yukon Fuel Company. Since Yukon Fuel Company was Crowley's only competitor in parts of western Alaska, there were concerns that Crowley would be left with monopoly power over fuel prices in these areas.

Delta Western

As part of a consent decree between the state and Crowley, Crowley was required to sell parts of its acquired assets to Delta Western, including several tugs and barges for shallow coastal and up-river waters in western Alaska, fuel storage capacity in Bethel, options to lease certain property Crowley owns in Bethel, and to allow access to fuel storage facilities in Nome, Kotzebue, and St. Michael.

Delta Western transports fuel from Puget Sound refineries direct to southerly regional hubs and communities in the study area; including Dillingham, Naknek, Bethel, St. George, and St. Paul. The company also delivers fuel and lubricants with barges to coastal cities, towns and villages, as well as marine vessels and remote logging and mining facilities. Delta Western has a major terminal and tank farm in Dutch Harbor that supplies other communities and services a number of the larger fishing and processing vessels operating in the Bering Sea.

Other

Ruby Marine in Nenana provides fuel barge service on the Nenana and Yukon Rivers. Sorenson Lighterage Services in Dillingham also has fuel barges that the company operates in western Alaska.

2.7.2 Tug and Barge

Ocean-going (or line haul) barges can hold one to six million gallons of fuel depending on their size (See Table 7). Actual capacity will vary depending on the dimensions of the tank barge. Some communities are accessible by line haul barges, while for other communities fuel must first be transferred from the line haul barge to a shallow draft barge, and then delivered to the community. At some regional hubs, the fuel is transferred to storage tanks for future delivery to smaller communities in the region.

For navigating shallow coastal and up-river locations, shallow draft tugs and barges are necessary. The barges can be only partially loaded to achieve minimal draft when low water conditions are present, although partial loading increases the transportation cost per gallon.

Table 7. Representative Fuel Barge Sizes and Capacities

Length (feet)	Width	Depth	Gallons
400	100	25	5,922,000
360	70	25	3,570,000
260	60	19	1,680,000
250	50	16	1,260,000
175	44	7	285,000
150	50	7	200,000
100	32	7	120,000
80	30	6.5	63,000

Sources: Crowley Maritime Corporation, 2007. West Coast & Alaska Ocean Barge Fleet. Accessed on September 27, 2007 at http://www.crowley.com/fuel-sales-distribution/oceanbarge-fleet.asp. Lighterage Barge Fleet. Accessed on September 27, 2007 at http://www.crowley.com/fuel-sales-distribution/lighterage-fleet.asp

In 2007, the cost for delivery via river fuel barge is about $0.007 per gallon per map mile of transport from the fuel hub.[6] Thus, for a village that is 100 map miles upriver from a regional fuel hub, the cost to deliver fuel is around 70¢ per gallon.

2.7.3 Air

Some communities, such as Anaktuvuk Pass or Lime Village, are not accessible by barge, and are too remote for overland transport so air delivery is the only option for supplying fuel. Other communities such as Buckland on the Buckland River or Nikolai on the Kuskokwim River may experience low water conditions that preclude barge service at times. When this happens, air transport is necessary.

At other times a community may not have purchased sufficient volumes in the prior summer. If fuel inventories reach critically low levels before the ice conditions permit water delivery, air transport is the only option.

Evert's Air delivers fuel to a large number of Alaska communities. The company operates DC-6 and C-46 aircrafts that can carry 2,000 and 5,000 gallons of fuel, respectively. These planes have a number of internal fuel tanks, from 2 to 16 per aircraft.

Currently, Evert's states they are not flying ULSD to Alaska villages, but foresee extra costs and challenges when they start. To deliver ULSD under current regulations, they will need to clean each tank before pumping ULSD. Dave Adams with Evert's Air in Fairbanks estimates that this will cost about $200 to $300 for each plane every time they change fuels (Adams, 2007).

2.7.4 Road or Overland

Few communities are connected by road in western or northern Alaska and very minor amounts of fuel move between communities by this mode. There are dedicated fuel trucks in larger communities for household heating fuel delivery.

Bonanza Fuel in Nome has a contract to deliver fuel to Teller in addition to Nome residents. Typically, air transport is used to supply Atqasuk but fuel deliveries from Barrow to Atqasuk have occasionally been made in winter using rolligons or similar equipment for tundra travel, often towing sled-mounted fuel tanks.

Bonanza Fuel also has a state contract to deliver fuel to Nome and Teller. The company has a fuel tank farm and a fuel tanker truck fleet with three 2,500 gallon and one 2,600 gallon fuel tankers. They also own a Tesoro gas station in Nome.

In some regions, frozen rivers become major arterials during winter months. After freeze-up, fuel deliveries from Bethel are made to villages up and down the Kuskokwim River. Village residents also tow sleds behind their snow machines with mounted drums.

[6] MAFA Analysis of Crowley Marine Services invoices. To simplify the analysis, a map-mile is adopted rather than a river-mile.

2.8 Aggregated Fuel Purchasing

Some project-area communities have formed groups to consolidate fuel purchases and obtain volume discounts at lower prices, when compared to independent purchases.

The question at hand is if certain communities no longer used the same diesel fuel as the rest of the group because of differences in fuel requirements, would there be an erosion of the benefits from volume discounts?

2.8.1 Volume Benefits

Fuel suppliers in rural Alaska offer volume discounts. In theory, when a company uses a volume-pricing objective it is seeking sales maximization within predetermined profit guidelines. A company using this objective prices a product lower than normal but expects to make up the difference with a higher sales volume. Volume pricing can be beneficial to a company because its products are being purchased on a large scale, and large-scale product distribution helps to reinforce a company's name as well as to increase its customer loyalty.

Based on interviews with fuel suppliers in rural Alaska, volume discounts generally follow the schedule shown in Table 8. This schedule of volume discounts generally apply across product lines.

Table 8. Typical Volume Discounts for Fuel Barge Delivery

Volume Range (in Gallons)	Price Differential
100,000 and up	base price
50,000 to 99,999	plus 5 cents
20,000 to 49,999	plus 10 cents
5,000 to 19,999	plus 15 cents
1,000 to 4,999	plus 25 cents

Source: Information obtained from Northern Economics' interviews.

Actual fuel price is based on posted base prices. The volume discounts are based on total volume of all purchased products and not necessarily given on a per product basis. Fuel purchasers in rural Alaska that form cooperatives and organized groups to consolidate fuel purchases to gain some "leverage" on the fuel suppliers and haulers by making large single product volume purchases will be affected by the per gallon price differentials on the products and increase in price differentials by volume class.

According to Crowley, the additional cost of a separate ULSD supply chain will manifest itself in larger differentials by quantity and per gallon prices for products. Hence, if single product orders of jet fuel or diesel fuel No. 1 are replaced by orders of some amount of jet fuel and some amount of ULSD, differentials will apply where they may have not before. These differentials are likely to increase (Personal communication with Royal Harris, Crowley Marine, 2007).

According to a sales manager at Delta Western, in the short-term, volume discounts or price differentials will be affected, due to the changes necessary to accommodate another grade of fuel, but in the long-term, volume discounts would approximate current levels.

Consolidating fuel purchases allows more efficient use of barge capacity and that reduces fuel handling and transportation costs. The effects of the EPA fuel rules therefore will depend on whether the delivery infrastructure would lose this efficiency.

2.8.2 Price Benefits

To assess the current benefits generally enjoyed by communities that consolidate fuel purchases, a comparison was done of the average fuel prices paid by groups of utilities that consolidated purchases versus the utilities that purchased fuel independently. Analysts used data from the 2006 PCE reports submitted by various utilities (but only for communities within the study area).

Table 9 shows the price differential between the two categories of fuel purchasers: 1) utilities that do not consolidate fuel purchases; and 2) groups that consolidate fuel purchases. In fiscal year 2006, the prices of fuel per gallon paid by utilities that consolidated purchases were on the average 67 cents lower than prices paid by utilities that purchased their fuel independently.

Table 10 shows the differences in average fuel prices paid by the two different categories of fuel purchasers by region. Average fuel prices paid by utilities that consolidated purchases were lower than those paid by utilities that do not consolidate purchases in all regions except the Northwest Arctic Borough.

Table 9. Comparison of Average Prices of Fuel per Gallon paid by Utilities by Category, FY 2006

Category	Average Price of Fuel per Gallon ($)
Utilities That Do Not Consolidate Purchases	2.79
Groups That Consolidated Purchases	
WAFG	2.02
AVEC	2.09
NSB	2.43
Sub-category average	**2.12**

Source: Northern Economics estimates based on FY 2006 PCE data.

Table 10. Comparison of Average Prices of Fuel per Gallon paid by Utilities Region by Category, FY 2006

Region	Utilities That Did Not Consolidate Purchases ($)	Groups That Consolidated Purchases ($)
Aleutians	3.05	NA
Bethel CA-- Aniak	2.98	NA
Bethel CA--Lower Kuskokwim	2.53	1.82
Dillingham CA	3.32	2.15
Kodiak Island	2.18	NA
Lake and Peninsula	3.20	2.15
Nome	2.25	1.86
Northwest Arctic Borough	2.44	2.57
North Slope Borough	NA	2.43
Wade Hampton	2.43	1.85

Yukon-Koyukuk CA	2.82	2.40

Source: Northern Economics estimates based on FY 2006 PCE data.
NA: Not applicable

It should be noted that these price benefits result from a number of factors besides volume discounts. The fuel prices are negotiated prices that result from competitive bidding. Cooperatives and organized groups that are consolidating fuel purchases and have larger fuel orders are generally successful in promoting competition by creating more interest among potential fuel supply competitors and in seeking cost-effective pricing with the use of multiple fuel price indexes, and, finally, taking advantage of seasonal fuel price changes.

Groups such as AVEC, WAFG, and the North Slope Borough issue requests for proposals (RFP) for the purchase and delivery of fuel. The RFP process allows competitive forces to work and each group selects the best price.

Volume pricing and discounts and the potential effects of EPA fuel rules are further discussed in the following section.

2.9 Purchasing Organizations

The organizations and cooperatives within the study area that consolidate fuel purchases include those discussed in the following sections.

2.9.1 Alaska Village Electric Cooperative (AVEC)

AVEC is a non-profit electric utility that serves 52 villages in the Interior and western Alaska, covering villages from as far north as Kivalina to Old Harbor on Kodiak Island in the south, and from Gambell on St. Lawrence Island in the west to Minto in the east. Minto is the only AVEC community accessible by road. All other AVEC communities are accessible by airplane or marine vessel only.

AVEC purchases about five million gallons of fuel annually. The fuel is stored in AVEC's bulk fuel tank farm facilities, many of which have been upgraded or completely rebuilt.

2.9.2 Western Alaska Fuel Group (WAFG)

WAFG is composed of seven electric utilities: 1) City of Buckland; 2) I-N-N Electric Cooperative, Inc. (INNEC); 3) Kotzebue Electric Association (KEA); 4) Naknek Electric Association (NEA); 5) Nome Joint Utility Systems (NJUS); 6) Nushagak Electric and Telephone and Telephone Cooperative, Inc. (NETC); and 7) Unalakleet Valley Electric Cooperative, Inc. (UVEC); all located in Bristol Bay, the Seward Peninsula or on Kotzebue Sound, Alaska. For fiscal year 2008, the fuel group sent out a request for proposals for purchase and delivery of approximately 5.9 to 7.3 million gallons of diesel engine fuel for use in electrical generation.

2.9.3 North Slope Borough

The North Slope Borough consolidates fuel purchases for all its communities including Barrow, Nuiqsut, Point Lay, Point Hope, Wainwright, Atqasuk, Anaktuvuk Pass, and Kaktovik. In the past five years, annual purchases have been between 4.6 million (FY06) and 5.7 million (FY03) gallons of fuel

The Borough also combines its fuel purchases with SKW/Eskimos Inc., a firm that provides industrial, earthwork, paving, and oil field services in the North Slope, making the total volume of fuel procured for the North Slope region even larger.

2.9.4 Northstar Gas/Wave Fuels and Transportation

Northstar Gas, formerly WAVE Fuels and Transportation, is a subsidiary of Western Alaska Village Enterprise. WAVE Fuels and Transportation was started in 1996 when eight villages along the Lower Kuskokwim River got together to consolidate fuel purchases and save money on fuel and transportation costs. After two years, the organization was serving 100 customers in 56 villages with almost five million gallons of fuel purchases yearly. Through competitive bidding and volume buying, this organization has lowered fuel prices for its customers. (WAVE, 2007)

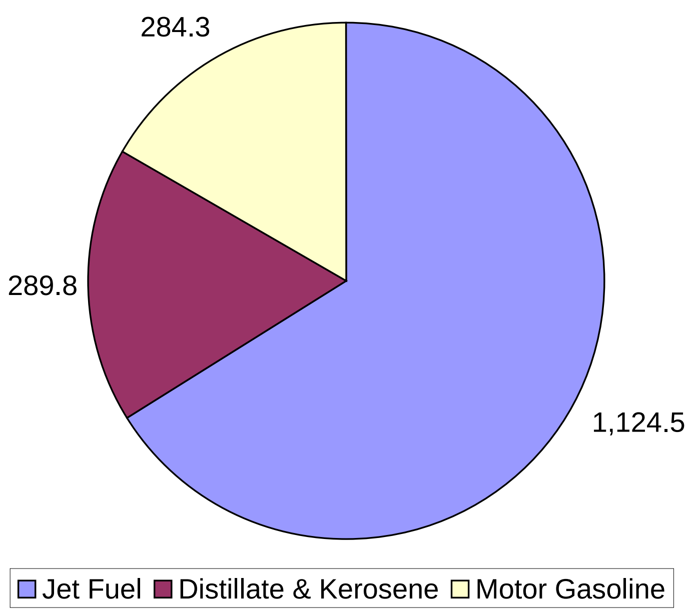
3 Alaska Fuel Demand

The consultant team developed two estimates of fuel demand; first, a statewide demand estimate provided the overall quantity of fuels consumed in Alaska and, second, a project area demand estimate provided specific estimates of fuel for northern and western Alaska.

3.1 Statewide Fuel Demand

Figure 6 shows the estimated sales of petroleum products within the State of Alaska as reported by the Energy Information Administration (EIA) in their report entitled *Prime Supplier Sales Volumes*. The total volume of petroleum products sold in 2006 is estimated at almost 1.7 billion gallons. Jet fuel accounts for the largest portion, accounting for about 1.1 billion gallons (66.2 percent). Motor gasoline sold was 284 million gallons (16.7 percent), which is a slightly smaller quantity than distillates and kerosene at about 290 million gallons (17.1 percent). In terms of distillate-like products, jet fuel accounts for 79.5 percent and distillates and kerosene account for 21.5 percent.

Figure 6. Annual Sales of Petroleum Products in Alaska, 2006
(Millions of Gallons)



Source: EIA, 2007a. *Prime Supplier Sales Volumes*. Accessed at http://tonto.eia.doe.gov/dnav/pet/pet_cons_prim_dcu_SAK_a.htm on October 24 2007.

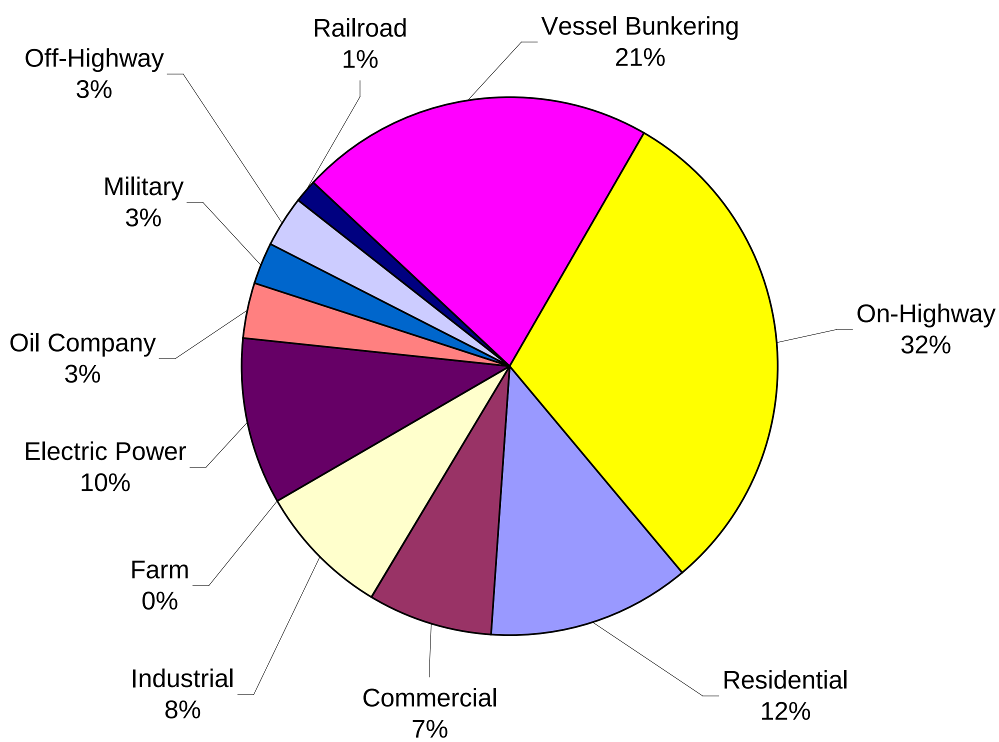
The EIA also provides information on the end uses of distillates and kerosene. The latest data available for end uses are for 2005 and show consumption of approximately 564.4 million gallons of distillates and kerosene, compared to the 2006 sales estimates of 289.8 million gallons.

Providers of the end use data are instructed to "report all volumes in accordance with what the product was sold as, regardless of the actual specifications of that product." (EIA, 2007b)

Anecdotal information obtained during the interviews for this report suggested that much of the distillate fuel shipped into rural Alaska was jet fuel, or jet fuel that did not meet Jet A specifications. The data from the two EIA sources suggest that roughly half of the distillate fuel and kerosene consumed in Alaska may have been refined as jet fuel but sold as another product.

Sales information by end use for Alaska (2005) is presented in Figure 7. On-highway use and vessel bunkering account for more than half of all distillate and kerosene use in the state. Traditional fueling or "bunkering" of deep-draft ocean-going vessels seldom occurs in Alaska, and this term primarily applies to the sale of diesel to the Alaska and Bering Sea fishing fleets. The commercial definition used by EIA includes local, state, and federal governments, and other public and private organizations.

Figure 7. Distillate and Kerosene Fuel Sales by End Use, 2005



Source: EIA, 2007b. Distillate Fuel Oil and Kerosene Sales by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/pet_cons_821use_dcu_nus_a.htm on October 24, 2007.

Figure 8 shows the statewide change in consumption of distillates and kerosene from 2000 through 2005. Vessel bunkering has changed over time but consumption in this sector in 2005 is approximately the same as it was in 2000.

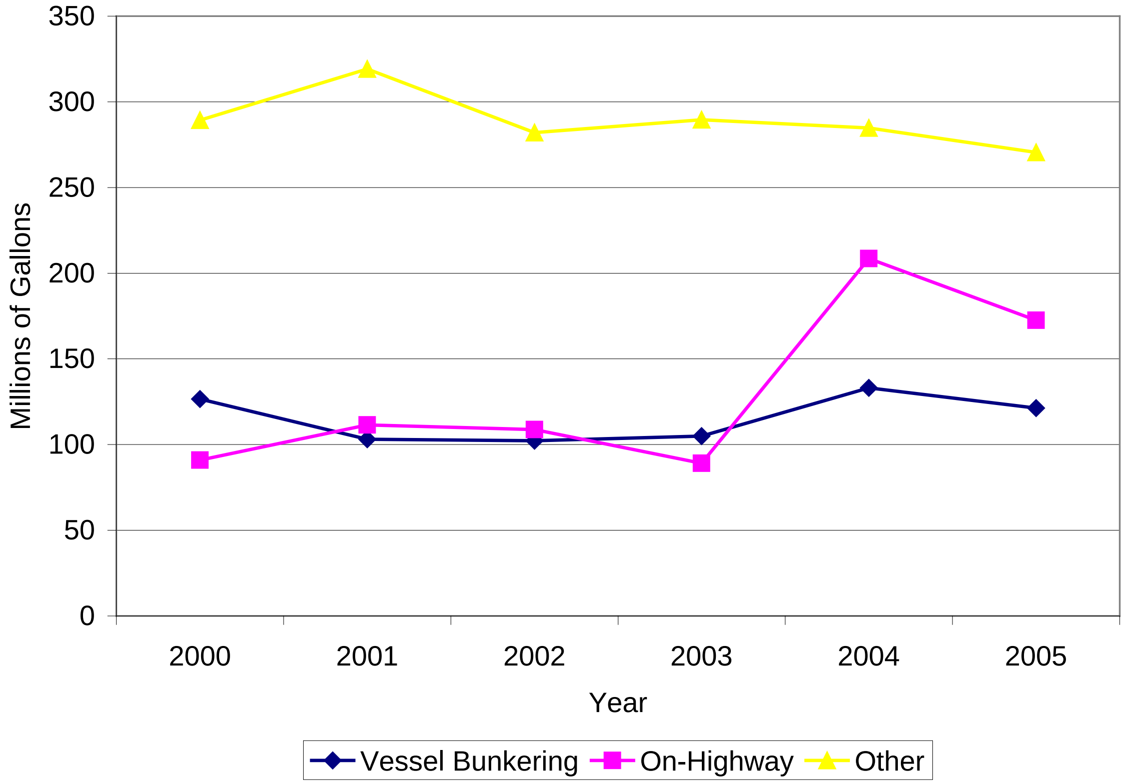
On-highway use ranged between about 90 million gallons and 110 million gallons per year until 2004, when it jumped to over 200 million gallons, and then declined to about 175 million gallons in 2005. This dramatic change is thought to be due to reporting changes since there is no supporting evidence to suggest that on-highway users increased their activities to the degree that fuel consumption would more than double. The Federal Highway Administration (FHWA) provides the on-highway data to EIA. In their Highway Statistics 2003 publication (FHWA 2003) the FHWA notes:

> The records of State agencies that administer the State taxes on motor fuel are the underlying source for most of the data presented in these tables. The FHWA estimates highway use of gasoline by subtracting estimated non highway use from the total use reported by the States.
>
> Over the last several years, there have been numerous changes in State fuel tax laws and procedures that have resulted in improved fuel tax compliance, especially for diesel fuel. The improved compliance has resulted in increased fuel volumes being reported by the States to FHWA. The trends shown in the tables reflect both improvements in tax compliance and changes in consumption.

The Alaska Department of Labor and Workforce Development data on industry employment shows that the average annual employment in the trucking industry in 2003 was about 2,800 persons. This estimate increased to 3,000 in 2004 and 3,100 in 2005 (ADOL&WD, 2007). The increase to 3,100 persons would be a 10.7 percent increase in employment, which does not suggest that the industry doubled its fuel consumption.

Consumption by the other end use sectors has declined since 2000. Additional detail for these other end use sectors is shown in Figure 9.

Figure 8. Distillate and Kerosene Fuel Sales by Major End Use Category, 2000-2005



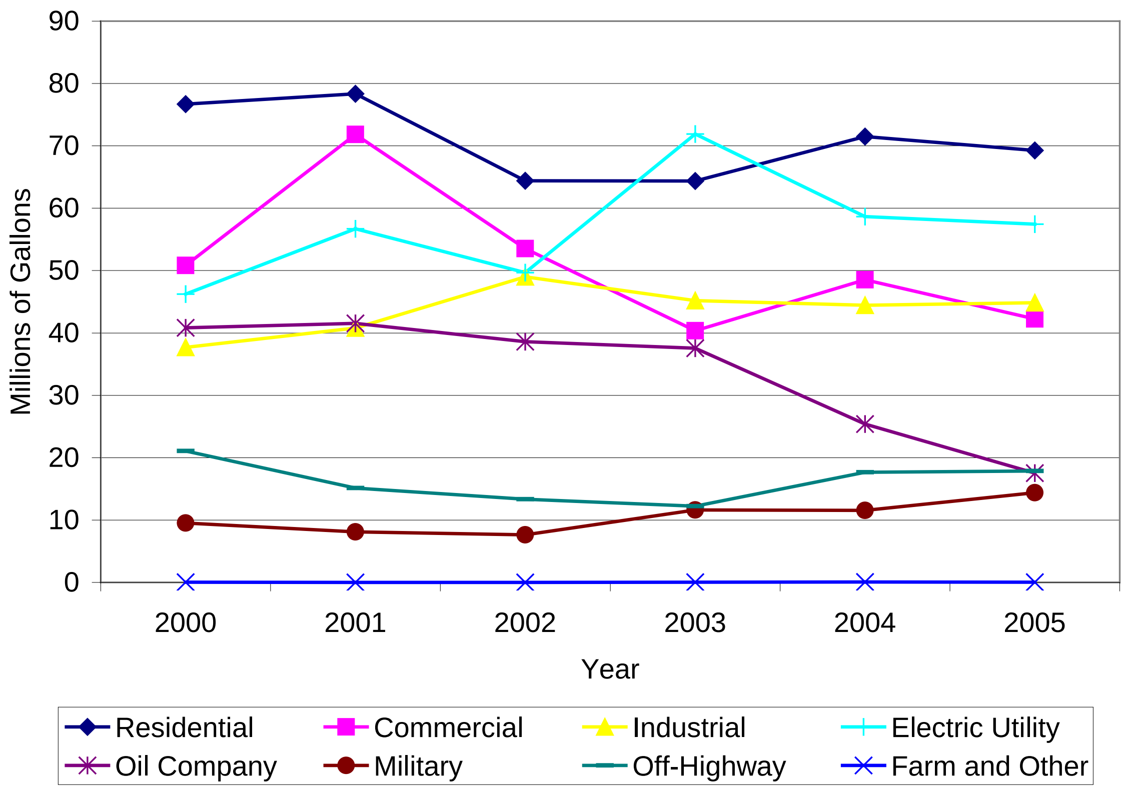
Source: EIA, 2007b. Distillate Fuel Oil and Kerosene Sales by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/pet_cons_821use_dcu_nus_a.htm on October 24, 2007.

Over the 2000 to 2005 time period, only three end use sectors experienced increases in annual distillate and kerosene consumption. These included electric utilities, which had the largest increase of approximately 11.2 million gallons over the five years, the industrial use segment, which increased by about 7.1 million gallons, and the military, which increased about 4.9 million gallons.

The other five sectors declined, with the oil company sector experiencing a 23.3 million gallon decline. Pipeline companies are included in the EIA's oil company definition so some of this decrease is due to switching pump stations on the Trans Alaska Pipeline System to the electric grid instead of burning jet fuel in turbine engines, which power the pipeline pumps.

The commercial sector decreased its consumption by about 8.6 million gallons and the residential sector declined by about 7.5 million gallons. The off-highway sector was about 3.2 million gallons below the 2000 consumption level, although 2004 and 2005 were above the levels experienced in 2001 through 2003. The farm sector was down slightly from its very low levels of consumption. Note that most sectors were down or flat in 2005 when prices for distillates and kerosene increased significantly. Total distillate and kerosene consumption in the state declined from 282.9 million gallons in 2000 to 263.6 million gallons in 2005. This was a reduction of 19.3 million gallons or a 6.8 percent decrease.

Figure 9. Distillate and Kerosene Fuel Sales by Other End Use Categories, 2000-2005



Source: EIA, 2007b. Distillate Fuel Oil and Kerosene Sales by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/pet_cons_821use_dcu_nus_a.htm on October 24, 2007.

3.2 Project Area Fuel Demand

Total distillate fuel consumption in the study area, excluding jet fuel, is estimated at 75.2 million gallons in 2006. This volume includes jet fuel sold as other products but excludes jet fuel sold and consumed as jet fuel. This volume estimate is shown in Table 11. The study area accounts for approximately 13.3 percent (75.2/564.4) of the total kerosene and distillates, excluding jet fuel, consumed in the state.

Table 11. Estimated Distillate Consumption, Excluding Jet Fuel, in Study Area, 2006

Community Category	Amount(Millions of Gallons)
Hubs	22.2
Sub-regional hubs	4.7
Villages and towns	24.3
Subtotal	51.2
Industrial	24
Total	**75.2**

Source: Estimate by Northern Economics, Inc.

Additional information on the derivation of these estimates is presented in the following subsections.

3.2.1 Storage Capacity Usage in the Study Area

Fuel sales are considered proprietary information and are not available from the major fuel distributors. Fuel taxes in the state are not reported by geographic location, so there are no secondary data that can be used to estimate fuel consumption in the project area. However, data of varying quality do exist for bulk fuel tank farms and storage capacity by community in the state. The information presented in this section for tank farms provides a preliminary estimate for fuel consumption in the study area. Adjustments to this tank farm data are described later in this section to arrive at estimated distillate and kerosene fuel consumption in the study area and the amount of regulated fuels.

Rural Bulk Fuel Tank Farms

Bulk fuel tank farm information from business plans submitted to the Alaska Energy Authority and attachments provided in the Denali Commission database (Denali Commission project database, 2007) indicates planned capacity additions average 850 gallons of petroleum products per person for communities of 100 to 1,000 persons. The capacity per capita is larger for communities of less than 100 persons because the standard tank design used in most villages may be oversized for communities of less than 100 person but smaller tanks would cost almost as much as a larger standard tank. A larger, standard tank may be more cost effective. Further, tank additions are sized to meet requirements 10 years in the future. Current consumption of all petroleum products is approximately 750 gallons per capita per year based on a review of available tank farm business plans for villages and towns. The same sources provide an average of approximately 1,700 gallons of storage capacity for hubs and 1,250 for sub-regional hubs (See Table 12).

A review of these business plans and the DCCED community database information for bulk fuel tank storage indicates that approximately 20 percent of the tank farm capacity is used by gasoline, leaving 80 percent of the capacity for distillate fuels.

Tank farm business plans and other sources also indicate that electric utilities in villages and towns require approximately 25 percent of the total capacity, while utilities in hubs and sub-regional hubs consume about 30 percent of total capacity. Aviation is estimated to require about 20 percent of tank farm capacity in hubs and about 15 percent in subregional hubs. Villages and towns in the study area do not typically store aviation fuels or distillate marine fuels. The total volume of ULSD per capita that might be required if regulated sources, including all power generation equipment, switched to ULSD is shown in the row titled Regulated Distillates. Regulated distillates exclude gasoline, aviation gasoline, jet fuel, and heating fuel. Separate tanks are not required for each use shown below but separate tanks would be required for certain fuels (e.g., ULSD and Jet A).

Table 12. 2006 Population and Per Capita Tank Farm Capacity Usage in Study Area Communities

Population/Storage Use	Hubs	Sub-regional Hubs	Village and Towns
Population	18,918	5,028	36,999
		Gallons per Capita	
1. Total Petroleum Products	1,700	1,250	750
2. Motor Gasoline	340	250	150
3. Total Distillate Products (1-2)	1,360	1,000	600
4. Electricity	510	375	190
5. Residential Heating	250	215	215
6. Marine	40	30	0
7. Aviation	340	190	0
8. Off-Road	50	40	25
9. Other	170	150	170
10. All Distillates, excl. Jet (3-7)	1,020	810	600
11. Regulated Distillates (10-5+(0.25*9))	640	480	260

Source: Estimates by Northern Economics, Inc.

Notes: The volumes shown for all distillates, excluding jet fuel, represent the maximum amount of ULSD that might be required in the study area if all uses except those needing jet fuel switched to ULSD. Regulated distillates are a portion of total distillates and indicate the volumes of ULSD that might be required if only regulated sources, including all power generation equipment, switched to ULSD. Gallons are rounded to nearest ten gallons in most instances, five gallons for certain uses. Approximately 25 percent of the Other category is anticipated to use ULSD.

As noted in the prior section, EIA estimates that off-road equipment consumes about three percent of total distillate and kerosene fuels in the state. A review of typical equipment found at the village level and a review of fuel consumption data for diesel engines employed in heavy equipment suggests that off-road equipment in villages would likely consume about the same percentage, so three percent is used in these estimates.

The Other category includes commercial, government, schools, and other organizations both public and private and is calculated as the balance between the total storage capacity and the volume required for the other uses. Approximately 75 percent of the fuel consumed in this category is considered to be heating fuel. Total distillates exclude gasoline, aviation gasoline, and jet fuel. Regulated distillates exclude gasoline, aviation gasoline, jet fuel, and heating fuel.

Table 13 is the result of multiplying the 2006 population for each community category by the estimated per capita storage capacity by use shown in Table 12. Table 13 indicates that total tank farm capacity in the study area is approximately 66.2 million gallons, and the total storage capacity for all distillates is approximately 53 million gallons. Excluding aviation fuels and gasoline approximately 45.6 million gallons of storage is required for distillates per year. The 45.6 million gallon estimate represents the maximum storage needed for ULSD if all uses of distillate fuels except those requiring jet fuels convert to ULSD. The regulated distillate estimate represents the storage capacity required for ULSD if only regulated uses made the transition.

Table 13. Total Tank Farm Capacity Usage in Study Area Communities, 2006

Storage Use	Hubs	Sub-regional Hubs	Village and Towns	Totals
	Millions of Gallons			
1. Total Petroleum Products	32.2	6.3	27.7	66.2
2. Motor Gasoline	6.4	1.3	5.5	13.2
3. Total Distillate Products (1-2)	25.8	5.0	22.2	53.0
4. Electricity	9.6	1.9	7.0	18.6
5. Residential Heating	4.7	1.1	8.0	13.8
6. Marine	0.8	0.2	0.0	0.9
7. Aviation	6.4	1.0	0.0	7.4
8. Off-Road	0.9	0.2	0.9	2.1
9. Other	3.2	0.8	6.3	10.3
10. All Distillates, excl. Jet (3-7)	19.3	4.1	22.2	45.6
11. Regulated Distillates (10-5+(0.25*9))	12.2	2.4	9.5	24.1

Source: Estimates by Northern Economics, Inc.

Notes: The volumes shown for all distillates, excluding jet fuel, represent the maximum amount of ULSD that might be required in the study area if all uses except those requiring jet fuels switched to ULSD. Regulated distillates are a portion of total distillates and indicate the volumes of ULSD that might be required if only regulated sources, including all power generation equipment, switched to ULSD. Approximately 25 percent of the Other category is anticipated to use ULSD.

It should be noted that the effective working storage capacity is about five to eight percent lower than the stated storage capacity. This situation is considered in the fuel demand estimates presented in the following subsection using a mid-point of 6.5 percent to account for the difference between stated capacity and working capacity.

3.2.2 Estimated Community Fuel Demand in Study Area Communities, 2006

As noted previously, some communities may have several fuel deliveries per year so an estimate of total bulk fuel tank capacity will underestimate the total fuel consumed in the study area. For example, Table 13 indicates that marine fuels may account for approximately 900,000 gallons of stated storage capacity in the study area, even though the estimated consumption for this sector is approximately 4.1 million gallons. Most of the marine distillate fuels are consumed in areas where the shipping season can extend from May until late October or early November and can receive multiple fuel deliveries, in comparison to other areas in the study area where the shipping season is from early to mid-July through early to mid-September.

The total estimated fuel consumption in the study area is considered to be about 15 percent greater than the working storage capacity in the study area. Of the approximately 9 million additional gallons of fuels due to multiple deliveries, about one-third, 3.2 million gallons, is associated with marine fuels.

The balance of 5.8 million gallons is distributed equally between the other uses in accordance with their storage capacity. Table 14 shows the distribution of the estimated 71 million gallons of petroleum products and their distribution among community types and uses. The distribution of total distillates, approximately 50 million gallons, and regulated distillates, approximately 27.9 million gallons, among community types is also shown.

Table 14. Estimated Fuel Consumption by Use in Study Area Communities, 2006

Storage Use	Hubs	Sub-regional Hubs	Village and Towns	Totals
	(Millions of Gallons)			
1. Total Petroleum Products	34.6	6.8	29.8	71.2
2. Motor Gasoline	6.6	1.3	5.7	13.6
3. Total Distillate Products (1-2)	28.0	5.5	24.1	57.6
4. Electricity	9.9	1.9	7.2	19.1
5. Residential Heating	4.9	1.1	8.2	14.1
6. Marine	3.4	0.7	0.0	4.1
7. Aviation	6.6	1.0	0.0	7.6
8. Off-Road	1.0	0.2	1.0	2.1
9. Other	3.3	0.8	6.5	10.5
10. All Distillates, excl. Jet (3-7)	22.5	4.7	22.8	50.0
11. Regulated Distillates (10-5+(0.25*9))	15.1	3.0	9.8	27.9

Source: Estimates by Northern Economics, Inc.

Notes: The volumes shown for all distillates, excluding jet fuel, represent the maximum amount of ULSD that might be required in the study area if all uses except those needing jet fuel switched to ULSD. Regulated distillates are a portion of total distillates and indicate the volumes of ULSD that might be required if only regulated sources, including all power generation equipment, switched to ULSD. Approximately 25 percent of the Other category is anticipated to use ULSD.

3.2.3 Estimated Industrial and Construction Demand in Study Area

In addition to fuel consumed in the communities within the study area, there are remote industrial enclaves that are major consumers of distillate products. The largest industrial enclave in the state is the oil industry and its operations at Prudhoe Bay and surrounding fields. This enclave is not addressed in this report. Other industrial enclaves are discussed below.

Red Dog Mine

The next largest industrial consumer is the Red Dog Mine, located north of Kotzebue in the Northwest Arctic Borough. The mine has a bulk fuel tank farm with approximately 15 million gallons of capacity located at the port site on the Chukchi Sea coast south of the village of Kivalina. Total fuel consumption is estimated at 16.8 million gallons per year. The mine is supplied by fuel barges direct from Puget Sound or Cook Inlet refineries and does not utilize any community-based storage facilities in the region.

There are no other mines of this scale operating in the study area. There are a number of small gold mines in the study area as well as a number of mining exploration camps that function during the summer and early fall months. The smaller operations and mining camps typically obtain fuel from the nearest hub or sub-regional hub and these volumes are captured in the estimates for the communities, but larger exploration operations are supplied by the major fuel distributors in the study area.

Donlin Creek, Pebble Mine

The proposed Donlin Creek mine located near the village of Crooked Creek on the Kuskokwim River is a large minerals exploration effort in the study area and is estimated to use between one and two million gallons of fuel per year during exploration. The proposed Pebble mine located near Iliamna is a much larger deposit and is estimated to use between two and four million gallons of fuel per year for exploration activities. Total fuel consumption for all mining activity in the study area, including Red Dog, which is not supplied from local communities, is estimated at approximately 21 million gallons.

Construction Industry

In addition to the mining sector, construction firms will often mobilize fuel supplies into communities for major construction projects since the fuel cost will be lower than purchasing from local suppliers. The construction sector, which is included in EIA's off-highway sector and accounts for approximately 75 percent of the off-highway use in the state, is estimated to use about four percent of the total fuel demand in the study area or about 3 million gallons of fuel per year.

3.3 Future Demand for Distillate Fuels in the State of Alaska and Study Area

There are a number of factors that will influence future demand for distillates in the state and the study area. This report considers the following factors in estimating future demand:

- Population change and household size
- Technological change
- Change in the use of electric appliances and equipment
- Price changes in heating fuel and electricity
- The response of consumers to this change

Each of these items is addressed in the following subsections.

3.3.1 Population Change and Household Size

The Alaska Department of Labor and Workforce Development recently published population projections for the state, boroughs, and census areas from 2006 to 2030 (Alaska Department of Labor and Workforce Development, 2007). Table 15 shows the Department's projections at five-year intervals through 2030 for the state and the major boroughs or census areas within the study area. There are distinct differences between regions within the study area with some anticipated to have substantial increases in population and some expected to lose population over the period. The compound annual growth rate between 2006 and 2030 for these boroughs and census areas combined is 0.84 percent.

Table 15. Population Projections for the State and Boroughs and Census Areas in the Study Area, 2006 through 2030

	2006	2010	2015	2020	2025	2030
State of Alaska	670,053	698,573	734,999	771,465	806,113	838,676
Borough or Census Area						
Yukon-Koyukuk Census Area	5,860	5,899	5,766	5,595	5,362	5,111
Nome Census Area	9,535	9,902	10,412	10,908	11,405	12,024
North Slope Borough	6,807	7,291	7,722	8,095	8,433	8,867
Northwest Arctic Borough	7,334	7,711	8,165	8,604	9,016	9,481
Bethel Census Area	17,031	17,774	18,590	19,457	20,333	21,354
Bristol Bay Borough	1,060	1,169	1,153	1,152	1,133	1,120
Dillingham Census Area	4,796	4,897	5,044	5,181	5,293	5,408
Lake & Peninsula Borough	1,557	1,586	1,560	1,510	1,443	1,364
Wade Hampton Census Area	7,553	7,910	8,455	9,069	9,709	10,427
Total for the Project Area	**61,533**	**64,139**	**66,867**	**69,571**	**72,127**	**75,156**

Source: Alaska Department of Labor and Workforce Development, 2007. Alaska Population by Area: 2006 to 2030. Excel files accessed at http://www.labor.state.ak.us/research/pop/projections/AkSubStatePopProj.xls on October 25, 2007.

The 2006 population estimate shown in Table 15 is slightly larger than the population estimate of 60,945 in the study area communities because some communities in the Lake and Peninsula Borough, for example, have ferry service and year-round fuel deliveries, and one community in the Aleutians East Borough (AEB) is in the study area although most of the AEB's communities also have ferry service and year-round fuel deliveries. Communities with ferry service and year-round fuel delivery were not included in the study area communities. The AEB and the Lake and Peninsula Borough are considered rural under the federal rules for ULSD.

Household size is an important factor to consider because with a given population, the smaller the household size, the greater the number of households, and the number of households is a key element in energy consumption. Household size in the U.S. and the State of Alaska has been decreasing over time and this trend is expected to continue.

The study area boroughs and census areas had an average household size of about 3.63 persons in 1990 and about 3.59 in 2000, a decrease of about 0.04 persons over the 10-year period. Assuming that this same rate of decrease continues into the future, the average household size will be approximately 3.48 persons in 2030.

The average household size and the resulting number of households are presented in Table 16. Population is projected to increase approximately 22.1 percent between 2006 and 2030, while the number of households is projected to increase approximately 25.3 percent. If all other factors remained the same, fuel consumption in the communities within the study (project) area could be expected to increase by approximately 25 percent.

Table 16. Estimated Population, Average Household Size, and Households in Study Area, 2006-2030

Year	Population	Average Household Size	Households
2006	60,945	3.57	17,086
2010	63,526	3.55	17,885
2015	66,228	3.53	18,744
2020	68,906	3.51	19,605
2025	71,438	3.50	20,433
2030	74,438	3.48	21,405

Source: Northern Economics Inc.

As shown in Table 17, there has been an outmigration from many rural communities during years from 2000 to 2006. There appears to more outmigration, amounting to 1 person in 5, in small villages less than 100 residents in size.

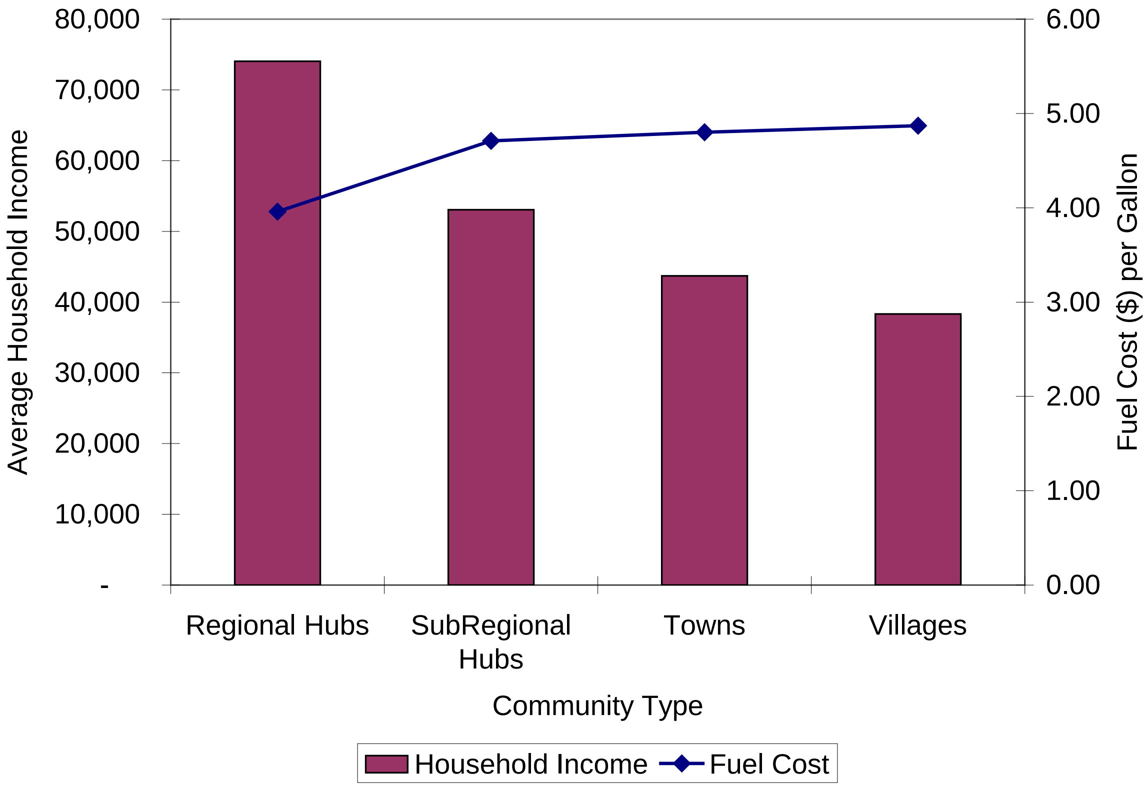
Table 17. Project Area Population Change by Community Type, 2000 and 2006.

Community Type	2000	2006	Loss/Gain	% of 2000
Villages				
Less than 100	2,958	2,370	-588	-19.9
Population 101 to 200	4,061	3,630	-431	-10.6
Population 201 to 300	5,603	5,565	-38	-0.7
Population 301 to 400	3,986	4,195	209	5.2
Sub-regional Hubs and Towns				
Population 401 to 500	5,808	6,190	382	6.6
Population 501 to 600	5,448	5,534	86	1.6
Population 601 to 1000	13,836	14,543	707	5.1
Villages, Sub-regional Hubs and Towns Subtotal	41,700	42,027	-327	-0.8
Hubs				
Dillingham	2,466	2,397	-69	-2.8
Kotzebue	3,082	3,104	22	0.7
Nome	3,505	3,540	35	1.0
Barrow	4,581	4,065	-516	-11.3
Bethel	5,471	5,812	341	6.2
Hubs Subtotal	19,105	18,918	-187	-1.0
Total	**60,805**	**60,945**	**140**	**0.2**

Source: U.S. Census Bureau, Census 2000, Census 2000 Summary File 1 (SF 1); Alaska Department of Community, Commerce and Economic Development, 2007.

Figure 10 shows estimated average household income in 2007 (on the left vertical axis) and 2007 fuel cost per gallon (on the right vertical axis) for project areas communities, by size. Smaller communities have lower average household incomes and somewhat increased fuel prices, especially when compared to regional hubs.

Figure 10. Project Area Communities, by Category, Average 2007 Household Income and 2007 Fuel Cost.



Source: Fuel costs from Current Community Conditions: Fuel Prices Across Alaska June 2007 Update. Alaska Department of Commerce, Community, and Economic Development. Accessed at http://www.commerce.state.ak.us/dca/pub/FuelSurveyJune07Web.pdf on December 13, 2007.

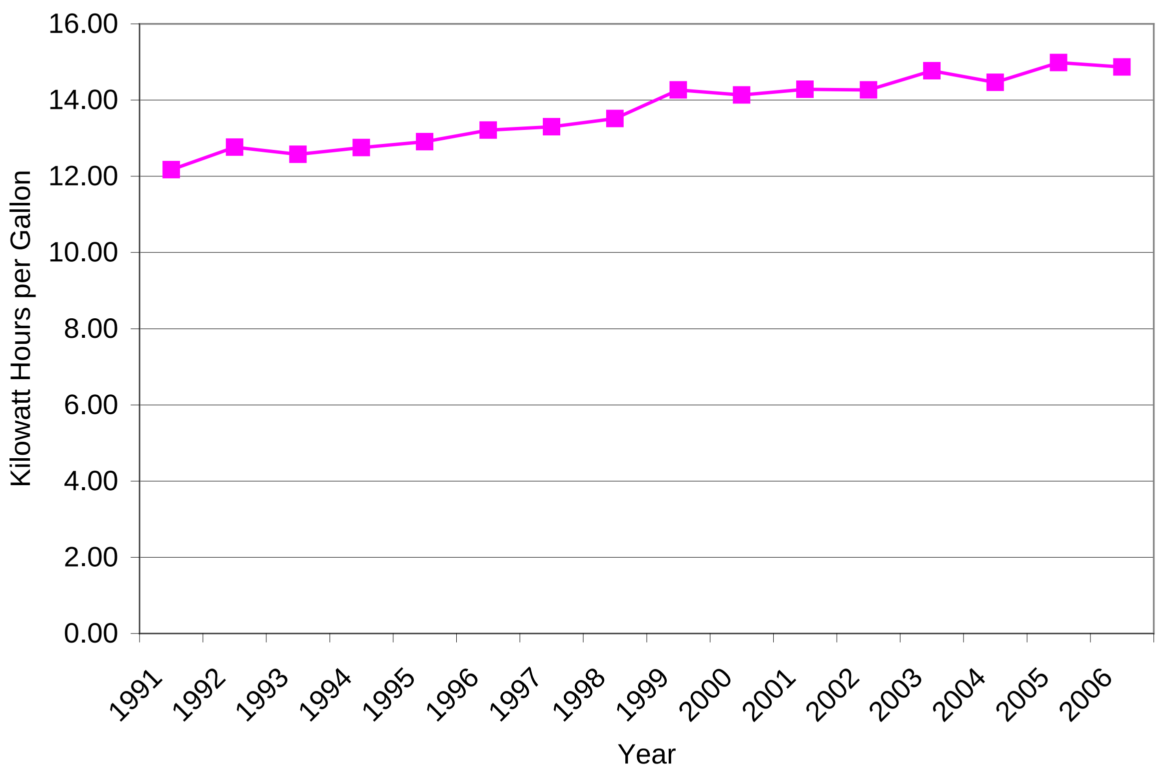
Household income data are from the 2000 Census (U.S. Bureau of the Census) and increased according to the Bureau of Economic Analysis data on changes in per capita personal income for the boroughs and census areas in the study area as calculated by Northern Economics. The data were accessed on December 14, 2007 and are available at http://www.bea.gov/regional/reis/drill.cfm. The estimate for 2006 was increased by the annual percentage increase in per capita income for the State of Alaska since 2006 local area data are not yet available.

3.3.2 Technological Change

Over time it is anticipated that technological improvements will continue and the efficiency of space heating equipment, electric appliances, electric generating equipment, and similar elements will improve. These improvements will contribute to incremental reductions in fuel demand over time. In addition to this equipment, continued technological improvements are anticipated for alternative energy projects in rural Alaska, which could further reduce petroleum demand.

Figure 11 shows the change in average electrical generation efficiency reported by utilities participating in the PCE program that has occurred over the 1991 to 2006 time frame. The average kilowatt hours per gallon of fuel have increased from slightly over 12 kWh per gallon to about 15 kWh per gallon.

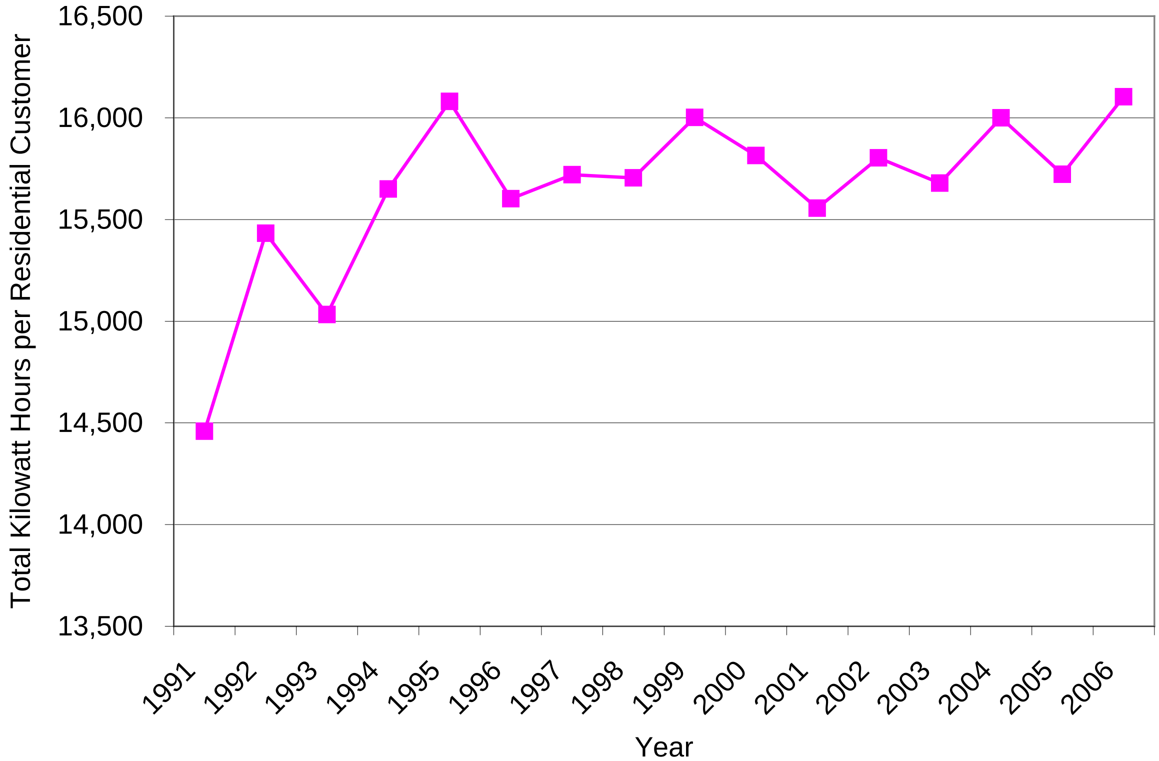
Figure 11. Average Kilowatt Hours per Gallon of Fuel, 1991-2006



Source: Calculations by Northern Economics, Inc. Data from Alaska Energy Authority, 2007. Statistical Report of the Power Cost Equalization Program, Fiscal Year 2006. Accessed at http://www.aidea.org/aea/PDF%20files/2007PCEStatisticsFY06.pdf on October 27,2007.

To some extent, increased efficiencies in electrical appliances are expected to be offset by a number of factors. These include the continuing increase in the number of electric appliances and equipment used in homes in rural Alaska, and the increasing size of homes and number of community facilities in most villages. Figure 12 shows the average kilowatt hours per residential customer for utilities participating in the PCE program. Since the mid-1990s the trend is for slightly higher electrical consumption per residential customer.

Figure 12. Average Kilowatt Hours per Residential Customer, 1991-2006



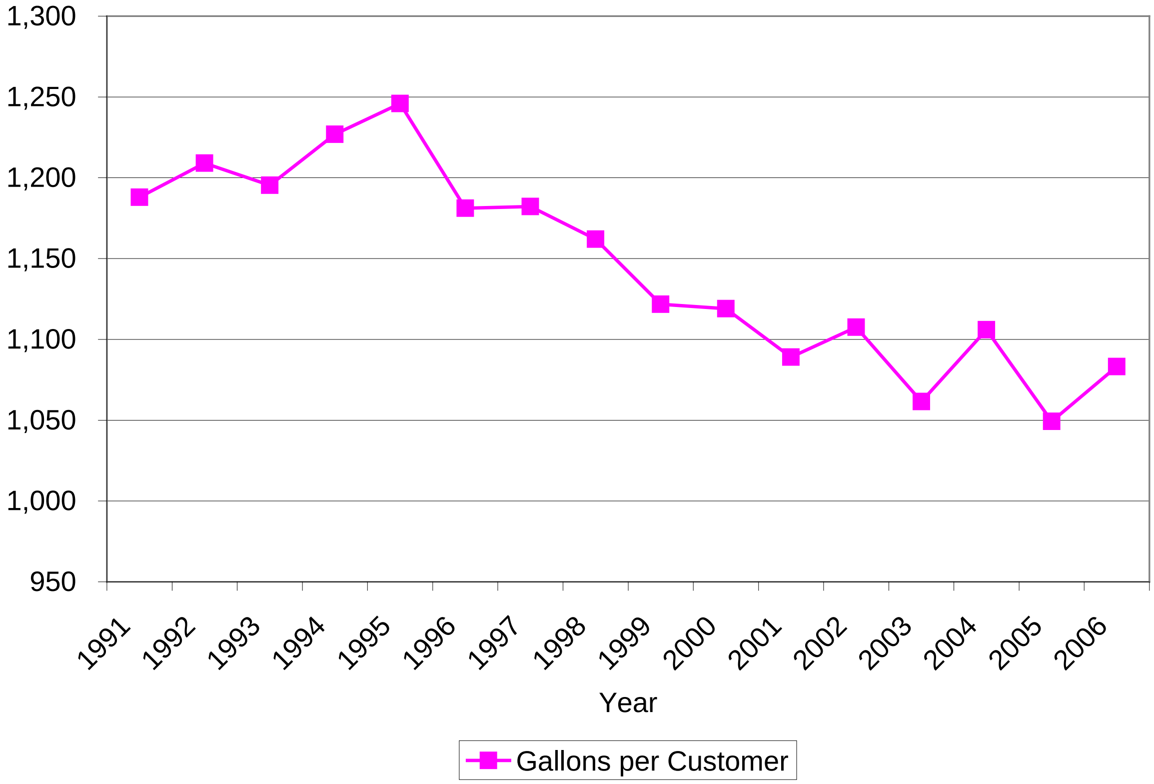
Source: Calculations by Northern Economics, Inc. Data from Alaska Energy Authority, 2007. Statistical Report of the Power Cost Equalization Program, Fiscal Year 2006. Accessed at http://www.aidea.org/aea/PDF%20files/2007PCEStatisticsFY06.pdf on October 27,2007.

The net effect of these factors is presented in Figure 13, which shows the average gallons consumed per residential customer for utilities participating in the PCE program. This estimate uses the total gallons consumed to produce electricity for all residential and commercial customers, as well as community facilities. The average gallons consumed has decreased from a peak of about 1,250 gallons per residential customer in 1995 to 1,050 gallons in 2005, with a slight increase to about 1,090 gallons in 2006. The trend suggests lower fuel consumption per residential customer in the future although possibly decreasing at a slower rate.

Similar trends are thought to exist for space heating use in the study area as fuel efficient Toyo and Monitor stoves and similar equipment have replaced older oil furnaces, but data are not available to document this opinion.

Benefits of using these stoves for space heating may have already been captured as many homes have already converted to the more fuel-efficient equipment. However, boilers and other commercially-sized heating equipment can last for 20 years or more so the response to higher prices may extend over a long period of time. The trend of lower fuel consumptions for residential heating is likely to continue lower but at a decreasing rate.

Figure 13. Average Gallons of Fuel Consumed per Residential Customer for PCE Utilities, 1991-2006



Source: Calculations by Northern Economics, Inc. Data from Alaska Energy Authority, 2007. Statistical Report of the Power Cost Equalization Program, Fiscal Year 2006. Accessed at http://www.aidea.org/aea/PDF%20files/2007PCEStatisticsFY06.pdf on October 27,2007.

Alternative energy options are increasing in the study area. Wind energy is being developed in a number of coastal communities where the wind resource is abundant. Interior villages have traditionally used wood for heating their residences or for supplementing oil-fired stoves. Wood and other types of biomass are being investigated for commercial scale heating and even gasification. High fuel and electricity prices have made these alternatives viable and the technologies are improving and becoming more efficient and cost-effective each year.

3.3.3 Response of Consumers to Price Changes of Heating Fuels and Electricity

Crude oil prices are at historic peaks at the time this report is being prepared. These prices have translated into substantial price increases for petroleum products and electricity in the study area. The future prices for crude oil are unknown but the EIA has developed scenarios of possible crude oil prices in the future. The price of crude oil could range from $40 per barrel to over $100 per barrel in 2005 dollars (EIA, 2007). Current prices are reaching new records but they are not expected to hold this extremely high level over the study period (See EIA's Annual Energy Outlook 2008 [Early Release] at http://www.eia.doe.gov/oiaf/aeo/prices.html).

The response of consumers to increases in prices for heating fuels or electricity is influenced by:

- Availability of substitutes
- Proportion of income spent
- Time period considered (i.e., time to adjust)
- Perceived permanency of price change
- Degree of necessity (versus luxury)

The EIA (Wade, 2007) estimated that the price response of residential consumers in the U.S. to a doubling of electricity prices (100 percent increase) would result in a short term response of a 20 percent decline in electricity consumption. The commercial sector would experience a 10 percent decline with the same cost increase. An analysis of electricity consumption in Bethel found that electricity consumption declines about 17 percent for every $1 increase in the price of fuel used for electrical generation (Northern Economics, Inc., 2007). This result suggests that the response of residents and businesses in the study may be similar to the U.S. data.

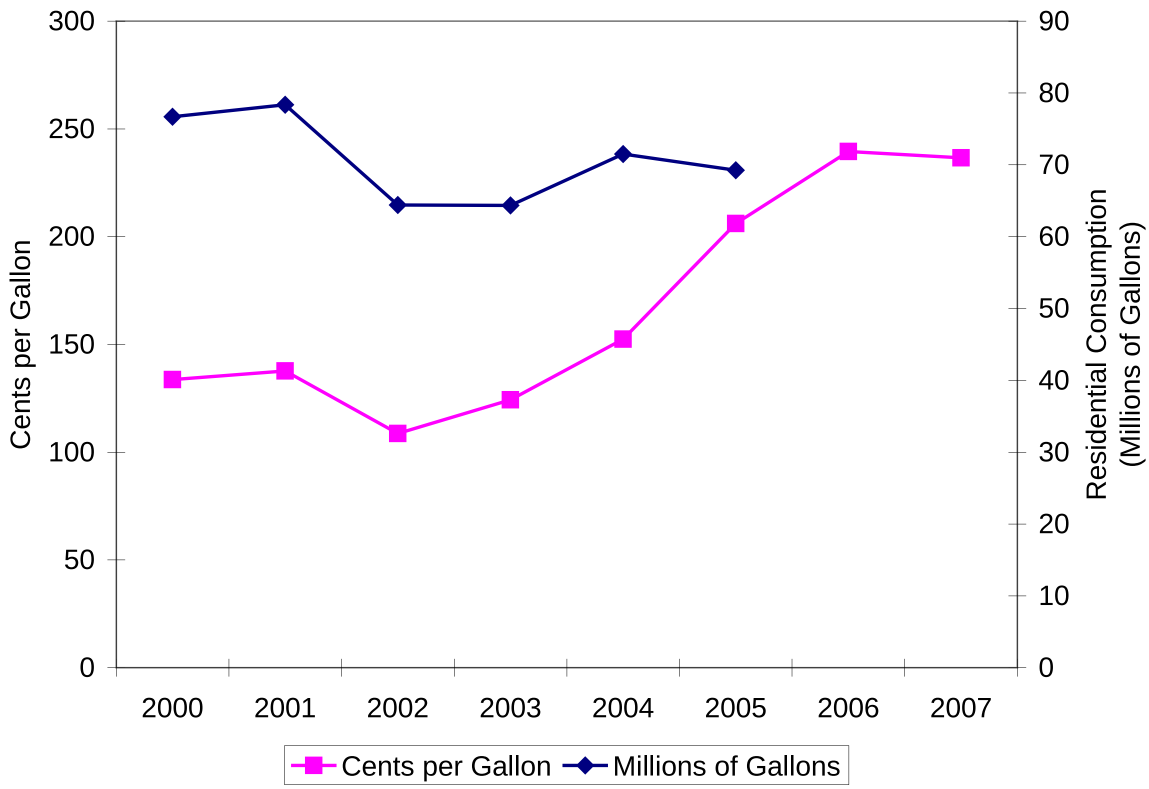
The response of consumers to high prices over a long period of time results in greater reductions in electricity or heating fuel consumption than short term increases as higher efficiency equipment is purchased and other improvements are made to reduce consumption. The EIA estimates that a long term, large increase in electricity prices will result in U.S. electricity consumption being reduced by almost half, and a long term, large increase in heating fuel prices will result in a 60 percent reduction in heating fuel consumption (Wade 2007).

The high prices for heating fuel have begun to reduce fuel consumption in the study area. For example, the community of Tanana is converting its washeteria to use wood for heating water and the building to replace as much fuel oil as possible, and residents are beginning to burn more wood to reduce heating fuel consumption.

However, many communities in the study area do not have access to major wood resources or to cost effective alternative energy sources (e.g., geothermal, conventional natural gas, coal bed methane, wind). As a result, it is not anticipated that communities heating with diesel will be able to reduce consumption of heating fuels as much as estimated by the EIA. Anecdotally, the consultant team has heard of young adults in rural Alaska moving back to live with their parents because of the difficulty in paying utility bills for both households.

Figure 14 shows the average annual prices in cents per gallon that Alaska residential consumers have paid for distillate fuels from 2000 through July of 2007. This price curve is compared with the residential consumption data that are only available through 2005. Prices in the study area are notably higher than the average statewide prices shown here. It is anticipated that the high prices in 2006 and 2007 will be reflected in lower consumption when the consumption data are reported.

Figure 14. Distillate Prices to Residential Consumers in Alaska and Residential Consumption



Sources: EIA, 2007b. Distillate Fuel Oil and Kerosene Sales by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/pet_cons_821use_dcu_nus_a.htm on October 24, 2007. EIA, 2007c. October 2007 Monthly Energy Review, Table 9.8c. No. 2 Distillate Prices to Residences: Selected Western States and U.S. Average. Accessed at http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T09.08c on October 28, 2007.

Future consumption of distillates and kerosene in the state and the study area will be influenced by two major drivers that are opposing forces. First, population growth and the resulting increase in households will result in greater demand for these fuels. Second, the response of consumers to the substantial increase in high fuel prices is reducing demand. Over the long run, we anticipate that reductions will occur in the consumption of electricity but because the PCE program subsidizes electricity rates in rural Alaska, the response will be substantially lower than the EIA analysis would suggest.

Reductions in household heating fuel consumption may decline about 35 percent from 2001 levels, which is approximately the same as EIA's three-year short term price elasticity estimate. We also anticipate that distillate demand for on-highway use will increase as vehicles with more fuel-efficient diesel engines replace gasoline-powered engines in the future.

The change in industrial demand in the study area could be significantly larger than the changes in community demand. The Donlin Creek mine could potentially use 50 to 60 million gallons annually, and demand at the Pebble mine, which is a vastly larger deposit, could approach 80 to 100 million gallons annually. Neither of these projects has been approved for production and there is a great deal of uncertainty regarding their development. The estimates shown for industrial represent the midpoint of a wide range of potential consumption by the industrial sector (See Table 18). It is anticipated that the Red Dog mine will continue to operate through 2030.

Table 18. Current and Projected Distillate and Kerosene Fuel Consumption in Alaska, 2005-2030

	2005	2010	2015	2020	2025	2030
End-Use Category	**(Millions of Gallons)**					
Residential	69.3	61.4	60.6	59.4	57.7	55.4
Commercial	42.2	37.4	37.0	36.3	35.2	33.8
Industrial	44.9	50.0	87.5	112.5	138.5	150.0
Farm and Other	0.0	0.1	0.1	0.1	0.1	0.1
Electric Power	57.5	57.5	58.5	60.5	62.2	63.6
Oil Company	17.5	20.0	25.0	30.0	35.0	40.0
Railroad	6.9	7.5	8.0	8.5	9.0	9.5
Vessel Bunkering	121.2	125.0	125.0	125.0	125.0	125.0
On-Highway	172.6	186.7	198.7	206.5	210.1	211.2
Military	14.4	15.0	15.0	15.0	15.0	15.0
Off-Highway	17.9	17.9	17.9	17.9	17.9	17.9
Total	**564.4**	**578.4**	**633.2**	**671.6**	**705.5**	**721.3**

Source: Estimates by Northern Economics, Inc.

The estimate for Alaska's oil company sector increases to reflect the potential construction of a natural gas pipeline as well as the expansion of exploration and production activities to the Chukchi Sea and other frontier areas. Railroad consumption has been increasing over time and this is anticipated to continue through 2030.

Vessel fueling is down from historic peaks and is anticipated to remain at approximately the same level as in 2005. The number of vessels participating in the state's fisheries has declined over time but further consolidation is expected to be minimal. On-highway consumption is expected to increase over time in line with expansion of the truck transportation industry and the conversion of vehicles to diesel engines in the future. Consumption by the military has increased slightly in the past few years in response to the expansion of the military's presence in the state. It is anticipated to increase slightly by 2010 and is then expected to remain stable. Off-highway consumption in the state has varied greatly over the years with no discernible trend and this estimate is a continuation of the latest EIA data.

Table 19 shows the projected fuel consumption in the study area through 2030 and the 2006 consumption estimate. Total community consumption of petroleum products and distillates is expected to remain near current levels or decline slightly over the next few years in response to substantially higher prices. Total distillate and kerosene consumption in the study area is expected to increase over time with anticipation that one or more major mineral deposits will be developed in the region.

Table 19. Projected Petroleum Fuels Consumption in the Study Area, 2006-2030

Use	2006	2010	2015	2020	2025	2030
	(Millions of Gallons)					
1. Total Community Petroleum Products	71.2	70.9	73.1	76.4	80.3	85.3
2. Motor Gasoline	13.6	13.5	13.4	13.2	12.9	12.6
3. Total Community Distillate Products (1-2)	57.6	57.3	59.7	63.2	67.4	72.8
4. Electricity	19.1	19.2	19.4	20.0	20.6	21.2
5. Residential	14.1	12.5	12.3	12.1	11.7	11.3
6. Marine	4.1	4.1	4.1	4.1	4.1	4.1
7. Aviation	6.4	6.6	6.9	7.1	7.4	7.7
8. Off-Road	2.1	2.2	2.3	2.4	2.5	2.6
9. Other	11.7	12.7	14.6	17.4	21.2	26.0
10. Distillates for Communities, Excluding Jet (3-7)	51.1	50.7	52.8	56.0	60.0	65.1
11. Industrial	24	30.0	87.5	112.5	137.5	150.0
12. All Distillates, excluding Jet (10+11)	75.1	80.7	140.3	168.5	197.5	215.1
13. Regulated Distillates (4+6+8+11+.25*9)	52.2	58.7	117.0	143.4	170.0	184.3

Source: Estimates by Northern Economics, Inc.

Notes: The volumes shown for all distillates, excluding jet fuel, represent the maximum amount of ULSD that might be required in the study area if all uses except those needing jet fuels switched to ULSD. Regulated distillates are a portion of total distillates and indicate the volumes of ULSD that might be required if only regulated sources, including all power generation equipment, switched to ULSD. Approximately 25 percent of the Other category is anticipated to use ULSD.

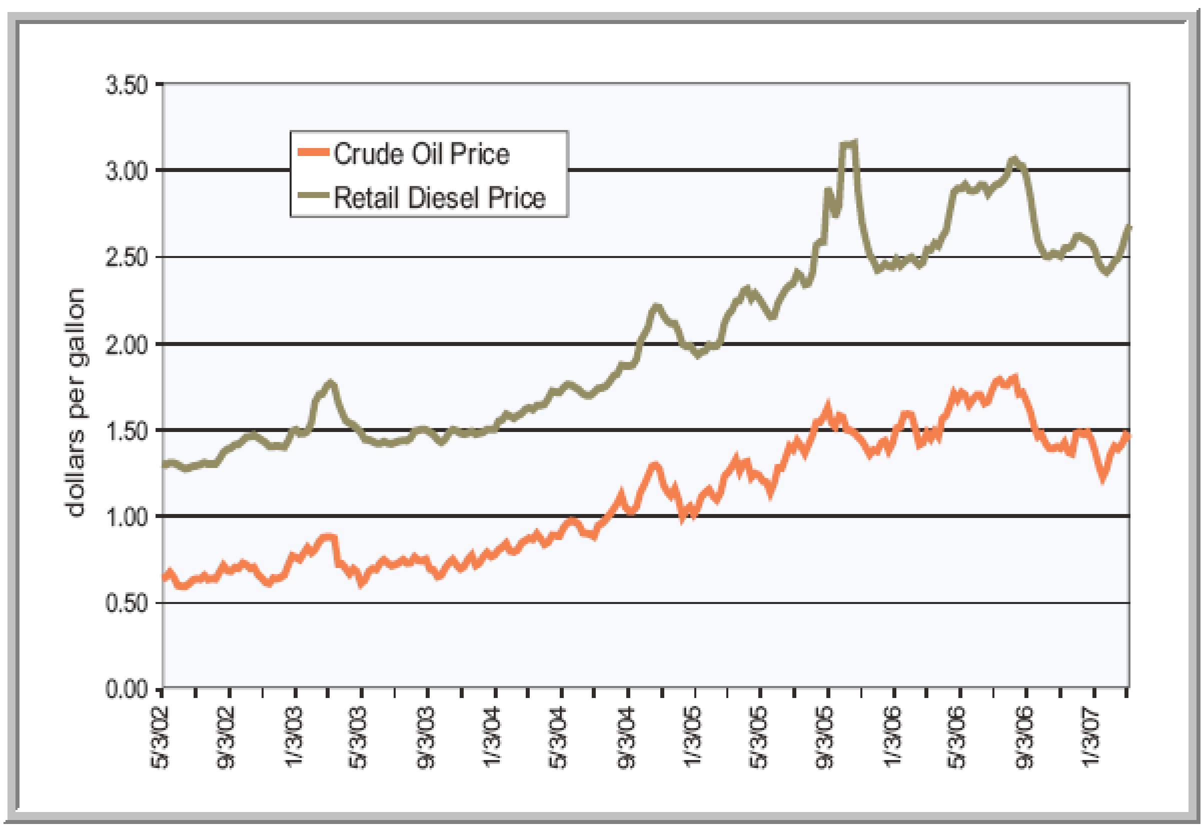
4 Fuel Costs and Electric Power Generation

The objective of this subsection is to assess the potential price differences between the various distillate fuels and to describe the effect of fuel costs on electric power generation. Rural communities across the state and in the study area rely heavily on distillate fuels to generate electricity and to heat their homes and buildings. While costs vary by region across the state, rural Alaska communities typically pay some of the highest energy costs in the U.S. In a 2007 survey of rural Alaska communities, western Alaska communities reported the highest average heating fuel retail price while residents in the northern Alaska in the North Slope Borough reported the lowest. Note the North Slope Borough subsidizes heating fuel for residential use.

4.1 Fuel Costs

One of the goals of this study is to assess the costs of transitioning to ULSD in rural western and northern Alaska. The development of a pricing estimate for ULSD prices starts with a review of the current pricing structures for distillate fuels. In analyzing pricing data for various distillate products, it is important to note that the prices of distillate fuels generally follow the price of crude (see Figure 15). However, as demonstrated in this chapter, market pressures can distort those prices. The next subsections review the pricing structure and compare pricing differentials for various distillate products for Anacortes, Washington, and Fairbanks and Anchorage.

Figure 15. Diesel Fuel Prices follow Crude Oil Prices, Dollars per Gallon



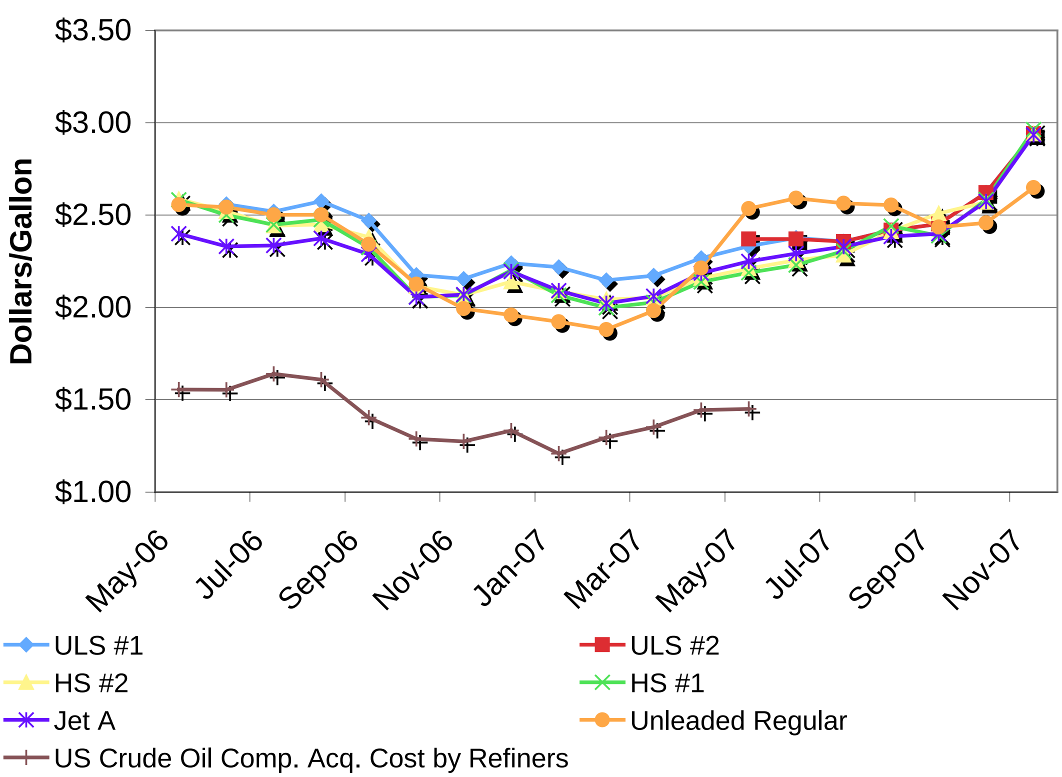
Source: Source: Energy Information Administration, EIA-X063, April 2007.

4.1.1 Fuel Cost Trending

The development of a pricing estimate for ULSD prices starts with a review of the current pricing. Data were collected for fuel prices over the last 16 months in Alaska (Fairbanks and Anchorage) and Anacortes, Washington. These data have been collected from the OPIS (Oil Price Information Service) and represent wholesale prices. Figure 16 through Figure 18 are a compilation of distillate prices for these three regions. What is most important about these curves is the shape. The variety of distillate product pricing for each region tends to move together and in some cases, the ULSD products tend to converge over time. There are no significant outliers in the data set.

Table 20 and Table 21 provide a price differential by month between USL No. 1 and Jet A, the two most likely fuels in a two-fuel scenario. Both are required fuels—ULSD is currently mandated by the EPA for on-highway vehicles and will apply to stationary engines in the future. (EPA, 2004) Jet A is necessary for any location that services jet or turboprop aircraft, and can also be used for home heating fuel oil. Therefore, the spread indicates the maximum cost differential for fuel to be used specifically for stationary power plants, diesel automotive, and diesel marine. Table 22 provides a pricing spread between high sulfur No. 2 and ULSD No. 2 with an average differential of 1.44 percent.

Figure 16. Anchorage Distillate Cost Comparison



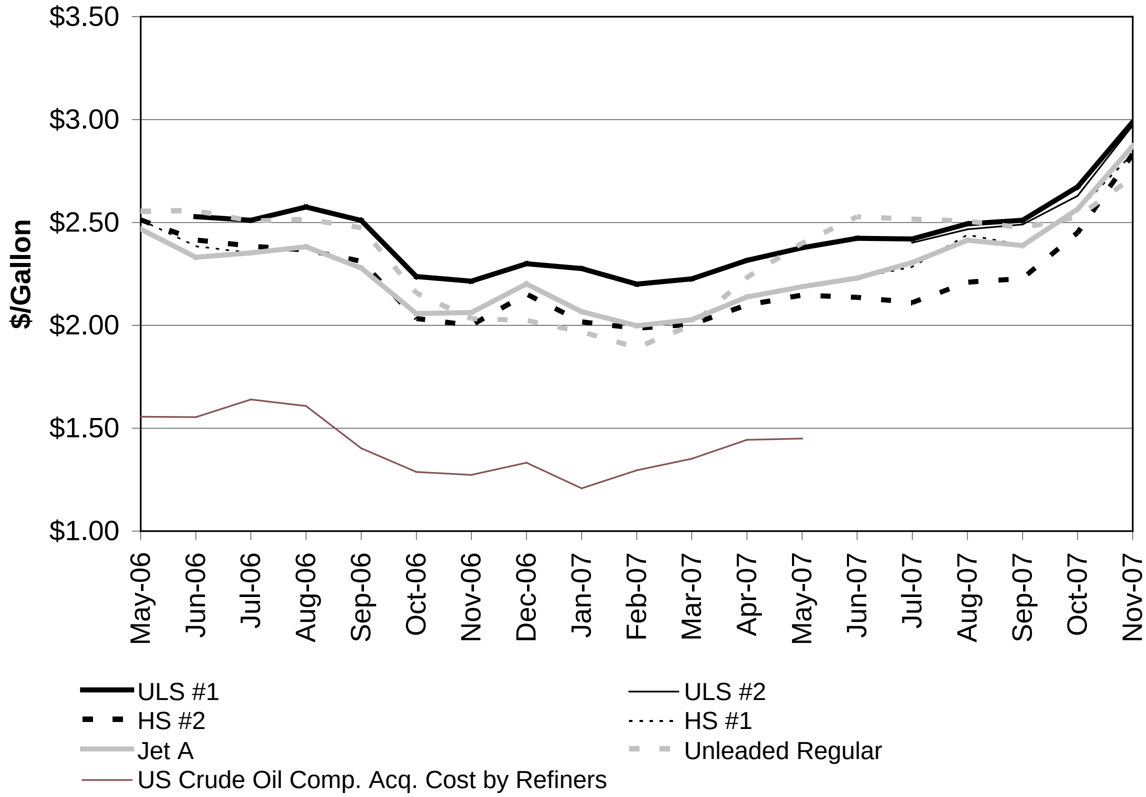
Source: OPIS Data, December 2007.

Table 20. Anchorage Pricing Differential per Gallon.

Month	ULS No. 1 ($)	Jet A ($)	Price Spread ($)	Pricing Spread (%)
June 2006	2.5588	2.3308	0.2280	9.78
July 2006	2.5189	2.3354	0.1835	7.86
August 2006	2.5754	2.3744	0.2010	8.47
September 2006	2.4704	2.2877	0.1827	7.99
October 2006	2.1763	2.0561	0.1202	5.85
November 2006	2.1547	2.0694	0.0853	4.12
December 2006	2.2400	2.1950	0.0450	2.05
January 2007	2.2178	2.0910	0.1268	6.06
February 2007	2.1468	2.0221	0.1247	6.17
March 2007	2.1722	2.0611	0.1111	5.39
April 2007	2.2670	2.1856	0.0814	3.72
May 2007	2.3320	2.2491	0.0829	3.69
June 2007	2.3767	2.2919	0.0848	3.70
July 2007	2.3569	2.3287	0.0282	1.21
August 2007	2.4179	2.3841	0.0338	1.42
September 2007	2.4515	2.3993	0.0522	2.18
October 2007	2.6218	2.5737	0.0481	1.87
November 2007	2.9405	2.9346	0.0059	0.20
Average			0.1014	5.06

Source: Northern Economics, OPIS.

Figure 17. Fairbanks Distillate Cost Comparison



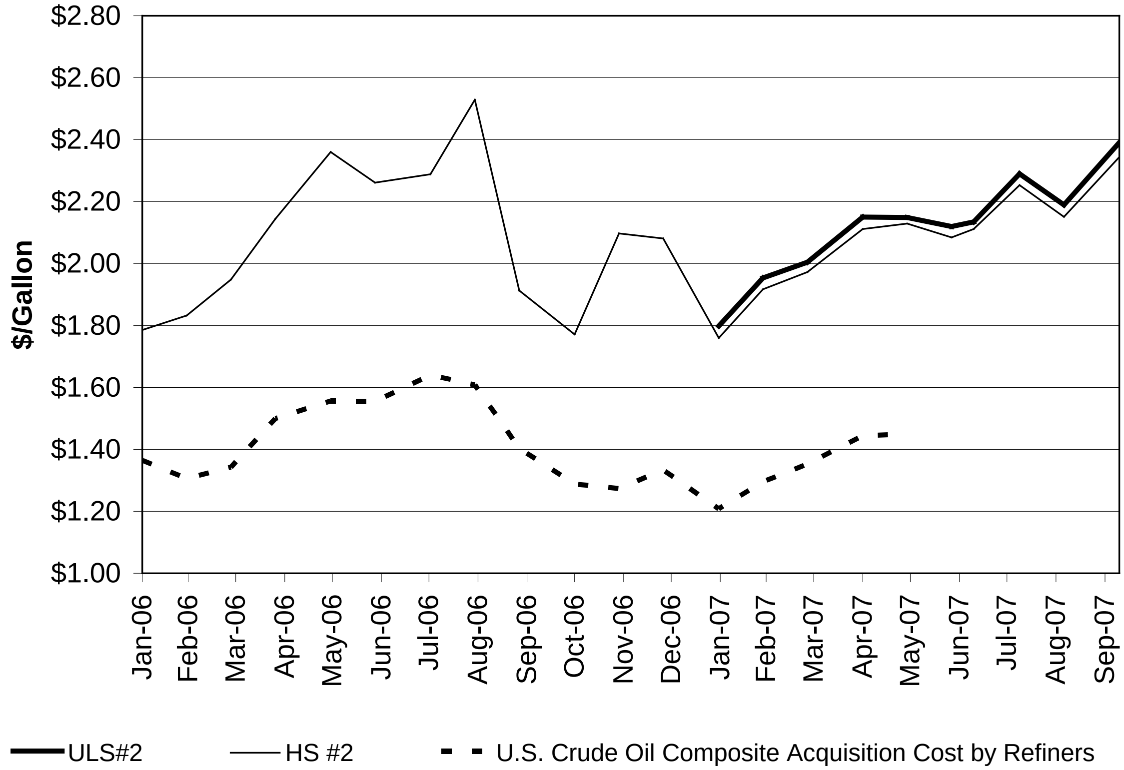
Source: OPIS data, November 2007.

Table 21. Fairbanks Pricing Differential per Gallon

Month	ULS No. 1 ($)	Jet A ($)	Price Spread ($)	Pricing Spread (%)
June 2006	2.5286	2.3315	0.1971	8.45
July 2006	2.5112	2.3523	0.1589	6.76
August 2006	2.5754	2.3822	0.1932	8.11
September 2006	2.5094	2.2796	0.2298	10.08
October 2006	2.2369	2.0577	0.1792	8.71
November 2006	2.2144	2.0631	0.1513	7.33
December 2006	2.3000	2.2019	0.0981	4.46
January 2007	2.2763	2.0663	0.2100	10.16
February 2007	2.2002	1.9983	0.2019	10.10
March-2007	2.2256	2.0278	0.1978	9.75
April 2007	2.3159	2.1380	0.1779	8.32
May 2007	2.3772	2.1878	0.1894	8.66
June 2007	2.4233	2.2300	0.1933	8.67
July 2007	2.4196	2.3054	0.1142	4.95
August 2007	2.4931	2.4141	0.0790	3.27
September 2007	2.5105	2.3884	0.1221	5.11
October 2007	2.6731	2.5652	0.1079	4.21
November 2007	2.9890	2.8727	0.1163	4.05
Average			**0.1621**	**7.85**

Source: OPIS, December 2007.

Figure 18. Anacortes Distillate Cost Comparison



Source: OPIS data, November 2007.

Table 22. Anacortes Pricing Differential per Gallon

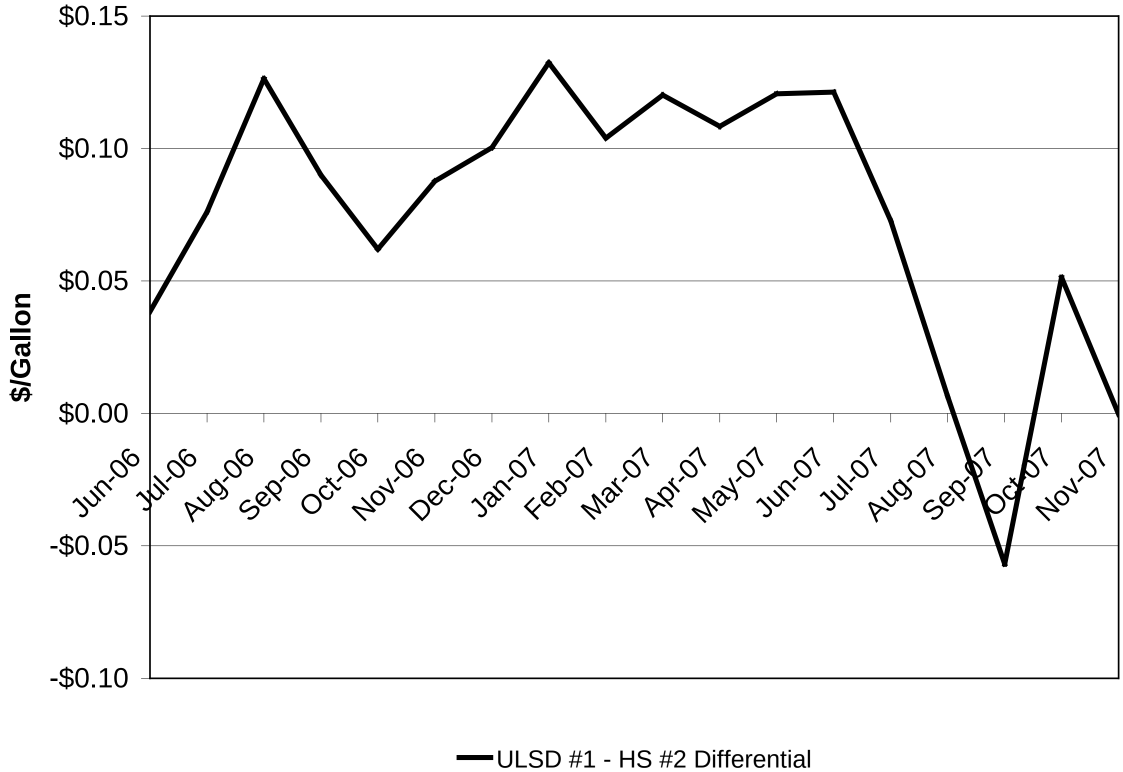
Month	ULS No. 2 ($)	HS No. 2 ($)	Price Spread ($)	Pricing Spread (%)
January 2006	1.8366	1.7855	0.0511	2.86
February 2006		1.8325		
March 2006		1.9480		
April 2006		2.1437		
May 2006		2.3604		
June 2006		2.2614		
July 2006	2.2624	2.2883	-0.0259	-1.13
August 2006		2.5292		
September 2006		1.9127		
October 2006		1.7710		
November 2006		2.0975		
December 2006		2.0809		
January 2007	1.7982	1.7599	0.0383	2.18
February 2007	1.9534	1.9171	0.0363	1.89
March 2007	2.0041	1.9723	0.0318	1.61
April 2007	2.1499	2.1115	0.0384	1.82
May 2007	2.1487	2.1289	0.0198	0.93
June 2007	2.1193	2.0842	0.0351	1.68
July 2007	2.1344	2.1114	0.0230	1.09
August 2007	2.2895	2.2534	0.0361	1.60
September 2007	2.1894	2.1506	0.0388	1.80
October 2007	2.3904	2.3439	0.0465	1.99
Average			0.0308	1.53

Source: OPIS, November 2007.

4.1.2 Diesel Fuel Differentials (ULSD vs. High Sulfur)

The data indicate that the local price differential between Jet A and ULSD No. 1 is between five and eight percent. Costs for ULSD are higher in Fairbanks because that product is shipped from Anchorage. In this section, we examine the differentials between ULSD products and High Sulfur (HS) products, especially No. 2 HS Diesel, which is used for home heating and can be used in stationary engines until mandated by the EPA regulations. These differentials indicate one of the cost impacts that the sulfur regulations would have on rural Alaska.

Figure 19. Price Differential of Anchorage ULSD No. 1 and HS No. 2 Diesel



Source: OPIS data, August 2007.

Price differences range from -0.06 cents/gallon to a high of 13.2 cents/gallon with an average difference of approximately 9.1 cents/gallon. The July and August prices had a significant decrease in the spread between ULSD No. 1 and HS No. 2 diesel. The September and October prices varied considerably and may reflect reporting, rather than actual differences. The percent difference between ULSD and HS No. 2 was four percent, slightly less than the difference between ULSD and Jet A.

In Fairbanks, the difference between ULSD No. 1 and HS No. 2 is significantly higher than for Anchorage (see Figure 20). The explanation for this is that all ULSD products are shipped by rail from Anchorage to Fairbanks, while the HS product is obtained from local refiners. The end result is an average pricing premium of 21.6 cents/gallon over HS No. 2, or a 10 percent premium.

Figure 20. Fairbanks ULSD No. 1/HS No. 2 Diesel and ULSD No. 1/HS No. 1 Differential

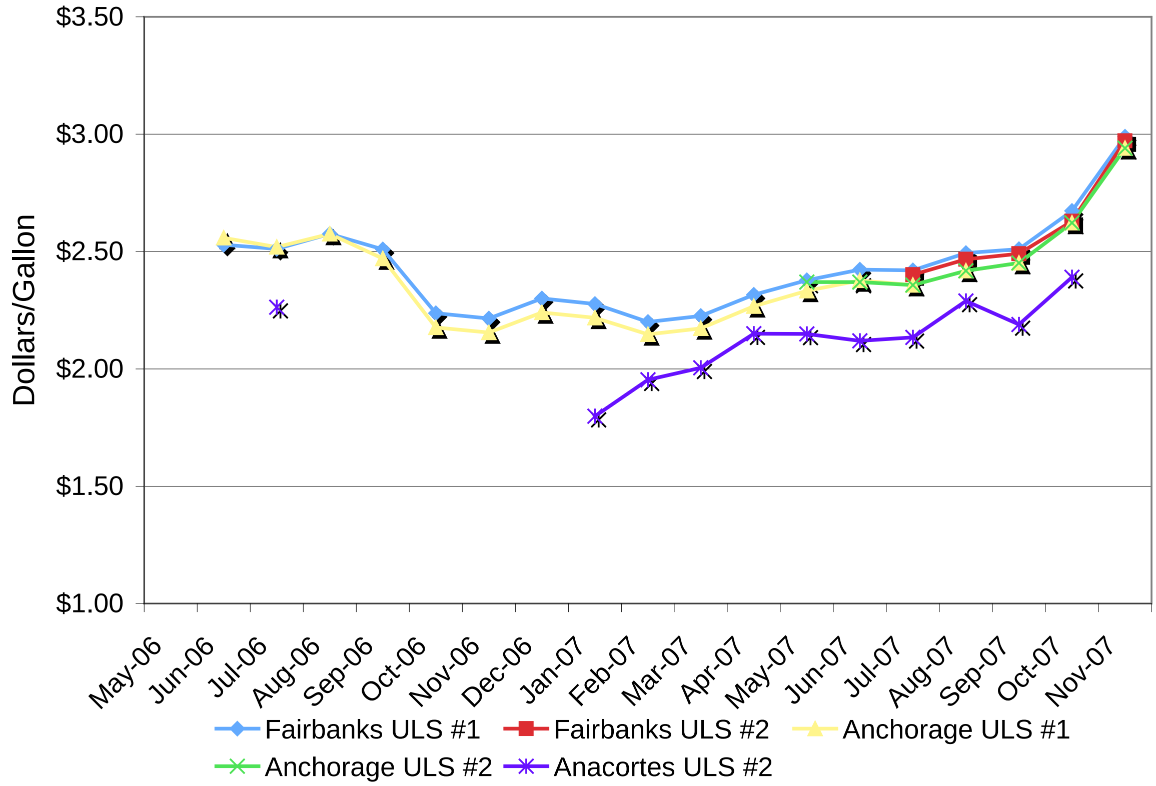
Source: OPIS data, December 2007.

In the Northwest, as evidenced by the distillate prices in Anacortes (Figure 18), there is very little differential between ULSD No. 2 and HS No. 2, on the order of 2.7 cents per gallon and a 1.44 percent premium for ULSD.

In Fairbanks there is a significant price difference between the ULSD and high sulfur products. The high sulfur products currently being refined in North Pole are significantly less expensive than the ULSD product that is shipped from Anchorage. Those portions of western Alaska served from the Fairbanks area would incur fuel costs for ULSD products that are 4.5 percent more expensive than Anchorage ULSD. Transportation costs may change that percentage differential.

Figure 21 places the Alaskan ULSD market in perspective. The Alaskan fuels are very tightly grouped with the Anacortes product being 20 to 25 cents/gallon lower in price. There are some indications that this price differential is closing. In identifying fuel costs for northern and western Alaska, shipping will be a dominant factor in pricing.

Figure 21. Alaskan Market ULSD Pricing

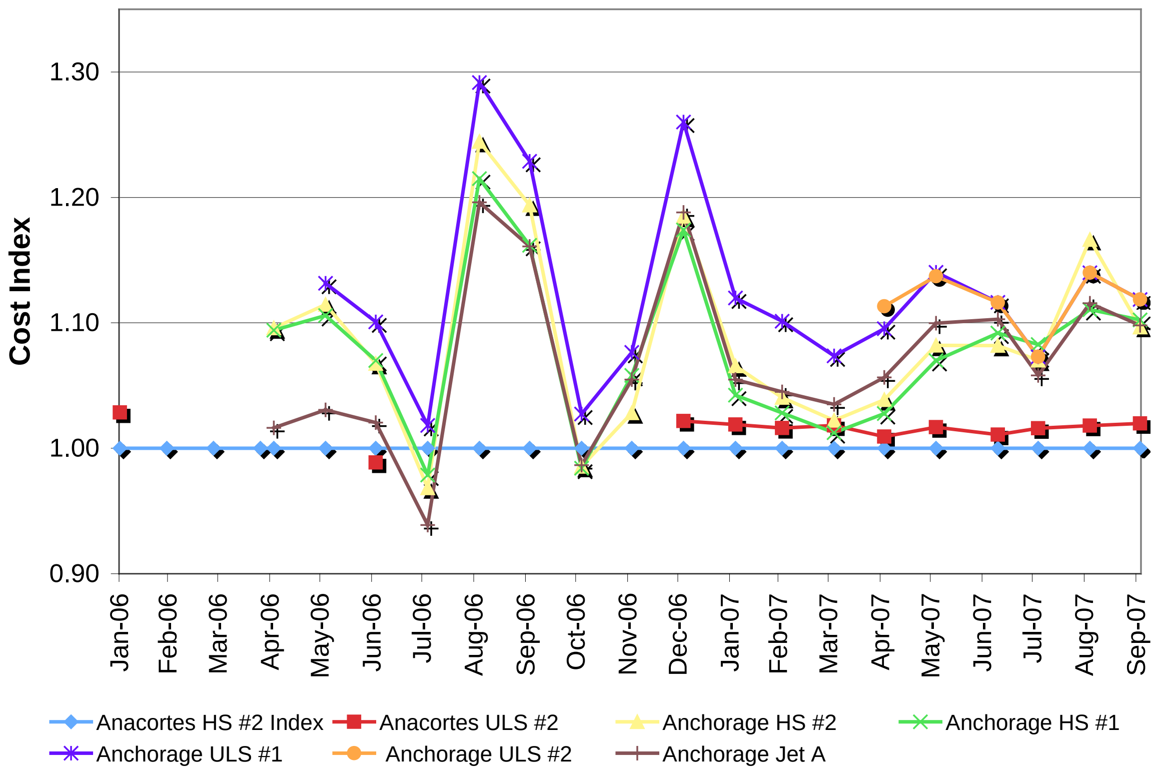


Source: OPIS data, August 2007.

4.1.3 Distillate Pricing Indices

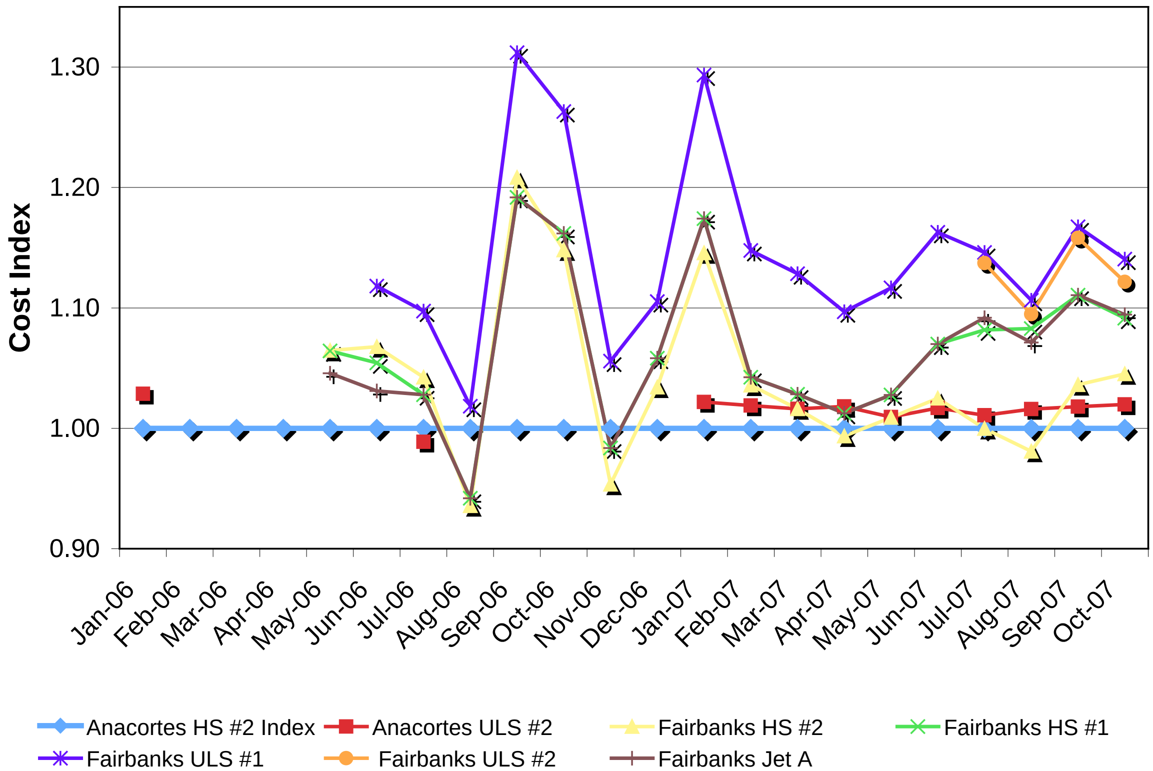
In analyzing the pricing data for the various distillate products, it is important to note that while the prices of distillate fuels generally follow the price of crude as shown in Figure 15, market pressures will distort those prices. Market fluctuations can be best demonstrated by indexing the price for distillates of interest to the price of another distillate. Fairbanks and Anchorage distillate costs were compared to Anacortes High Sulfur No. 2 Fuel Oil. Results are shown in Figure 22 and Figure 23 below. For both the cost index was calculated by dividing the OPIS market price of the respective fuel to the OPIS market price of HS No. 2 for that time period.

Figure 22. Anchorage Distillate Cost Multipliers/Anacortes Base Price



Source: OPIS data, November 2007

Figure 23. Fairbanks Distillate Cost Multipliers/Anacortes Base Price

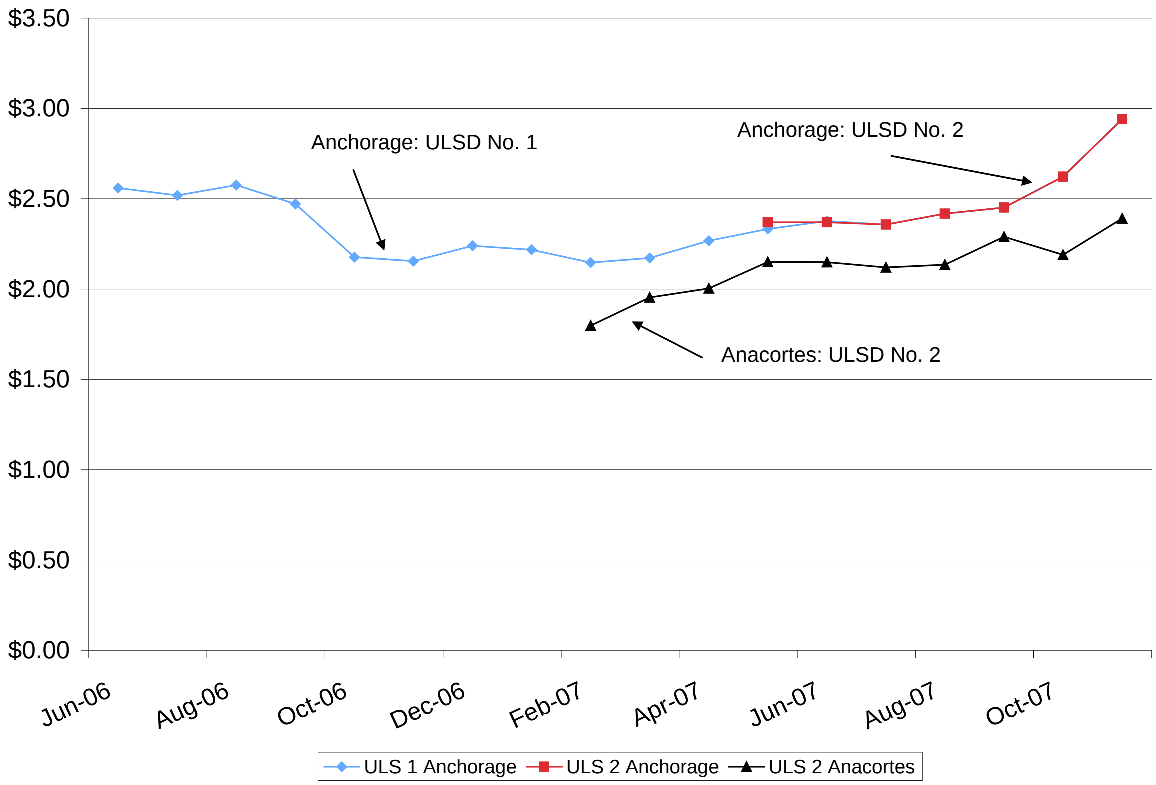


Source: OPIS, November 2007.

The Alaskan distillate prices track well together and were both subject to price spikes relative to Anacortes HS No. 2. There appears to be an adjustment towards a 10 percent premium (Alaska) for ULSD fuels over HS #2 in Anacortes. These data were further refined to look at Alaskan fuel prices indexed to Jet A (the high sulfur fuel in a two fuel scenario). Composite crude prices were also indexed to allow for future price predictions.

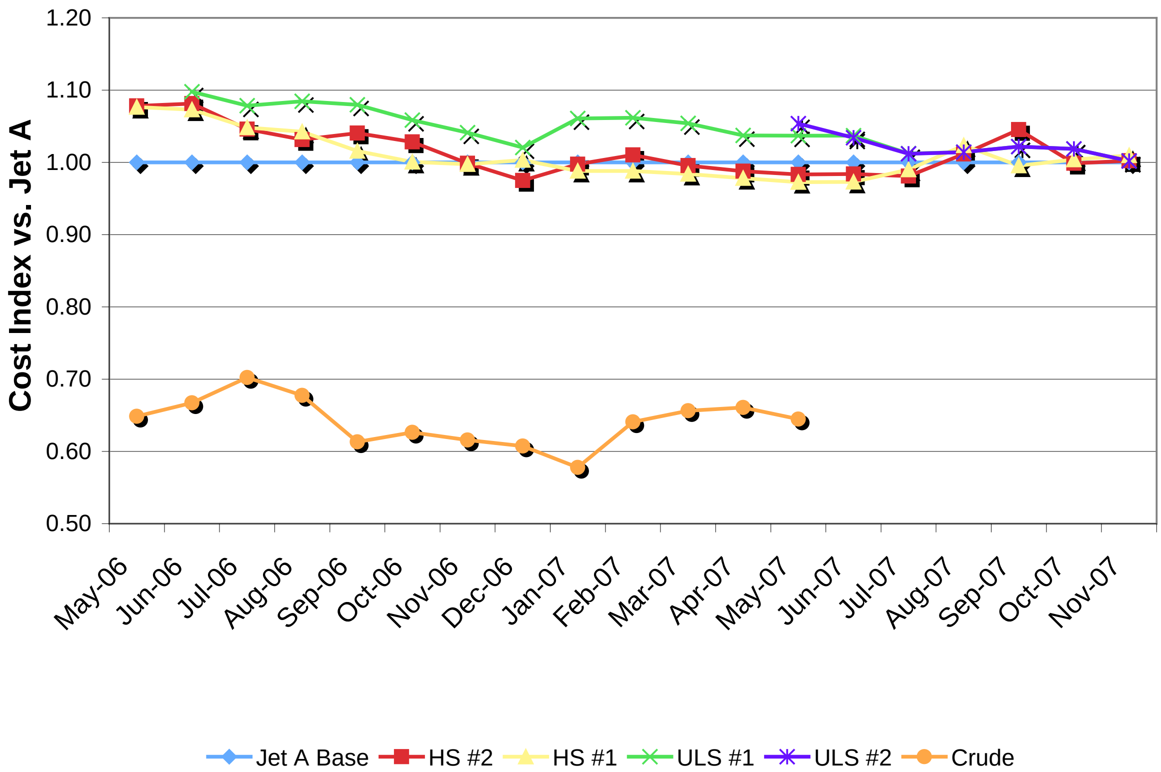
Figure 24 illustrates price differences between Anchorage and Anacortes, for ULSD No. 1 and No. 2 for the period June 2006 to November of 2007. Anacortes' prices are for ULSD No. 2, while Anchorage prices reflect both ULSD No. 1 and ULSD No. 2. ULSD No. 2 has only been reported for Anchorage since May 2007. The average price difference between Anchorage and Anacortes is $0.30 per gallon.

Figure 24. ULSD Prices ($/gallon), Anchorage and Anacortes, No. 1 and No. 2, June 2006 to November 2007.



Source: OPIS, December 2007.

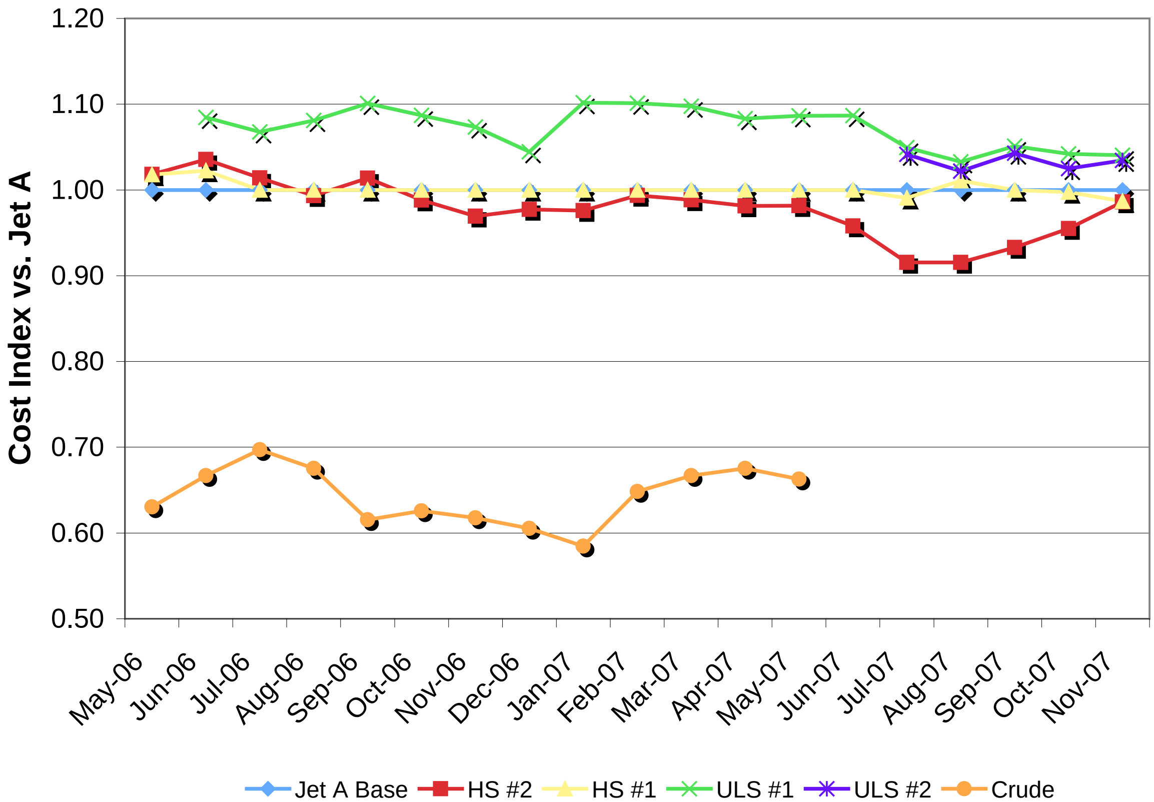
Figure 25. Anchorage Distillate Fuel Multipliers (indexed to Jet A)



Source: OPIS, December 2007.

The data in Figure 25 indicate that in a two-fuel case, ULSD No. 1 would incur an approximate five percent premium over Jet A, based on Anchorage rack prices, though they are converging. Similar data for Fairbanks rack prices are shown in Figure 26. From a strictly Fairbanks perspective, the cost premium of ULSD No. 1 over Jet A is 7.85 percent.

Figure 26. Fairbanks Distillate Fuel Multipliers (indexed to Jet A)



Source: OPIS data, December 2007.

It is important to note in all these analyses that the population samples are very small. Pricing is consistent with the EPA prediction that the market will absorb any additional manufacturing costs and that any ULSD premium will be small. The Tesoro Refinery in Nikiski has commissioned their ULSD facilities and is capable of producing 10,000 barrels per day of ULSD product (No. 1 or No. 2). The Flint Hills refinery has opted to buy USLD on a wholesale basis from Tesoro, and the future of the proposed North Slope ULSD refinery appears doubtful[7].

4.2 Electric Power Generation

The State of Alaska has addressed the issue of high energy costs in rural Alaska by implementing energy assistance funding programs. One of these programs serves as an excellent surrogate in describing the costs and characteristics of generating electricity in rural Alaska. Collecting data from all the utilities in the state would be a time consuming and costly project. Instead, we use data from the Power Cost Equalization (PCE) program, which provided subsidies in 2006 to 85 participating utilities covering 181 rural communities. The program has collected an extensive database of information submitted by participating electric utilities. The PCE program (under

[7] Alaska Journal of Commerce: *Plant death equals more trucks on roads,* December 2, 2007.

Alaska Statute 42.45.100) pays a portion of electric bills for consumers served by utilities participating in the program. State and federal offices/facilities, commercial customers and public schools are excluded from PCE. Participation in the PCE program was limited by statute to utilities meeting certain requirements as part of the programs enabling legislation:

- The utility provided electric service to the public for compensation
- During calendar year 1983, the utility had less than 7,500 megawatt hours of residential consumption or less than 15,000 megawatt hours if two or more communities were served
- During calendar year 1984, the utility used diesel-fired generators to produce more than 75 percent of its electrical consumption

Other criteria may be applied under provisions of the PCE program. For the purpose of this study, communities in the PCE list that are on the road, ferry, or railroad system or located in southcentral and southeast Alaska were excluded from this review. A total of 122 communities were included in this analysis

The following section provides a summary of the PCE data and discusses the typical features of a rural community/utility in terms of variables like population, number of residential customers, total fuel used, total cost of fuel, average price of fuel per gallon, and total diesel-generated kilowatt-hours.

4.2.1 A Description of Typical Features in Utility Generation and Fuel Use

Table 23 shows the average, minimum, and maximum values for different variables based on PCE information on selected communities that are within our project area. The summary statistics under the column "Selected PCE Communities" do not include data on the following large/hub communities (with population of over 1,000): 1) Naknek; 2) Hooper Bay; 3) Dillingham; 4) Kotzebue; 5) Nome; and 6) Bethel. Also provided in the table are data for typical towns and hubs in the Project Area, including non-PCE communities.

Table 23. Summary of 2006 PCE Data for Selected Northern and Western Communities Served by the PCE Program

Variable	Selected PCE Communities (Population <1000)			Typical Town	Typical Hub
	Average	Minimum	Maximum		
Population	329	26	899	437	5,888
Number of Residential Customers	98	15	272	84	1,620
Number of Community Facilities	9	2	31	6	16
Total kWh Sold	1,248,180	90,096	5,423,106	1,235,124	40,532,907
Total Fuel Used (gallons)	108,426	1,926	666,692	104,853	3,167,728
Total Cost of Fuel ($)	258,881	4,815	2,042,100	256,022	10,398,885
Average Price of Fuel/Gallon ($)	2.46	1.51	4.73	2.44	3.28
Total Diesel-Generated kWh	1,473,002	28,840	8,826,194	1,497,970	43,385,600

Source: 2006 PCE Data, Alaska Energy Authority. Average refers to an arithmetic mean. Typical town refers to those Project Area communities that are smaller than hubs.

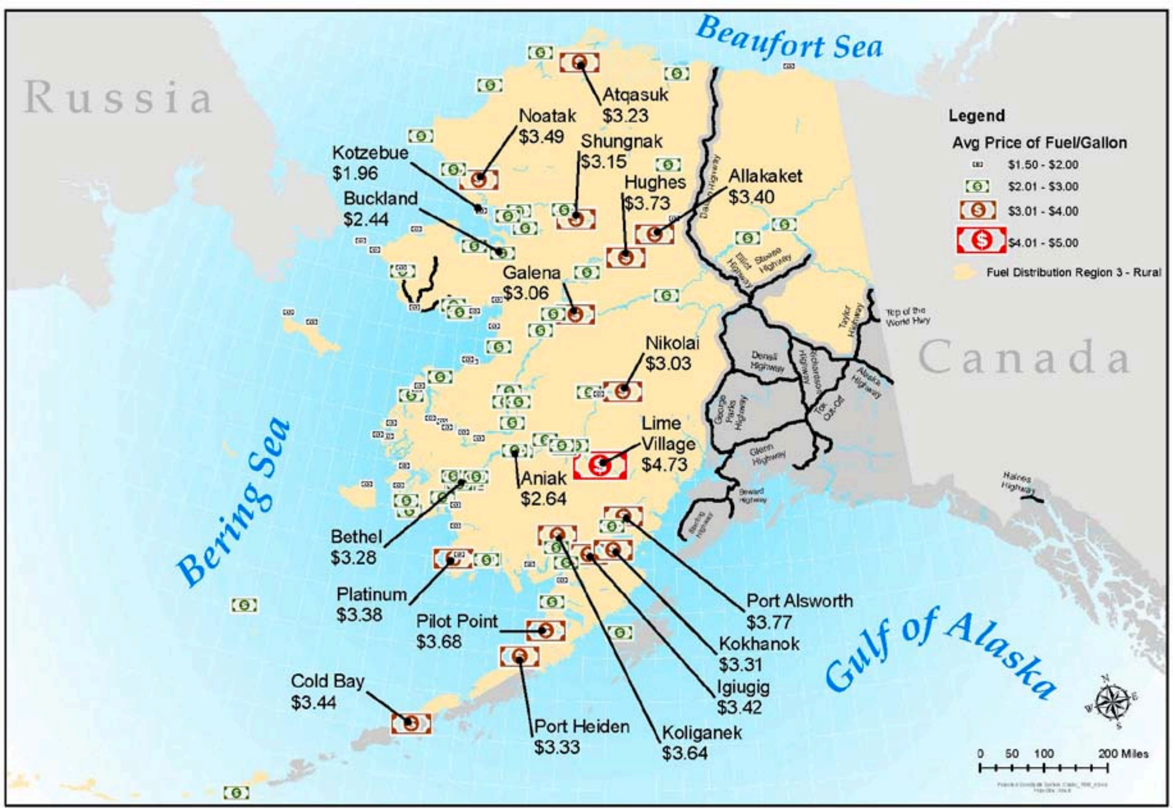
4.2.2 Average Fuel Prices per Gallon and Volume of Fuel Consumed by PCE Utilities

To assess if there are geographic differences in fuel prices and consumption, we developed maps showing the average price of fuel per gallon (see Figure 27) and the total fuel volume used (see Figure 28) for the selected PCE communities. The data reflect 2006 information provided to the Alaska Energy Authority under the PCE program by electric utilities.

Communities that paid higher average prices per gallon of fuel in 2006 (ranging between $3.00 to $4.73 per gallon) include Twin Hills ($3.00), Nikolai, Galena, Shungnak, Atqasuk, Bethel, Kokhanok, Port Heiden, Platinum, Allakaket, Alatna, Igiugig, Cold Bay, Noatak, Koliganek, Pilot Point, Hughes, Port Alsworth, and Lime Village ($4.73). There is not really any obvious regional pattern in the average fuel price distribution. The map does show, however, that most of the communities that paid higher prices for fuel are inland communities, and the coastal communities paid relatively lower fuel prices. Lime Village requires air delivery of its fuel supplies, which accounts for a major portion of the fuel cost in the community.

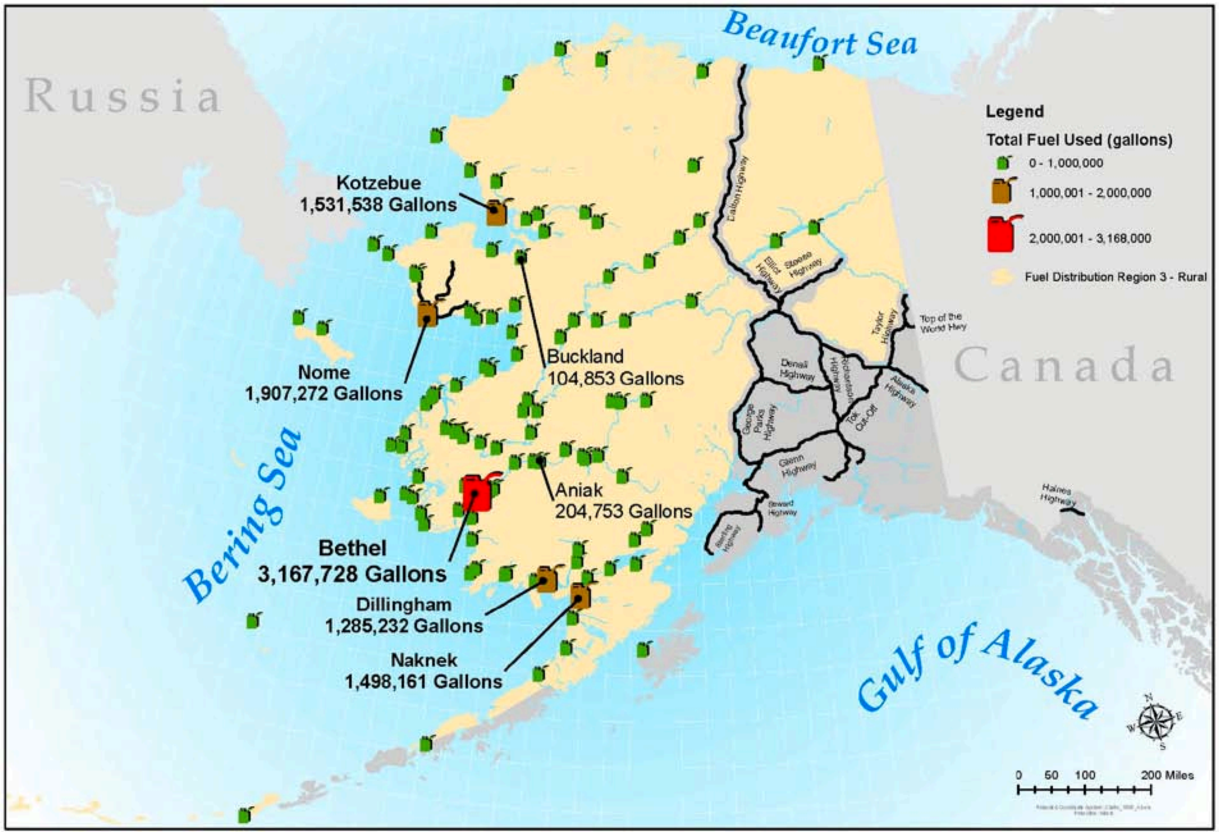
In terms of total fuel used for power generation, utilities in the larger hub communities naturally reported the highest fuel consumption—Bethel, Kotzebue, Nome, Dillingham, and Naknek. All the rest of the utilities reported less than one million gallons of fuel consumption for generating power (see Figure 28).

Figure 27. Average Price of Fuel per Gallon in Selected PCE Communities in Northern and Western Alaska, 2006



Source: Map developed by Alaska Map Company with 2006 PCE information on utility fuel consumption.

Figure 28. Total Fuel Used by Electric Utilities for Power Generation in Selected PCE Communities in Northern and Western Alaska, 2006



Source: Map developed by Alaska Map Company with 2006 PCE information on utility fuel consumption.

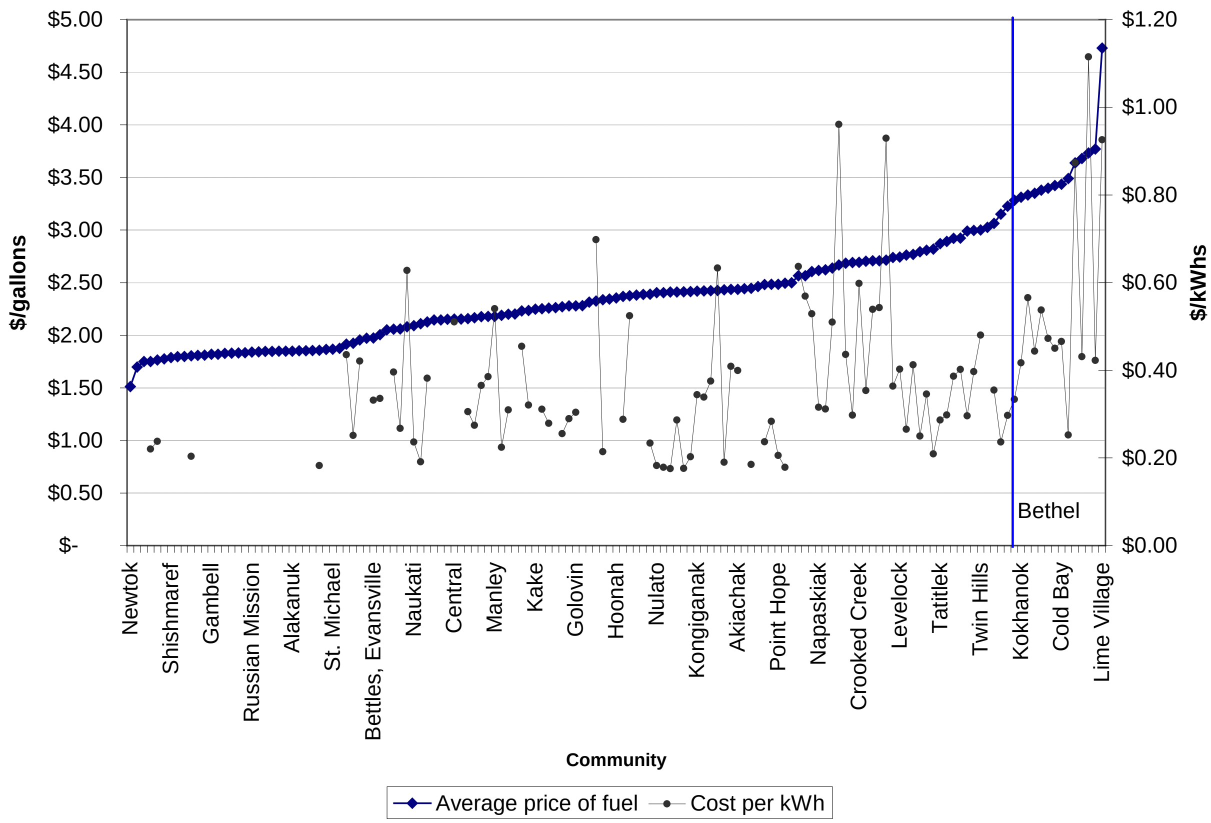
Figure 29 is another illustration of average fuel prices per gallon paid by selected PCE communities (the solid dark bar) and the typical small village and typical hub communities selected for this study (along the horizontal axis). Costs ranged from $1.50 per gallon (Newtok) on the left to approximately $3.75 per gallon on the far right (Lime Village).

Bethel, which reported the highest volume of fuel used for electric generation, had a relatively high average price of $3.28 per gallon of fuel in 2006. Other large-volume purchasers, however, do show lower average fuel prices, under $2 per gallon.

Bethel fuels prices are higher than would be expected given the size of the utility because it relies upon fuel distributors in the community to provide and maintain the fuel tanks necessary to hold a year's worth of fuel inventory. The utility believes that reduced capital expenditures and reduced maintenance and operating costs associated with this strategy more than offset higher fuel prices.

Figure 29 also shows the cost per kWh (on the right vertical axis) in project-area communities with available data. The figure shows a weak correlation between the cost per kWh and fuel prices per gallon shown on the left vertical axis. There is a significant variation indicating that the cost per kWh is to a great degree determined by other factors than reported fuel costs.

Figure 29. Average Fuel Prices Reported by Selected PCE Utilities, 2006



Source: 2006 PCE Data, Alaska Energy Authority

5 Storage and Distribution Costs

This section provides information on capital costs, based on 58 Denali Commission bulk fuel projects in the study area along with other information collected by the project team. Annual costs of operations and maintenance, including repair and replacement, are presented, based on the same 58 projects with a summary of amortized and annual operating costs. Distribution and cleaning costs are discussed later in this section.

5.1 Storage Facilities

Storage facilities are either permanent or temporary, and the size and type of storage facilities will depend on location, current tank farm capacity, community demand, and whether fuels must be segregated (i.e., Jet A used for aircraft cannot be contaminated). ISO tanks and 55-gallon fuel drums would generally be regarded as temporary storage while traditional steel tanks would be permanent. The selection of an appropriate storage facility is an important decision for a community due to the high capital costs of larger tanks, the operational issues associated with transporting large numbers of drums, and the fact that smaller capacity storage may not be sufficient to last until the next fuel delivery.

5.1.1 Capital and Operating Costs

The hubs and sub-regional hubs are well-equipped to manage the transition to ULSD. Hubs and sub-regional hubs typically have sufficient tank capacity and the necessary number of tanks to accept and store Jet A, other high sulfur distillates, gasoline products, and fuel for newer engines that require ULSD.

However, it will take tank cleaning or several years of inventory turnover (blend down) for existing tanks with high sulfur fuels to achieve compliance with the ULSD requirements. If the blend-down approach is used, it may be necessary to supply and store fuel with ULSD specifications at hubs and subregional hubs that have a small number of engines that require ULSD fuels. In 2007 Crowley shipped (on speculation) 55-gallon drums of ULSD in containers to its hub communities in the event that ULSD might be required in a region.

As 2010 approaches, towns and villages may require one or more ISO tanks and/or 55-gallon fuel shipments to meet the need for ULSD fuels before the blend-down approach has achieved necessary sulfur levels. The number of smaller communities and villages, out of 151 total communities in the project area, that would require drums and ISO tanks, is unknown. A few villages may require new steel fuel tanks if they do not have the number and size of tanks required to segregate ULSD and still meet the requirements for other fuels. The number of such communities is also unknown. The costs of a new steel fuel tank are discussed in the next section.

5.1.2 New Steel Fuel Tanks

Average capital costs for new tanks, based on Denali Commission projects, are shown in Table 24 for the 146 communities in the project area that are outside of regional hubs. Size and costs are based on 58 projects that are completed or near completion.

Table 24. Estimated Average Capital Costs for Any Required New Tanks by Community Type

Category	Number in Area	Average Population	Average Project Gallons	Average Capital Cost $/gallon	Estimated Cost, Tank 23,000 gallon	Cost Ratio (%)	Cost Per Capita ($)
Sub-Regional Hubs	9	559	870,000	7.39	$169,970	100	304
Communities	37	585	404,000	10.50	$241,500	142	413
Villages	100	154	156,000	17.80	$409,400	241	2,658
Total	146						

Source: Northern Economics, Inc. Denali Commission, Alaska Energy Authority.
Note: capital costs are based on projects from the period 2002 to 2006. Nominal dollars are shown. The five regional hubs are excluded.

As expected, smaller villages need less storage capacity, while capital costs expressed on a per gallon basis are higher. Costs for a standard 23,000 gallon tank range from $170,000 (rounded) in sub-regional hubs to $409,000 (rounded) in villages. Average costs of installing a new tank in villages are 2.4 times more expensive than sub-regional hubs. Costs per tank will decline if more than one is installed, with an estimated $280,000 per tank for more than one.

Even more significant is the average capital cost per resident. Costs per capita in sub-regional hubs and towns are approximately $300 and $400, respectively, but increase to almost $2,700 per resident in villages.

A key assumption in the cost estimates presented here is that tank farm facilities have adequate foundations to add a single additional tank; design requirements from the Denali Commission state a 10-year growth period should be factored into site engineering and development of a tank farm.

Single steel tank cost estimate

A single steel tank in a village is estimated to cost $420,000 (rounded) each, based on Denali Commission capital costs per gallon of $17.80 for village-size projects. In addition, each new 23,000 gallon tank would require a marine header and pipes, estimated at $80,000 by professional cost estimators based on their experience in rural Alaska. The total of the two costs is rounded to $500,000. Again, this is for a single tank that may be considered under scenarios listed in report sections 6, 7, and 8. Selection of an additional tank will be driven by specific assumptions noted on each scenario.

For purposes of this analysis, the $500,000 in-place cost of an additional steel tank with headers and piping is amortized over a 40-year period. At 5.5 percent interest, and 100 percent debt financing, annual payments are $31,160.

Operations costs, including maintenance (O&M) and repair and replacement (R&R) estimates, are an additional $8,050 per year; insurance, at $0.10 per gallon, is another $2,300. The total is $41,510 or $1.80 per gallon, for a single season's fill and draw-down. The cost of a new steel tank is likely prohibitive.

Table 25 illustrates the amortization of a steel tank, over 40 years, with project area operations and maintenance percentages (percent of capital costs). Note that only the first and last five-year payment schedules are shown.

Table 25. Amortization of One Steel Tank, over 40 Years, with Annual Capital and Operating Costs.

	Year 40 Full Loan - Single 23,000 gallon tank						
	Principal	$500,000			O&M %	0.95%	
	Term	40	Years		R&R %	0.66%	
	Rate	5.5%			Total	1.61%	
	Payment	$(31,160.17)			Inflation	1.50%	
Year	Beginning Balance	Interest	Payment	Principal Payment	Ending Balance	O&M + R&R	Total Annual
1	$500,000	$27,500	-$31,160	$3,660	$496,340	$8,050	$39,210
2	$496,340	$27,299	-$31,160	$3,861	$492,478	$8,171	$39,331
3	$492,478	$27,086	-$31,160	$4,074	$488,404	$8,293	$39,453
4	$488,404	$26,862	-$31,160	$4,298	$484,107	$8,418	$39,578
5	$484,107	$26,626	-$31,160	$4,534	$479,572	$8,544	$39,704
35	$155,662	$8,561	-$31,160	$22,599	$133,063	$13,355	$44,515
36	$133,063	$7,318	-$31,160	$23,842	$109,221	$13,555	$44,715
37	$109,221	$6,007	-$31,160	$25,153	$84,068	$13,759	$44,919
38	$84,068	$4,624	-$31,160	$26,536	$57,532	$13,965	$45,125
39	$57,532	$3,164	-$31,160	$27,996	$29,536	$14,174	$45,335
40	$29,536	$1,624	-$31,160	$29,536	$0	$14,387	$45,547

Source: Northern Economics; Denali Commission, Alaska Energy Authority, Business Plan Worksheets

To establish typical operating and maintenance costs for steel tanks, a sample was drawn from six completed bulk fuel projects within the project area, totaling $22 million of capital cost. Average projected operations and maintenance (O&M) costs were 0.95 percent of total capital costs, while repair and replacement (R&R) costs averaged 0.66 percent for the same projects, for a total annual cost of 1.61 percent on the average.

In dollars, projected O&M costs were $23,985 per year, with R&R costs of $21,934 for total estimated annual costs of $45,919. These costs will vary with the size of the installed tanks.

On a per gallon basis, O&M costs averaged $0.196 per gallon, with R&R costs of $0.1743 for a total of $0.37 per gallon. In addition, $0.10 per gallon is required for insurance purposes.

Total average O&M and insurance costs per gallon were $0.47 for the six projects; this is lower than the $1.80 per gallon estimated earlier and reflects the size (i.e. demand capacity) of the samples.

Data on O&M costs for ISO tanks are not available, so these steel tank costs were also used for ISO tanks.

5.1.5 ISO Tanks

Once communities require sufficient fuel volumes to use ISO containers, these containers would need to be purchased or leased for each community. The point at which communities would be better served by ISO containers than by fuel drums appears to be at an annual fuel consumption rate in excess of 2,200 gallons or about 40 drums.

ISO containers are the same dimensions as a 20-foot van and have a net capacity of around 5,000 gallons. New ISO containers cost around $50,000 each. Crowley recently purchased a used ISO tank and delivered it to Seattle for a total cost of around $15,000 to $16,000. These amounts represent costs of about $3.00 to $3.20 per gallon of capacity for a used ISO container and $10.00 per gallon of capacity for a new ISO container.

Total ISO tank capital costs are estimated at $110,000 (rounded). This cost is based on a purchase quote of $50,000 per tank in Seattle, $8,500 of transportation costs by truck and barge (to a point mid-way on Alaska's west coast) and on to each village by barge. Engineering, permitting, civil construction, and general overhead to install the ISO tank are estimated at $50,000.

These engineering, siting, permitting, and surveying costs, along with environmental costs, do ***not*** include foundation costs—the most expensive single cost in the Denali Commission's bulk fuel program experience.

For purposes of this analysis, the $110,000 in place cost of an ISO tank is amortized over a 20-year period, half of the projected 40 years used for larger, fixed, steel tanks. This amortization period reflects the shorter life expectancy of ISO tanks. At 5.5 percent interest, and 100 percent loan financing, annual payments are $9,200.

Operations costs, including maintenance and repair and replacement estimates, are an additional $1,800 per year. Insurance, at $0.10 per gallon, is another $500. The total operations cost is about $11,500 or $2.30 per gallon for a single season's fill and draw-down. The actual cost to consumers would likely be greater to reflect differences between wholesale and retail operations costs.

Table 26 illustrates the amortization of an in-place ISO tank, over 20 years, with project area operations and maintenance percentages (percent of capital costs). Note that only the first and last five-year payments are shown.

Table 26. Amortization of an ISO Tank, over 20 Years, with Annual Capital and Operating Costs.

Year 20 Full Loan - ISO Tank							
	Principal	$110,000			O&M %	0.95%	
	Term	20	Years		R&R %	0.66%	
	Rate	5.5%			Total	1.61%	
	Payment	$(9,204.73)			Inflation	1.50%	
Year	Beginning Balance	Interest	Payment	Principal Payment	Ending Balance	O&M + R&R	Total Annual
1	$110,000	$6,050	-$9,205	$3,155	$106,845	$1,771	$10,976
2	$106,845	$5,876	-$9,205	$3,328	$103,517	$1,798	$11,002
3	$103,517	$5,693	-$9,205	$3,511	$100,006	$1,825	$11,029
4	$100,006	$5,500	-$9,205	$3,704	$96,301	$1,852	$11,057

5	$96,301	$5,297	-$9,205	$3,908	$92,393	$1,880	$11,084
15	$45,982	$2,529	-$9,205	$6,676	$39,307	$2,181	$11,386
16	$39,307	$2,162	-$9,205	$7,043	$32,264	$2,214	$11,419
17	$32,264	$1,775	-$9,205	$7,430	$24,834	$2,247	$11,452
18	$24,834	$1,366	-$9,205	$7,839	$16,995	$2,281	$11,486
19	$16,995	$935	-$9,205	$8,270	$8,725	$2,315	$11,520
20	$8,725	$480	-$9,205	$8,725	$0	$2,350	$11,555

Source: Northern Economics; Denali Commission, Alaska Energy Authority, Business Plan Worksheets

5.1.6 55-Gallon Fuel Barrels (Drums)

Re-usable steel drums would need to be purchased or leased for use. A 55-gallon round steel drum could cost around $50 to $70, depending on the quantity purchased, according to a recent price list from a manufacturer in Connecticut (Yankee Containers, 2007). This represents a cost of $0.91 to $1.27 per gallon of capacity. Vendors usually require a drum deposit, reflected in the total delivered fuel cost, to assure drums are returned in good physical condition. The actual number of drums that are returned is unknown, as is the cost of backhaul, cleaning, and inspection. In many cases, steel drums are not returned for fuel use and may be placed in a landfill, crushed and returned for recycling, or simply left in place. The latter can result in spills of hazardous materials, depending on care and attention of consumers.

5.2 Distribution and Cleaning Costs

The following sections address the distribution and cleaning costs that could occur as part of the transition.

5.2.1 Steel Tanks

Tank cleaning costs obtained from the North Slope Borough suggest that cleaning of community tanks in a remote area could cost $28,000 for three tanks with a capacity of 780,000 gallons. This rough estimate does not include sludge disposal or mobilization costs, but it does provide an estimate of cleaning costs. Airfare for personnel and air freight shipment of the necessary equipment could cost an additional $7,000 to $9,500, though these costs could be much higher in more remote locations. Disposal of sludge would also need to be factored into the cost.

Tank cleaning and waste disposal are operating costs that will likely affect any shipper using its tanks for multiple fuels since mistakes will be made and fuels will become contaminated and not meet the necessary specifications. Because of the cost of cleaning, individual shippers will need to determine the most cost-effective way of handling the different types of fuels.

5.2.2 Barge Shipping

Diesel and gasoline products are transported in multiple compartment barges. Larger “line haul” barges going to hub communities have separate piping and pumping systems to keep gasoline and diesel products separate. Barges delivering fuel to smaller villages might not have sufficient piping and compartments to accommodate current products and ULSD and therefore changes would be required to barge piping and pumping systems to keep ULSD segregated, or tanks would have to be cleaned and additional fuel deliveries made.

Currently, fuel barges, hub fuel tank depots, river barges, local dock fuel headers, and local fuel tanks may mix minor amounts of the three diesel fuel specifications (No. 2, No.2/No. 1 blends, No. 1, and Jet A) since minor amounts of mixing of multiple specifications of diesel fuel do not have a material impact on fuel performance in engines and heating units. However, relatively small amounts of ULSD can contaminate Jet A due to additives, and conversely relatively small amounts of Jet A or other high sulfur distillates can contaminate ULSD. While the contaminated fuel could be used for heating purposes or possibly power generation, the contaminated barge tanks would likely need to be cleaned.

Barge cleaning costs

Emerald Services is the contractor Crowley currently uses for environmental services such as barge cleaning. Emerald recently cleaned one of Crowley’s 360-foot, 80,000-barrel, 14-compartment barges to a military specification for between $25,000 and $30,000 (Crowley, 2007). This cost covered cleaning only and did not include disposal costs or lost revenues from the barge not being available for other work.

Hoses from the barges to headers or storage tanks also require cleaning before and possibly after they are used to ship ULSD to prevent product contamination. This could be done with a pigging operation and manual cleaning of other affected areas of the system that are unreachable by the pigs.

These barges hold 3,360,000 gallons (80,000 barrels) and, at $30,000 per cleaning, costs are approximately $0.009 per gallon.

5.2.3 ISO Tanks and Drums

The cost of fuel in ISO tanks is estimated to cost about $0.90 to $1.00 more than bulk delivery so the cost in regional hubs might average $5.40 to $5.50 per gallon if delivered in ISO tanks, to the hubs, and $1.20 to $1.50 more per gallon ($5.70 to $6.00) delivered into other communities from the hubs.

Cost estimates for cleaning ISO tanks were not available from organizations that were contacted by the consultant team.

Old fuel drums have littered the landscape in rural Alaska for decades and only in the recent past have efforts been made to collect these drums, dispose of their contents in a safe manner, and remove them from rural Alaska. There is reluctance on the part of many in rural Alaska to see drums become a new standard for shipping petroleum products because of the fear that they will not be properly disposed of.

Drums may be delivered by barge or cargo plane; they usually require a deposit and empty drums may be back-hauled by barges to a collection point. As delivered fuel, these extra drum costs are included in the price per gallon. Collection and backhaul costs may be partially paid by drum deposits, but areas without barge service have much more difficulty returning drums.

It is anticipated that ULSD deliveries could be made with 55-gallon drums. If a community's annual consumption of ULSD is less than 1,650 gallons, drums are the most cost-effective means of transport.

Using 55-gallon drums to transport small quantities of fuel might be the most feasible way to serve smaller communities, especially with the price of fuel constraining communities' ability to purchase large quantities. However, the drums would require special handling to load and unload them from a barge. The labor and equipment costs associated with this additional handling would be incurred at each port or community. In larger volumes, drums can be shipped inside a container van.

Drums could likely be reused as long as they are clean. The potential for contamination of fuel drums and the associated fines may discourage carriers from reusing drums that have been kept out of their control, without cleaning them first. If several drums were cleaned at a time, the cost per drum would likely be small. One alternative to hauling empty drums out of the community is to refill them onsite.

In August 2007, Crowley representatives stated that the cost of a drum of ULSD in their regional hub communities would be $350 per drum or about $6.36 per gallon to the fuel supplier. The average cost of heating and diesel fuel in these communities was about $4.50 per gallon, so the delivered cost per gallon for drums was approximately $1.80 to $1.90 higher than bulk delivery. Actual costs to the consumer would reflect profit and risk margins over and above delivered costs.

This range of costs is anticipated to be higher in smaller villages if drums are shipped by fuel barge. However, individual barrels can be shipped as deck cargo on freight barges, which have lower transportation rates. In 2006, Galena was able to obtain fuel in drums at a lower price than bulk delivery. Small volumes of ULSD could be accommodated this way with perhaps minimal, if any, price impacts. It is unlikely regular shipments of fuel would be sent as individual barrels due to increased handling and storage (tie-downs, for example) that would be needed.

5.2.4 Air Transport

If weather is problematic, river water levels are low, or a cold winter results in fuel use that exceeds local supply, fuel deliveries may be made by air, typically via a DC-6 fuel tanker with a capacity of 4,750 gallons. In 2007, the cost for delivery via air is estimated to be 1.0-1.4 cents per gallon per map mile of air transport from the fuel hub or up to $1.40 per gallon air delivery of 100 miles.[8]

Evert's Air is a major shipper of fuels throughout Alaska. The company uses two types of fuel planes, with capacities of about 2,000 gallons and 5,000 gallons, to deliver fuel (Adams, 2007).

Due to the diverse fuel needs across the state, it is unlikely that an air transport company would emerge to supply only ULSD. Instead, companies flying fuel to communities are likely to carry

[8] MAFA Analysis of Small Air Fuel Delivery Service Cost Estimates.

most types of fuel on an alternating basis. Rather than incurring an upfront cost associated with tank cleaning, it is much more likely that air transport companies would clean tanks as a regular, recurring expense. These costs would be integrated into the rates charged to their customers.

Only four communities (Alatna, Arctic Village, Hughes, Atqasuk) reported, in the June 2007 community heating fuel and gasoline survey (DCCED, 2007), 100 percent air delivery. Other communities reported a combination of air and barge or air and truck, but 92 percent of reporting communities indicated barge service (83 percent) or truck transport (9 percent) were the main stays of fuel transport to their community.

5.2.5 Road and Overland

Transportation of ULSD on the few rural Alaska roads or on frozen rivers would likely be with fuel trucks. Prior to shipping ULSD in fuel trucks, vehicle tanks would need to be cleaned and the waste properly disposed of. As an alternative, if there is enough volume in a community, a dedicated fuel truck could be purchased to handle ULSD.

A used fuel truck would cost approximately $30,000 and up, depending on the age of the truck and the capacity (Trucker.com, 2007). Shipment of the truck from the purchase location to the community in which it is used would add to the cost. A dedicated ULSD fuel truck is likely an option only in regional hubs.

If fuel trucks are used for multiple types of fuel, their tanks would need to be cleaned prior to loading ULSD or Jet A to prevent contamination. Otherwise, if the trucks are used solely for ULSD, the operating costs would be in line with existing diesel operations.

A complete switch to ULSD in a community would allow fuel trucks to use ULSD to gradually flush (blend) the tanks down to required sulfur levels over time. This would avoid any upfront costs to manage the transition.

5.2.6 Rail and pipeline

Rail tank cars move distillates between Anchorage, Fairbanks, and North Pole, and ULSD will be transported this way between Anchorage and North Pole. Pipelines presently move ULSD and other fuels from Nikiski to Anchorage. These facilities are not located within the study area. However, some of the fuel that is later delivered in western and northern Alaska communities will be transported through pipeline or in a rail tank car. Since this transportation will incur costs which would be covered in the price of fuel, this section presents some information about these fuel transportation modes.

The Alaska Railroad Corporation (ARRC) accommodates 20,000-gallon tank cars for transporting fuel (ARRC, 2007). Flint Hills has purchased tank cars that are dedicated to moving the ULSD from Anchorage to Fairbanks and they are empty on the return. The cost of the rail equipment and the ARRC's charge for transporting the fuel are covered in the OPIS price differential between ULSD at Anchorage and Fairbanks noted earlier in this report.

The pipeline could also require cleaning before or after it is used to ship ULSD but Tesoro moves sufficient volume and types of products through the pipeline that it can use other products to avoid contamination. For example, it could move motor gasoline, which has very low sulfur content, through the pipeline prior to shipping ULSD to reduce sulfur levels. It can also move Diesel No. 1 and other products after the ULSD to remove the lubricity agent and avoid contaminating Jet A.

6 Ultra Low-Sulfur Diesel Fuel Transition Scenarios

For this project, three fuel transition scenarios were developed to reflect different ways rural Alaska may transition to ULSD. These scenarios provide decision makers and other stakeholders a tool for evaluating the impacts and outcomes of alternative courses of action. The scenarios help articulate different views of the future and were developed by project staff in consultation with ADEC.

The three fuel scenarios provide a broad spectrum of potential response, from just the minimal amount of ULSD that is needed for new engines (Scenario 1) to full conversion (Scenario 3). These are designed to reflect alternative courses of action—alternative ways of implementing rural Alaska's transition to ULSD. They are not necessarily representative of a specific community or regional hub; each of the 151 communities in the project area will have a unique set of fuel needs.

Scenario 1 is described as the *Warranty Scenario*, Scenario 2 is described as the *Compliance Scenario*, and Scenario 3 is described as the *Full Conversion Scenario*.

Figure 30 summarizes all three fuel transition scenarios and impacts on existing fuel distribution and storage infrastructure. The figure illustrates the transition period from now until 2014 and beyond. Figure 30 also outlines the differences in timing for each scenario with respect to ULSD distribution and storage requirements for the different fuel uses (i.e. highway diesel fuel, non-road equipment, stationary diesel power, locomotive and marine, home heating, and Jet A).

Figure 30. Remote Rural Alaska Community ULSD Transition Scenarios.

Timeline: 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | To 2030

Scenario 1 - Convert selected NR + LM + Stationary Power engines to ULSD in order to meet New Engine Warranty Requirements

	2007	2008	2009	2010	2011	2012	2013	2014
Highway Diesel Fuel	15 ppm barrels	15 ppm barrels	15 ppm barrels	→	Transition to 15 ppm ISO Tanks			→
Non-road equipment	Non-ULSD	→		15 ppm ISO tanks for new engines		Allow for gradual turnover in old engines that do not require ULSD. Old engines use NONULSD depending upon price. At some point it may be cost effective to convert existing steel tanks to ULSD and switch old engines over to available tankage or ISO tank fuel stream as capacity allows.		
Stationary Diesel Power	Non-ULSD	→		15 ppm ISO tanks for new engines				
Locomotive, Marine	Non-ULSD	→		15 ppm ISO tanks for new engines				
Home Heating	Non-ULSD	Home heating continues to use nonULSD in existing fuel handling system (header and tankage). When volumes are sufficient to warrant new ULSD tanks, swap spots - ULSD in tanks, NONULSD remains in tanks where available or build new capacity for NONULSD						
JET A	Jet A	Jet A Fuel Spec Market (Aircraft) continues to use Jet A in existing fuel handling system (header and tankage). When volumes are sufficient to warrant new ULSD tanks, swap spots - ULSD in tanks, NONULSD remains in tanks where available or build new capacity for NONULSD						

Scenario 2 - Convert NR + LM + Stationary Power engines to ULSD (Compliance)

	2007	2008	2009	2010	2011	2012	2013	2014
Highway Diesel Fuel	15 ppm barrels	→		15ppm tankage	→			
Non-road equipment	In remote rural Alaska villages, one fuel header and tank farm often uses Jet A to serve diesel engine, fuel oil and Jet A requirements	Start to run ULSD	thru tanks to flush	15ppm tankage	→			
Stationary Diesel Power		→	Start to run ULSD	thru tanks to flush	15 ppm tankage	Allow for gradual turnover in old engines that do not require ULSD		
Locomotive, Marine		Start to run ULSD	thru tanks to flush	15ppm tankage	→			
Home Heating		→		Maintain separate NONULSD fuel supply from ULSD. Use existing tankage capacity, new ISO tanks, or new steel tanks based on cost-effectiveness of volumes in each stream				
JET A		→		Maintain separate NONULSD fuel supply from ULSD. Use existing tankage capacity, new ISO tanks, or new steel tanks based on cost-effectiveness of volumes in each stream				

Scenario 3 - Convert existing "diesel fuel system" to ULSD, add new capacity for JET A where required

	2007	2008	2009	2010	2011	2012	2013	2014
Highway Diesel Fuel	15 ppm barrels	→		15ppm tankage	→			
Non-road equipment	In remote rural Alaska villages, one fuel header and tank farm often uses Jet A to serve diesel, fuel oil and Jet A requirements	Start to run ULSD	thru tanks to flush	15ppm tankage	→			
Stationary Diesel Power		Start to run ULSD	thru tanks to flush	15ppm tankage	→			
Locomotive, Marine		Start to run ULSD	thru tanks to flush	15ppm tankage	→			
Home Heating		Start to run ULSD thru tanks to flush clean in order to achieve 15 ppm spec in local tankage			→			
JET A		Maintain separate NONULSD fuel supply from ULSD. Use existing tankage capacity, new ISO tanks, or new steel tanks based on available capacity in existing tanks and cost-effectiveness of using ISO tanks vs. new steel tanks.						

Assume that it takes 3 turns of inventory to make 15 ppm spec in local tank farm & fuel delivery system when converting to 15 ppm. In order to use existing tank farms in communities that are sized for one main fuel delivery per year, need to start three years in advance in order to make 15ppm spec.
In communities where Jet A is the one main fuel delivery per year, may need to build separate fuel header and tanks for Jet A before starting to run ULSD through existing system in order to avoid contamination or if practical based on volumes, provide temporary Jet A fuel handling and storage system (i.e., ISO tanks) until new tankage capacity is installed

The following sections describe the scenarios in more detail. The first two scenarios involve the degree to which a two-grade diesel fuel infrastructure system is put into place and the third scenario involves a full conversion to ultra low sulfur diesel.

6.1 Scenario 1: The Warranty Scenario

This scenario represents the likely first step in the transition to ULSD in rural Alaska communities. This scenario is characterized by delivery to communities of relatively small amounts of ULSD on an "as needed basis," just enough to serve only those engines requiring use of ULSD to meet new engine emission and warranty requirements.

Under this scenario, communities will initially receive multiple distillate product deliveries:

1) ULSD for new (2007) heavy duty on-highway diesel engines;
2) non-ULSD for unregulated uses; and
3) Jet A fuel for aircraft in regional (hubs) and sub-regional centers. In addition, communities would also receive aviation gas and unleaded gasoline, but this description only addresses distillate fuels.

Under this scenario, the timing for transition of the different fuel uses for the years from 2007 through 2009 is:

- ULSD will be transported in 55-gallon drums by barge in volumes that meet the fuel requirements for 2007 model year trucks (highway diesel fuel). Drums could be shipped individually, in small batches, or in containers if larger volumes are needed.
- Non-ULSD fuel will be shipped to communities in amounts required for all non-road equipment, stationary diesel power, locomotive and marine, and home heating. There are no modifications in the fuel storage and handling system for non-ULSD fuel.
- Jet A will continue to be shipped to hubs and sub-regional hubs where jet fuel is required for aviation purposes and there are no modifications in the infrastructure system to handle this fuel.

Under this scenario, the timing for transition of the different fuel uses for the years from 2010 until the end of 2011:

- For highway diesel engines, some communities like the regional transportation hubs would start transitioning from deliveries of ULSD in barrels to higher volume deliveries contained in ISO tanks. An ISO tank has a maximum capacity of 5,900 gallons. Smaller volumes of ULSD may still be shipped in barrels from major hubs (i.e., Barrow, Kotzebue) to smaller communities to meet needs of mobile engines that require ULSD.
- ULSD will be shipped in ISO tanks to meet fuel requirements of new non-road equipment engines, new stationary diesel power engines, and for locomotive and marine diesel engines.
- Home heating fuel will continue to be shipped in similar volumes as before and no modifications in the fuel storage and handling system will be required.

- Jet A will continue to be shipped to hubs and sub-regional hubs where jet fuel is required for aviation purposes and there will be no modifications in the infrastructure system.

Under this scenario, timing for transition of the different fuel uses for the years from 2012 to 2030 is:

- Communities will continue to transition over time to shipments and storage of ULSD from barrels to ISO tanks to meet fuel requirements of all new mobile and stationary source engines. At some point it may be cost-effective to convert existing steel tanks for ULSD storage and use ISO tanks for non-ULSD fuels.
- Home heating fuel would not switch to ULSD. Depending on the storage requirements for ULSD and for non-ULSD fuel, home heating fuel could either be stored in existing steel tanks or ISO tanks.
- Jet A will continue to be shipped to hubs and sub-regional hubs where jet fuel is required for aviation purposes; storage and handling of Jet A will have to be separated from the ULSD stream.

Based on data from the Oil Price Information Service (OPIS), a company that tracks fuel prices in various fuel market centers, ULSD has been available in the Anchorage and Fairbanks racks since June of 2006. Currently, ULSD in 55-gallon drums is available in several regional hubs (Bethel, Nome, and Kotzebue) to serve fuel requirements of new diesel trucks. This ULSD was delivered by barge in steel-walled containers. Teck-Cominco, operator of the Red Dog Mine in the Northwest Arctic Borough, has also received shipments of ULSD contained in ISO tanks for their new diesel engines.

6.2 Scenario 2: The Compliance Scenario

This scenario is characterized by shipment of higher volumes of ULSD, enough to cover all "impacted" engines that have to switch by 2010 to be in compliance with the EPA fuel rules. This includes all mobile sources (on-highway, non-road, locomotive, marine) regardless of model year, and "impacted" stationary source engines—this includes new power generation diesel engines (2011 model year engines).

Given the EPA rules, starting in 2010, distributors would need to transport (and communities would have to store) adequate volumes of ULSD to serve fuel demand for the engines that by law need to switch to ULSD. In this case, due to larger volumes, there will be a need for dedicated ULSD tanks in many communities.

Since EPA rules do not apply to home heating and jet fuel, there will be no switch from these fuels to ULSD under this scenario. It is anticipated that residents will resist switching to ULSD if there is a price differential in the cost of currently used heating fuel (typically downgraded Jet A) and ULSD. Therefore, separate storage and transfer systems will have to be available for non-ULSD use.

The potential timing of the transition under this scenario is as follows:

- From 2007 to the end of 2008, ULSD will be shipped in barrels to supply fuel requirements of new on-highway diesel engines. The fuel distribution, storage, and handling system will continue to handle non-ULSD fuel for non-road, stationary diesel power, locomotive, marine, home heating, and jet engine requirements.

- From 2008 to 2010, some operators will begin flushing tanks with ULSD. By the end of 2010, the tanks will be fully flushed of high sulfur fuel and ready for ULSD. This is important because in 2010, ULSD will be required for use in all mobile source engines and new stationary source engines. Some tanks will remain dedicated to non-ULSD use for home heating and jet requirements. After 2010, a greater proportion of the fuel inventory in the communities will need to meet the 15 ppm standard, as the number of model year 2011 and later stationary, non-road, and marine engines increase.
- After 2010, there will be a gradual flushing and turnover of existing tanks for stationary diesel power, as old engines for power generators get replaced with new engines. Home heating fuel would not switch to ULSD; however, depending on the storage requirements for ULSD and for non-ULSD fuel, home heating fuel could either be stored in existing steel tanks or ISO tanks. Likewise, Jet A will continue to be shipped to hubs and sub-regional hubs where jet fuel is required for aviation purposes; storage and handling of Jet A will have to be separated from ULSD, due to the lubricity additive in ULSD and the high sulfur content of Jet A.

6.3 Scenario 3: The Full Conversion Scenario

With the exception of Jet A, this scenario represents the full conversion of all distillate fuels to ULSD to serve all engines whether regulated or not, including home heating.

In this case, the existing distribution and storage infrastructure systems will be converted to ULSD use and if needed, new infrastructure will be added to handle Jet A fuel. For full conversion (and to be in compliance by 2010) flushing of storage and transfer systems would start in 2008.

The following sections briefly discuss some of the implications of the rules on different categories of communities.

7 Scenario Costs

This section discusses the capital and operational costs associated with ULSD transition in a typical village under the three scenarios described in Section 6.

7.1 Scenario 1: ULSD Fuel for New Engine Warranty Requirements

This scenario could occur in a community where local diesel fuel can be reliably segregated between high sulfur fuel and ULSD fuel. Only those diesel engines that require ULSD would use it, while older diesel engines would continue to burn other fuels, assumed here to be Jet A. The key parameters driving fuel demand under this scenario include the initial demand for each diesel end-use market, and the speed at which old engines are replaced by new ones. Volumetric requirements for ULSD would grow over decades as new diesel engines are introduced to the village. In reality, new diesel engines are likely to arrive in groups or batches, but to simplify the analysis it is assumed that the transition will be slow and steady.

Table 27 shows ULSD demand as a function of engine turnover. As an example, a remote rural village has an assumed total diesel demand of 300,000 gallons a year. Approximately 200,000 gallons a year is associated with internal combustion diesel engines; of that total, half (100,000 gallons) is used to generate power and the other half (100,000 gallons) is used in local mobile engines like trucks and construction equipment. The remaining 100,000 gallons a year is used as heating oil. If the entire local diesel engine stock turns over roughly every 30 years, the demand for ULSD fuel might increase on the order of 6,700 gallons per year.

Table 27. ULSD Fuel Demand as a Function of Engine Turnover

Engine Turnover	Average ULSD Fuel Demand Growth	ULSD Fuel Demand in Year 10
40-year engine turnover	5,000 gallons per year	50,000 gallons
30-year engine turnover	6,667 gallons per year	66,667 gallons
20-year engine turnover	10,000 gallons per year	100,000 gallons
10-year engine turnover	20,000 gallons per year	200,000 gallons

Source: MAFA Seed Values for Economic Model assuming an annual village demand of 200,000 gallons a year for diesel engines (including highway diesel, non-road equipment, stationary diesel power and marine engines).

Note: Fuel efficiency is assumed constant.

Table 28 illustrates diesel fuel requirements projected under scenario 1. The 300,000 gallon total is used as an input factor for the cost model discussed later in this report.

Table 28. Diesel Fuel Requirements under Scenario 1

	Total Diesel Engine Demand (gallons per year)	New Engine ULSD Warranty Requirements Growth Rate (gallons per year)
Highway diesels	5,000	167
Non-road equipment	50,000	1,667
Stationary diesel power	100,000	3,333
Locomotive, marine	45,000	1,500
Home heating	100,000	0
Jet A aircraft engine	0[a]	0
Total	300,000	10,000 gallons per year or 100,000 gallons at Year 10 of ULSD or 200,000 gallons at Year 10 of high sulfur diesel

[a] The aviation fuel market in small villages tends to be served by aviation gasoline. Turboprop aircraft and jets that require Jet A fuel typically operate only in larger sub-regional hubs and regional hubs.

Source: MAFA Seed Values for Economic Model (subject to revision in consultation with other team member technical memos)

7.1.1 End-User Infrastructure Considerations

One challenge under this scenario concerns the case where a new ULSD-specification diesel engine is installed at a power plant where two or three older engines remain to provide swing or back-up power. The local power plant operator could either reconfigure the fuel systems to keep feeding traditional diesel fuel to the old engines and ULSD to the new engine, or convert all of the fuel systems to ULSD to simplify field operations (see Scenario 2).

The cost savings of creating and sustaining a dual fuel system at the electric utility level would have to outweigh both the costs of segregating the power plant day tank fuel systems and the risk of catalytic converter failure and premature engine failure if high sulfur diesel fuel is mixed with ULSD.

Assuming that the cost differential between high sulfur diesel fuel and ULSD is six cents a gallon based on the most recent OPIS data (November 2007), the potential annual cost savings of Scenario 1 are summarized in Table 29 (for partial versus full conversion, coastal hub) and Table 30 (for partial versus full conversion, upriver community).

Table 29. Electric Utility Options – Partial vs. Full conversion to ULSD for a Coastal Hub

Partial Conversion	Equipment/Storage & Transfer Infrastructure	Fuel	Annualized Cost ($)
	Prime Mover (1 unit)	ULSD – 75,000 gallons/year X $3.56/gallon	$267,000
	Secondary/back-up Units (2 each)	Jet A – 25,000 gallons/year X $3.50/gallon	$87,500
	Design and install dual fuel systems (piping, day tanks, monitoring systems) ($20,000)	(5 year amortization)	$4,000
	TOTAL Direct Cost		**$358,500**
	+ Heightened Risk of Jet A fuel mix-up getting into Prime Mover requiring ULSD		
Full Conversion			
	Prime Mover + Secondary/Backup Units	ULSD – 100,000 gallons/year X $3.56/year	**$356,000**
Finding: The full conversion option may cost *slightly* less than a partial conversion (356,000/358,500 = 99.3%).			
Conclusion: Even though the partial conversion may provide some short term savings for Jet A fuel burned in the older units due to the lower cost of Jet A compare to ULSD (Coastal hub premium for ULSD ~ 6¢/gallon), the cost of new dual fuel systems combined with the heightened risk of a local fuel mix-up *favors converting all units over to ULSD*			

Source: MAFA, 2007

Table 30. Electric Utility Options – Partial vs. Full conversion to ULSD for an Upriver Community

Partial Conversion	Equipment/Storage & Transfer Infrastructure	Fuel	Annualized Cost ($)
	Prime Mover (1 unit)	ULSD – 75,000 gallons/year X $3.62/gallon	$271,500
	Secondary/back-up Units (2 each)	Jet A – 25,000 gallons/year X $3.50/gallon	$87,500
	Design and install dual fuel systems (piping, day tanks, monitoring systems) ($20,000)	(5 year amortization)	$4,000
	TOTAL Direct Cost		**$363,000**
	+ Heightened Risk of Jet A fuel mix-up getting into Prime Mover requiring ULSD		
Full Conversion			
	Prime Mover + Secondary/Backup Units	ULSD – 100,000 gallons/year X $3.62/year	**$362,000**
Finding: The full conversion option may cost about the same as a partial conversion (362,000/363,000 = 99.7%).			
Conclusion: Even though the partial conversion may provide some short term savings for Jet A fuel burned in the older units due to the lower cost of Jet A compared to ULSD (Upriver ULSD premium ~ 12¢/gallon), the cost of new dual fuel systems combined with the heightened risk of a local fuel mix-up *favors converting all units over to ULSD*			

Source: MAFA, 2007

7.1.2 Fuel Supply Chain Considerations

Under this scenario, the volumes of ULSD required are relatively low and grow as the stock of diesel engines turns over. The annual volumes of ULSD relative to the overall diesel market could range from a few thousand gallons in any given year for new diesel vehicles, equipment, or engines to roughly 100,000 gallons a year for a new electric utility prime mover diesel engine (7,600 hours x 200kW ÷ 15 kWh/gallon). Consequently, in the absence of a large construction project requiring new equipment or the installation of a new electric utility prime mover, the ULSD volume requirements might be a few thousand gallons a year. These small ULSD volume circumstances raise a number of questions, including:

- What are the economic options to supply and store low volumes of ULSD to the remote rural village?
- At what point does it become economical to reuse the existing bulk fuel tanks for ULSD?

There are five basic supply and storage options to consider for low volumes of ULSD fuel:

- 55 gallon drums shipped as deck freight
- 55 gallon drums shipped as packaged cargo or containerized freight
- 5,000 gallon ISO container fuel tanks (used or new)
- Convert existing bulk fuel tank(s) to ULSD by running fuel volumes down and filling with ULSD for three inventory turns in order to achieve the 15 ppm sulfur specification (blend down in existing tanks)
- Convert existing bulk fuel tank(s) to ULSD by running fuel volumes down prior to draining and cleaning the tank in order to achieve the 15 ppm sulfur specification with first fill of ULSD (clean existing tanks)

Cost estimates and results for each of these alternatives in a typical remote rural Alaska village are reviewed in detail in Section 7.4.3 below. Under the given assumptions, for annual volumes less than 1,100 gallons (20 drums) a year, the delivery and storage of ULSD in drums appears to be a cost-effective approach. For annual volumes from 1,100 gallons up to 1,650 gallons a year, taking the time to package the 55-gallon ULSD drums for containerized cargo appears to be a low cost alternative.

As annual ULSD requirements grow above 1,650 gallons (40 drums) a year, the conversion of existing bulk fuel tanks to ULSD and allowing for three inventory turns in order to achieve a 15 ppm specification appears to be a low cost alternative. If existing bulk fuel tanks cannot be converted to exclusive ULSD fuel storage, used ISO container fuel tanks are less costly than 55-gallon drums for annual volumes above 1,650 gallons (40 drums). New ISO container fuel tanks are less costly than 55-gallon drums for annual volumes above 3,850 gallons (70 drums).

7.2 Scenario 2: ULSD Fuel for Mobile Sources + New Stationary Power Generating Units ULSD Fuel for All Diesel Engines

In contrast to the end-use fuel market split between old and new diesel engines as described above, this fuel supply scenario assumes that ULSD fuel (15 ppm) will be supplied for all mobile source diesel engines and regulated stationary source engines by December, 2010. It envisions a rapid transition from high sulfur fuel to ULSD for between one-third and two-thirds of the total diesel fuel demand in a village depending upon when new stationary power generating units (2007 model year+) are added. For the example provided, this amounts to 100,000 to 200,000 gallons of fuel per year.

The balance of diesel demand in the village typically comes from heating oil for space heating. The rapid transition could occur in 2010 with the use of new tanks or reuse of newly cleaned existing bulk fuel tanks. Alternatively, the rapid transition could occur in 2008 by reusing existing bulk fuel tanks and running three turns of ULSD inventory through them (2008, 2009, 2010) with the goal of meeting the 15 ppm specification by December, 2010. Table 31 illustrates demand under this scenario. The table shows two cases: 1) old stationary diesel units are retained and will continue to run on unregulated diesel or Jet A (2A); and 2) old stationary diesel power units are replaced with new units that require ULSD (2B).

Table 31. Diesel Fuel Requirements Under Scenario 2: Convert all Mobile Source + Regulated Stationary Source Engines to ULSD

	Total Diesel Demand (gallons per year)	ULSD Demand All Diesel Engines – Retain old stationary diesel power units (2A) (gallons per year)	ULSD Demand All Diesel Engines – Replace old stationary diesel power units with new units requiring ULSD (2B) (gallons per year)
Highway Diesels	5,000	5,000	5,000
Non-road equipment	50,000	50,000	50,000
Stationary Diesel Power	100,000	0	100,000[9]
Locomotive, marine	45,000	45,000	45,000
Heating Oil	100,000	0	0
Jet A Aircraft Engines	0	0	0
Total	**300,000**	**100,000**	**200,000**

Source: MAFA Illustrative Values for Economic Model

7.2.1 End-User Infrastructure Considerations

The scenario where ULSD is provided for all diesel engines would appear to simplify operational considerations compared to a dual fuel system for old and new engines. While ULSD is expected to provide adequate performance for old engines, there are some operational risks during the transition period. The blending down of small amounts of high sulfur fuel with the new ULSD fuel may stir up sediment or pull a higher than average concentration of waxes and trace organic molecules from the existing system into the new fuel, which could lead to the need for more frequent changes of fuel filters in both old and new engines. In addition, it may contribute to loss of a positive seal around older seals and gaskets.

To the extent that operators of existing diesel engines maintain or anticipate the need for additional fuel filter changes and a new set of seals, there may be a slight increase in

[9] Based on analysis presented in Table 29, assume that the electric utility converts all units to ULSD once it has a need to convert one unit to ULSD.

maintenance requirements. If operators do not anticipate the potential need for additional filters and seals, the transition to ULSD presents a risk that filters will clog and seals will leak, leading at a minimum to poor performance.

7.2.2 Fuel Supply Chain Considerations

Under this scenario, the volumes of ULSD required could range from 33 percent to 67 percent of the total diesel fuel requirements for a typical village. That represents from 100,000 to 200,000 gallons a year. These large volumes raise a number of questions, including:

- What are the economic options to supply/store large volumes of ULSD to the remote rural village?
- How do the costs of reusing existing bulk fuel tanks compare to building new tanks?

There are four basic supply and storage options to consider for high volumes of ULSD fuel:

- 5,000 gallon ISO container fuel tanks (used or new)
- Convert existing bulk fuel tank(s) to ULSD by running fuel volumes down and filling with ULSD for three inventory turns in order to achieve the 15 ppm sulfur specification ("blend down in existing tanks")
- Convert existing bulk fuel tank(s) to ULSD by running fuel volumes down prior to draining and cleaning the tank in order to achieve the 15 ppm sulfur specification with first fill of ULSD ("clean existing tanks")
- Build new fuel headers and bulk fuel tank(s) for ULSD

Cost estimates and results for each of these alternatives in a typical remote rural Alaska village are reviewed in detail in the following section. Given an annual volume of 200,000 gallons, conversion of existing bulk fuel tanks to ULSD with a three inventory blend down approach beginning in the summer of 2008 appears to be the most economical alternative.

The blend down approach is less expensive than cleaning due the small incremental cost of buying ULSD fuel sooner compared to the additional cost of mobilizing specialized crews and equipment to drain and clean tanks in remote rural villages. Because of their relatively small size and the incremental need to purchase containers, the ISO container tanks alternative is more expensive than reuse of existing tanks. The most expensive approach is to build a separate new bulk fuel system exclusively dedicated to ULSD. To the extent that existing tanks cannot be reused for ULSD, the use of ISO container tanks merits consideration before building a separate new bulk fuel tank system due to potential cost savings.

7.3 Scenario 3: ULSD Fuel for Diesel Engines and Heating Oil

In contrast to the diesel engines scenarios described above, this fuel supply scenario assumes that ULSD will be supplied for all diesel engines plus the heating oil market by December 2010. It envisions a rapid transition from high sulfur fuel to ULSD for the total diesel fuel demand in a village. For the example provided, this amounts to 300,000 gallons of fuel per year. The rapid transition could occur in 2010 with the use of new tanks or reuse of newly cleaned existing bulk fuel tanks.

Alternatively, the rapid transition could occur in 2008 by reusing existing bulk fuel tanks and running three turns of ULSD inventory through them (2008, 2009, 2010) with the goal of meeting the 15 ppm specification by December, 2010. This scenario would simplify operational considerations, especially for many rural villages served by gasoline powered aircraft, since a full transition eliminates the need to consider a separate fuel delivery and storage system for Jet A to accommodate smaller volumes for non-ULSD specified usage contemplated in Scenarios 1 and 2. In sub-regional hubs and regional hubs served by turboprop and jet aircraft, the ongoing need for Jet A fuel to serve jet and turboprop needs requires at a minimum the designation and ongoing separation and maintenance of a dual-fuel system (one for ULSD and a smaller one for Jet A). Table 32 illustrates results for this scenario.

Table 32. Diesel Fuel Requirements under Scenario 3

	ULSD Demand for Old + New Engines (gallons per year)
Highway diesels	5,000
Non-road equipment	50,000
Stationary diesel power	100,000
Locomotive, marine	45,000
Home heating	100,000
Jet A aircraft engine	0
Total	300,000

[a] The aviation fuel market in small villages tends to be served by aviation gasoline. Turboprop aircraft and jets that require Jet A fuel typically operate only in larger sub-regional hubs and regional hubs.

Source: MAFA Illustrative Values for Economic Model

7.3.1 End-User Infrastructure Considerations

While ULSD is expected to provide adequate performance for old engines and existing heating appliances, there are some operational risks during the transition period. The blending down of small amounts of high sulfur fuel with the new ULSD fuel may stir up sediment or pull a higher than average concentration of waxes and trace organic molecules from the existing system into the new fuel, which could lead to the need for more frequent changes of fuel filters in both old and new engines. In addition, it may contribute to loss of a positive seal around older seals and gaskets.

To the extent that operators of existing diesel engines maintain or anticipate the need for additional fuel filter changes and a new set of seals, there may be a slight increase in maintenance requirements. If operators do not anticipate the potential need for additional filters and seals, the transition to ULSD presents a risk that filters will clog and seals will leak, leading at a minimum to poor performance

Similarly, to the extent that home and building owners maintain or anticipate the need for additional fuel filter changes, there may be a slight increase in maintenance requirements. If home and building owners do not anticipate the need for additional maintenance, the transition to ULSD presents a risk that filters may clog more frequently leading, at a minimum, to poor performance of heating equipment.

7.3.2 Fuel Supply Chain Considerations

Given an annual volume of 300,000 gallons, conversion of existing bulk fuel tanks to ULSD with a three inventory blend down approach beginning in the summer of 2008 appears to be the most economical alternative. The blend down is less expensive than tank cleaning due the small incremental cost of buying ULSD fuel sooner compared to the additional cost of mobilizing specialized crews and equipment to drain and clean tanks in remote rural villages.

The possibility of a price spike for cleaning services becomes a particular possibility if a large demand for cleaning emerges in 2010. Conversely, given the transition of refinery markets to ULSD in Seattle/Port Angeles and Alaska, the potential for a price spike for ULSD fuel beginning in 2008 and extending through 2010 appears modest (compared to high sulfur diesel fuel).

Because of their relatively small size and the incremental need to purchase containers, the ISO container tanks alternative is more expensive than reuse of existing tanks. The most expensive approach is to build a separate new bulk fuel system exclusively dedicated to ULSD. To the extent that existing tanks cannot be reused for ULSD, the use of ISO container tanks merits consideration before building a separate new bulk fuel tank system due to potential cost savings.

7.3.3 ULSD Demand Side Scenario Summary

For small volumes (<1650 gallons per year) delivery and storage of ULSD via 55-gallon drums appears to be an economical alternative. As volumes increase above 1,650 gallons per year, reuse of existing bulk fuel storage tanks with a three-inventory blend down beginning in the summer of 2008 is the most cost-effective approach. At high volumes (200,000+ gallons per year), the reuse of existing bulk fuel storage tanks with a three-inventory blend down beginning in the summer of 2008 remains a cost effective approach.

7.4 Potential Changes in Fuel Supply Chain

Costs of potential changes in the fuel supply chain are listed in this section.

7.4.1 Potential Changes in the Fuel Supply Chain with the Introduction of ULSD

In remote rural villages where Jet A is not required on an ongoing basis since aviation needs are met by aviation gasoline, the least-cost transition to ULSD involves:

- Drain down of excess Jet A inventory at the end of a heating season in the spring of 2008 and subsequent use of drained fuel as a local heating oil
- Refill of re-designated bulk fuel tank with ULSD over the course of a three season, minimum three inventory blend down to achieve a 15 ppm specification

In remote rural sub-regional hubs or regional hubs where Jet A is required for turboprop and jet aviation needs, the least-cost transition to ULSD involves:

- Drain down of excess Jet A inventory at the end of a heating season in the spring of 2008 and subsequent use of the Jet A fuel for aviation requirement or home heating fuel

- Refill of re-designated bulk fuel tank with ULSD over the course of a three season, minimum three inventory blend down to achieve a 15 ppm specification
- Designation of bulk fuel tanks for Jet A

7.4.2 Incremental Cost of Potential Changes in Fuel Supply Chain Infrastructure

Table 33 shows current and future price differentials for ULSD No. 1 (new cold weather fuel regime) versus Jet A blends (current fuel regime) at the Anchorage OPIS rack (which appears to largely be a reflection of the rack prices of the Tesoro refinery).

Table 33. ULSD No. 1 vs. Jet A Price Premium at Anchorage Rack

	Price Premium (ULSD No. 1 vs. Jet A)	Long Term Price Premium (ULSD No. 1 w/lubricity vs. Jet A)
$ per gallon	4 cents per gallon	5 cents per gallon
$ per MMBtu	30 cents per MMBtu	38 cents per MMBtu

Source: MAFA Illustrative Values for Economic Model

7.4.3 Basic Remote Rural Fuel Supply Alternatives

There are several remote rural fuel supply alternatives, including 55-gallon drums, 5,000-gallon ISO container tanks (used or new), reuse of existing bulk fuel storage tanks using a blend down approach, reuse of existing bulk fuel storage tanks after draining and cleaning, and building a separate new bulk fuel storage system. The following is a list of the assumptions used to illustrate the differences between these alternatives.[10]

- ULSD No. 1 Density = 6.76 lb/gallon
- 55-gallon drum dry weight = 24 pounds, 4.16 per hundred weight (cwt)
- $3 per cwt wharfage fee
- River barge deck freight = $0.208 per cwt per one-way map-mile
- River barge containerized freight = $0.134 per cwt per one-way map-mile
- River fuel barge freight cost component = $0.112 per cwt per one-way map-mile
- Real discount rate = 5 percent, use in net present value calculation for 2008-2030

Low Volume 55-gallon drums as deck freight on river barge

Fifty-five-gallon drums as deck freight on a river barge appear to be the least-cost alternative for small volumes of fuel since there are little or no fixed costs to amortize over the volume of fuel. Local delivery may consist of local labor and household scale equipment (four wheelers, trailers,

[10] MAFA developed assumptions from review of Crowley Maritime Invoices and Alaska Fuel Supplier price quotes for ULSD in 55-gallon drums delivered to a shipping wharf.

trucks) to transport the drums. An average cost of $20 per drum is assumed to cover local reuse and backhaul to the refinery for reuse/refurbishment.

Medium low volume 55-gallon drums as package/container freight on river barge

Fifty-five-gallon drums as package (hi cube) or other ISO containerized freight on a river barge appear to be a least-cost alternative for modest volumes of fuel (30-50 drums) since there are a few set-up costs to amortize over the volume of fuel. Local delivery may require larger scale equipment to transport the packaged/containerized drums. An average cost of $20 per drum is assumed to cover local reuse and backhaul to the refinery for reuse/refurbishment.

Medium low volume 5000-gallon ISO container fuel tanks on river barge

The estimated cost of ISO container fuel tanks (international standard 8′ x 20′ shipping container) is as follows:

- Used – $16,000 in Alaska in slow market
- Used – $24,000 in Alaska in higher demand, limited supply market
- New – $50,000 in Alaska

ISO container fuel tank tare weight is 64 cwt. Depending upon the local availability of heavy equipment, the ISO container fuel tank may need to be delivered empty to enable its safe placement on shore where it can be filled from a river fuel barge or intermediate fuel pumping operation.

Transportation, engineering, permitting, and installation costs to meet regulatory requirements for longer term storage in a community could increase the total costs to an estimated $110,000 in a remote village.

Barge Modifications and Other Equipment

Ocean-going and river barges have multiple compartments to carry several products on a voyage. Modifications may be necessary to further compartmentalize a barge in order to carry an additional product. Additional piping and associated labeling and instrumentation is likely going to be necessary to separate ULSD from other fuels. In the absence of additional compartments, cleaning of selected tanks to carry ULSD will be necessary. On average, these costs are estimated to be on the order of 1.2 cents/gallon for ocean barges and 4.2 cents/gallon for much smaller scale river barges.[11]

Refiners have indicated that they will not add lubricity additives to barge shipments to avoid potential contamination issues. Villages and towns are unlikely to have adequate equipment or trained personnel to add lubricity additives so it is anticipated that the fuel distributors will put equipment on some ocean-going barges to add lubricity agents. A rough order-of-magnitude

[11] See Appendix C Excel Workbook "ULSD_Cost Estimate", tabs "Ocean Barge Fleet" and "Lighterage Barge Fleet" for detailed supporting calculations.

cost estimate for this equipment is $50,000. The amortized cost of the equipment per each gallon of ULSD delivered in a year by a barge would be on the order of 1 cent per gallon.

Use Line Cleaning In Between Fuel Types vs. New Separate Fuel Header

Crowley reports that it is cleaning marine header fuel lines by pigging and by sequencing delivery of gasoline after delivering Jet A and before it switches to ULSD fuel delivery to reduce the potential for sulfur contamination. The estimated cost for the setting up the new procedure combined with the ongoing change in operations appears to be on the order of 1 to 2 cents per gallon.

Alternatively, if the fuel sequencing and pigging to keep the marine fuel header clean for ULSD deliveries is not found to yield consistent results (there is no evidence that this approach does not work), a new separate marine header and pumping system for ULSD could be installed to maintain a separate fuel system that reduces the risk of ULSD contamination. The incremental cost for a separate project to design, engineer, mobilize/demobilize, install, inspect, and test a new separate ULSD marine header, pumps and piping for a rural remote village appears to be on the order of $80,000.[12]

Reuse Existing Bulk Fuel tanks vs. Build New Bulk Fuel Tanks

To the extent that ULSD is a substitute fuel for existing diesel fuel supplies, the reuse of existing bulk fuel tank storage capacity merits consideration as an alternative to the high cost of constructing new bulk fuel tanks in remote rural villages.

One approach to reuse the existing bulk fuel tank capacity is to begin running ULSD through the tanks three seasons in advance of when the 15 ppm specification is required in order to provide adequate dilution of residual higher sulfur fuel over the course of three inventory turns.

Assuming the fuel in the diesel tank delivered in the summer of 2007 was 3,000 ppm Jet A, Table 34 provides an example of how subsequent deliveries of ULSD could be used to blend down to a 15 ppm specification by December 2010.

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[12] MAFA Analysis of Estimations Inc. and HMS bulk fuel tank farm estimates. The average cost for all of the components in the marine header, pumps and piping for a typical remote rural tank farm is on the order of $60,000 installed as part of a larger bulk fuel tank farm project with a total cost on the order of millions of dollars. As a stand-alone project not associated with a larger tank farm project, the marine header and one or two smaller tanks will have to absorb design, engineering associated with a retrofit, contractor mobilization and demobilization, contractor overhead and profit (risk) on a small job—leading to a rough estimate of $80,000 for a complete new separate header system.

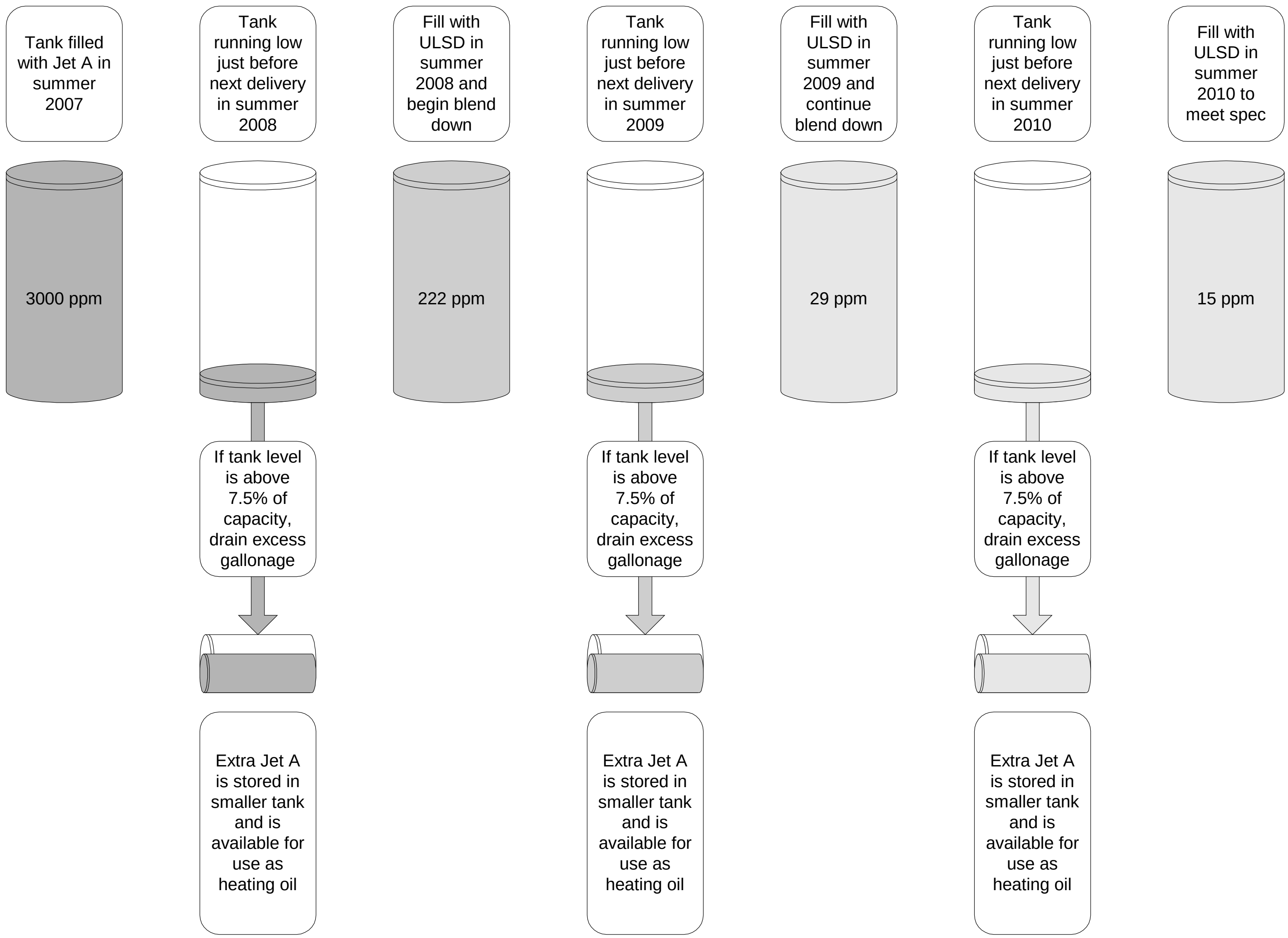
Table 34. Three Turns of Inventory to Blend Down to 15 ppm ULSD specification

Tank	Product	Date	Delivery Volume (g)	Sulfur (ppm)	Remaining Volume (g)	Tank Starting Sulfur (ppm)	Tank Ending Sulfur (ppm)
Diesel	Jet A	July-07					3,000.0
	ULSD	July-08	22,000	14.0	1,650	3,000.0	222.3
	ULSD	July-09	22,000	14.0	1,650	222.3	28.5
	ULSD	July-10	22,000	14.0	1,650	28.5	15.0

Source: MAFA Calculations

This example requires that the amount of fuel left in the tank from the prior heating season is roughly 7.5 percent of the annual fuel delivery tank capacity. In order to consistently achieve this in the field, a fuel tank is required to receive the amount of prior year's fuel that exceeds the maximum tank inventory (1,650 gallons) before the new ULSD delivery. The fuel from this tank can be used as a source for heating oil in the next heating season. An example of this approach is schematically described in Figure 31. This transition re-uses existing fuel tanks, with a blend down technique, instead of adding new and costly steel tanks.

Figure 31. Ultra Low Sulfur Diesel (ULSD) Transition in Remote Rural Alaska Communities



Source: MAFA, 2007.

An alternative approach to the blend down with ULSD is to drain and clean piping and tanks prior to filling with ULSD with the goal of removing sufficient sulfur that whatever sulfur remains after the cleaning is insufficient to raise the sulfur concentration of the fuel above 15 ppm. The blend down is less expensive than tank cleaning due the small incremental cost of buying ULSD fuel sooner compared to the additional cost of mobilizing specialized crews and equipment to drain and clean tanks in remote rural villages. Especially if a large demand for cleaning emerges in 2009-2010, a price spike for cleaning services becomes a distinct possibility. Conversely, given the transition of refinery markets to ULSD in Seattle/Port Angeles and Alaska, the potential for a price spike for ULSD fuel beginning in 2008 and extending through 2010 appears modest (compared to high sulfur diesel fuel).

If the existing tank farm owner is unable or unwilling to reuse their tanks and new bulk fuel storage tanks need to be built, the cost for a new 23,000-gallon tank in a remote rural village of 400 residents would be on the order of $280,000 up to $409,000, depending on location, foundation work, and other cost factors. The marine fuel header would cost on the order of $80,000. Thus, a separate fuel loading, pumping, piping, and storage system could cost on the order of $360,000. For a village of 150 households, this amounts to an incremental cost of $2,400 per household.

Medium low volume 4750-gallon load on DC-6 airplane fuel tanker

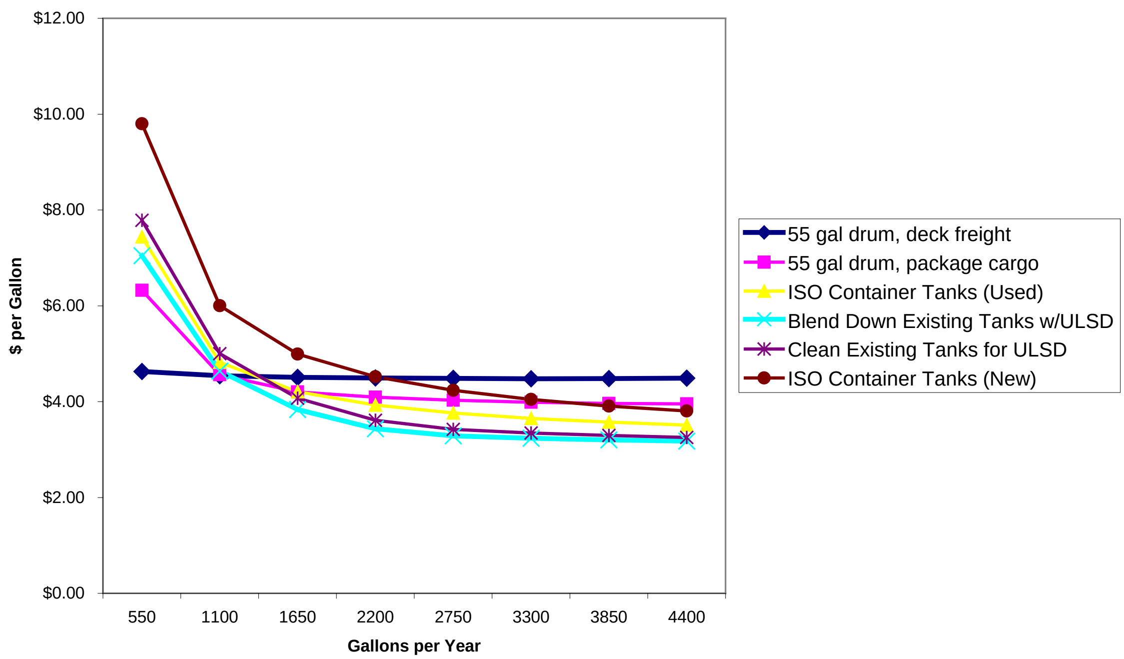
Finally, in some remote rural communities, river barge deliveries may not be an option due to low water or lack of adequate river access. In these cases, diesel fuel may need to be flown in via air fuel tanker. Based on project interviews and cost estimates from 2007, the estimated cost of fuel delivered by DC-6 is somewhere in the range of 1.5 cents per one-way map mile. A 200-mile one-way delivery (400-mile round trip) would cost about $3.00 per gallon for air delivery on top of the price of fuel delivered to the air tanker.

Based on the cost development described above, the prices per gallon for small and large volume deliveries are summarized in the figures below.

Small Volumes – (New Engine Warranties Scenario)

Figure 32 illustrates the cost of fuel delivery to a rural village, using river transport and local storage, over a range of approximately 500 to 5,000 gallons. At low use levels, 55-gallon drums, delivered as deck cargo, are the most cost effective. At higher use levels, the blend down process is most cost effective.

Figure 32. Total Cost of ULSD Fuel Delivery Options (River transport and local storage)

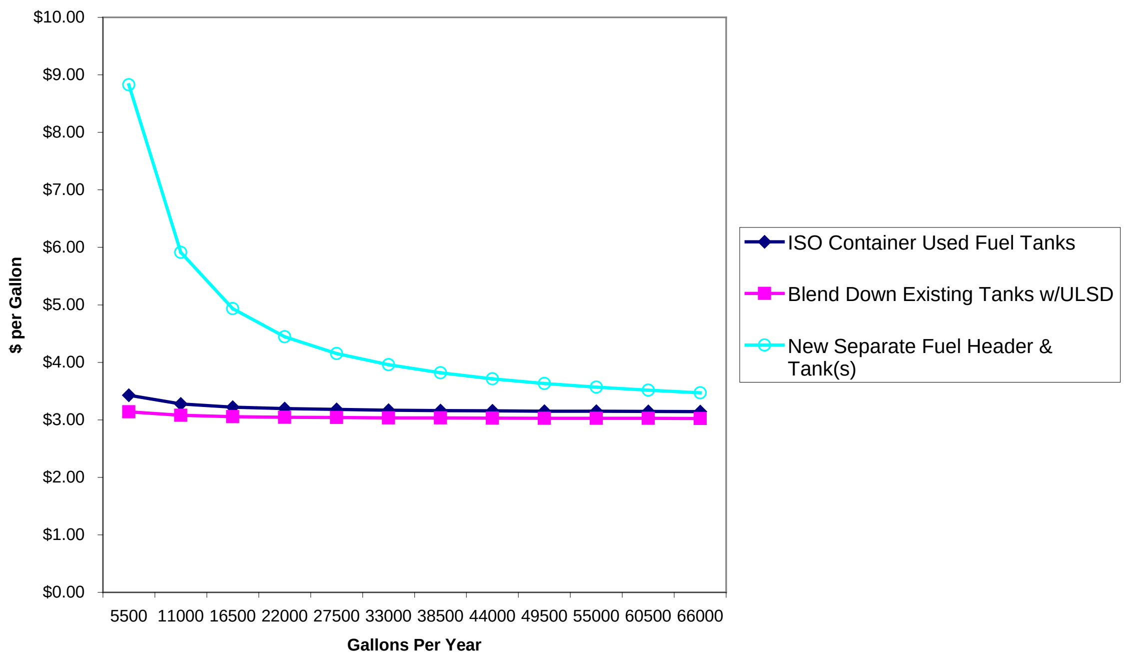


Source: MAFA, 2007

Larger Volumes – (All Engines, All Engines + Heating Oil Scenarios)

Figure 33 shows cost curves for larger volumes, from approximately 5,000 gallons to 70,000 gallons. Again, the blend down process is most cost effective over all volumes, followed by ISO tanks and, most costly, construction of a new steel tank and header.

Figure 33. Total Cost of ULSD Fuel Supply Options (River transport and local storage) Illustrative Rural Village Example Comparing Blend-Down to ISO Containers or New Fuel Headers and Tanks



Source: MAFA 2007.

8 Incremental Household Costs: Fuel and Power

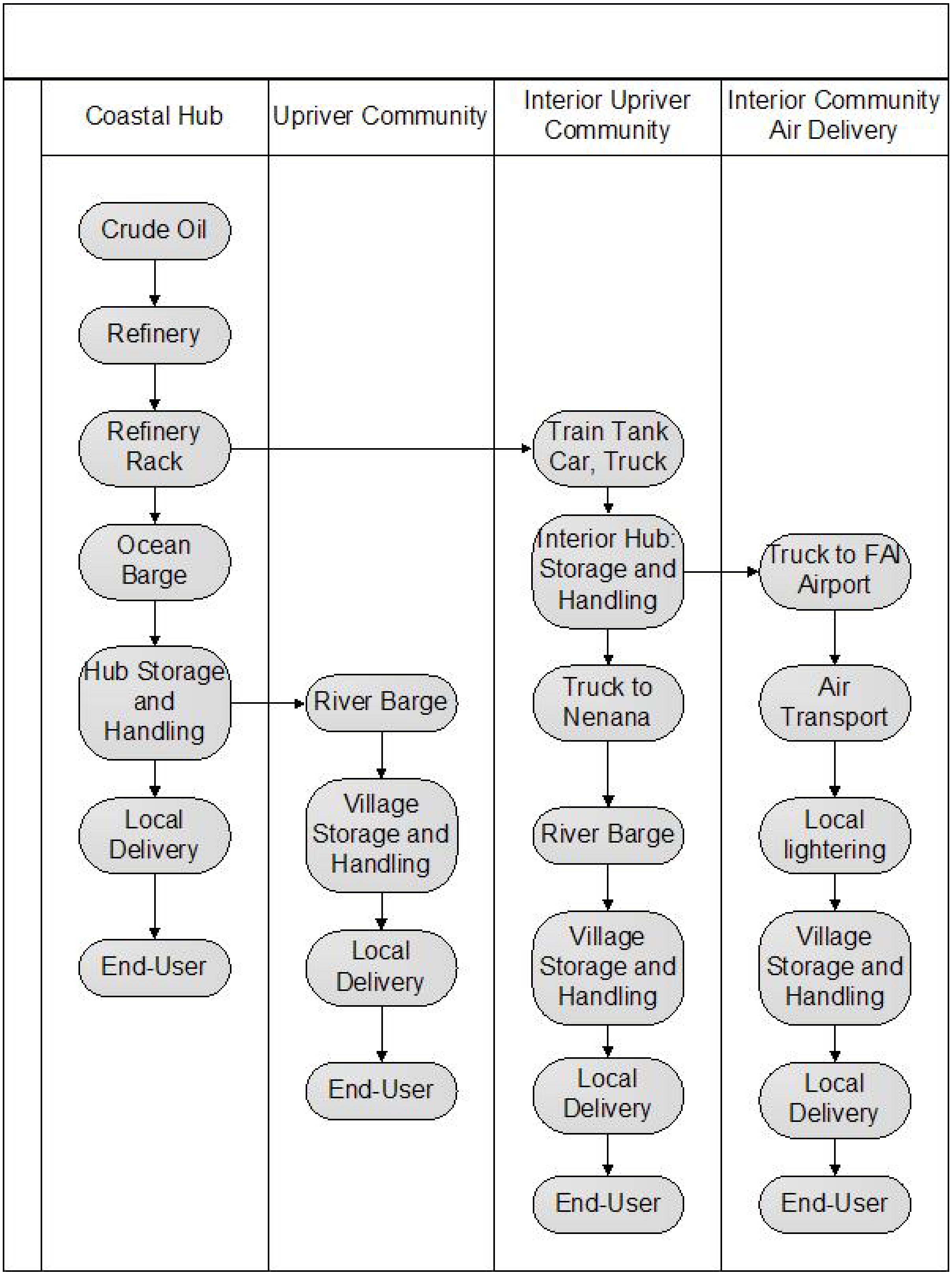
This section provides information on cost flows, from defined cost centers, and uses a detailed cost model to develop cost impacts to households for the years 2008 to 2030.

8.1 Fuel Supply Chain & Associated Costs

The incremental cost differences for ULSD fuels in rural Alaska begin at the source: crude oil. Figure 34 illustrates the fuel supply chain from crude oil to the end-product consumer. The schematic is illustrative and shows major cost centers in the fuel supply chain; there are other fuel supply activities, not specifically delineated, such as trucks hauling fuel from distribution tanks to local residential tanks which are included in the cost model as an individual line item within the local delivery category.[13]

[13] See Appendix C.

Figure 34. Fuel Supply Chain



Source: MAFA, Northern Economics.

8.2 Cost Centers

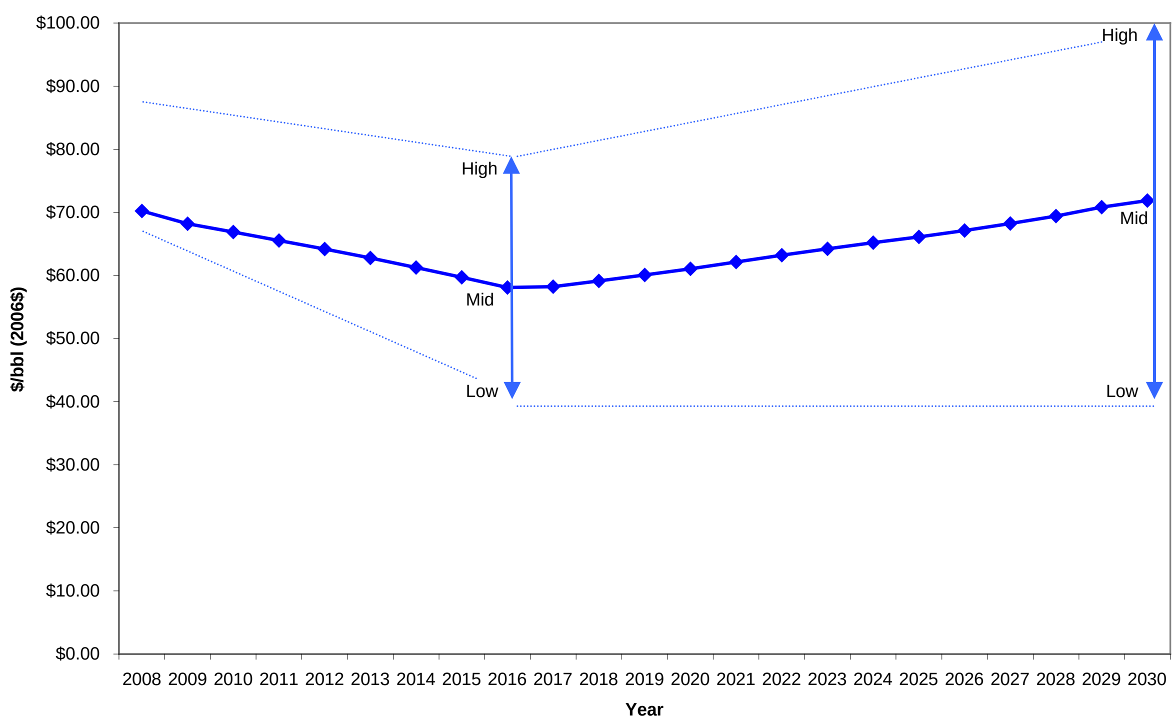
For purposes of this study, Anchorage was used as the pricing base rather than Fairbanks. This was done for two reasons: First, the Tesoro refinery expansion is not sized to meet total ULSD demand in the state through the year 2030, so prices for distillate fuel from Tesoro will be constrained by Puget Sound refinery prices plus shipping to Alaska. Second, the OPIS data set for Anchorage fuel prices is somewhat more complete than Fairbanks, providing slightly more confidence in the averaging of costs.

8.2.1 Crude oil

The base case fuel price projection for the ULSD cost model begins with the EIA Annual Energy Outlook 2008 (December 2007 early release) price for crude oil and adds the costs to refine, transport, store and deliver fuel products to end-users.

The EIA Annual Energy Outlook 2008 long –term price projections for crude oil appear in Figure 35.

Figure 35. EIA AEO 2008 (early release December 2007) Crude Oil Price Projection



Source: MAFA. EIA 2008, Early Release.

The use of ULSD fuel does require additional additives. Most important is the use of a lubricity additive for use in diesel engines; it would not be necessary for use in fuel oil but those costs will be included in all ULSD costs. Pour point depressants can be used to create an arctic grade product and that cost would be added to all No. 2 fuel prices.

These costs for additives have not been included in any of the above cost predictions, which are driven by crude oil prices. The reason for this is that the additives' cost will be added to the final price, usually at time of delivery.

The type and amount of fuel additives used to treat ULSD is crude and process specific, so a range of numbers is presented below. These costs are based on information received from additive manufacturers.

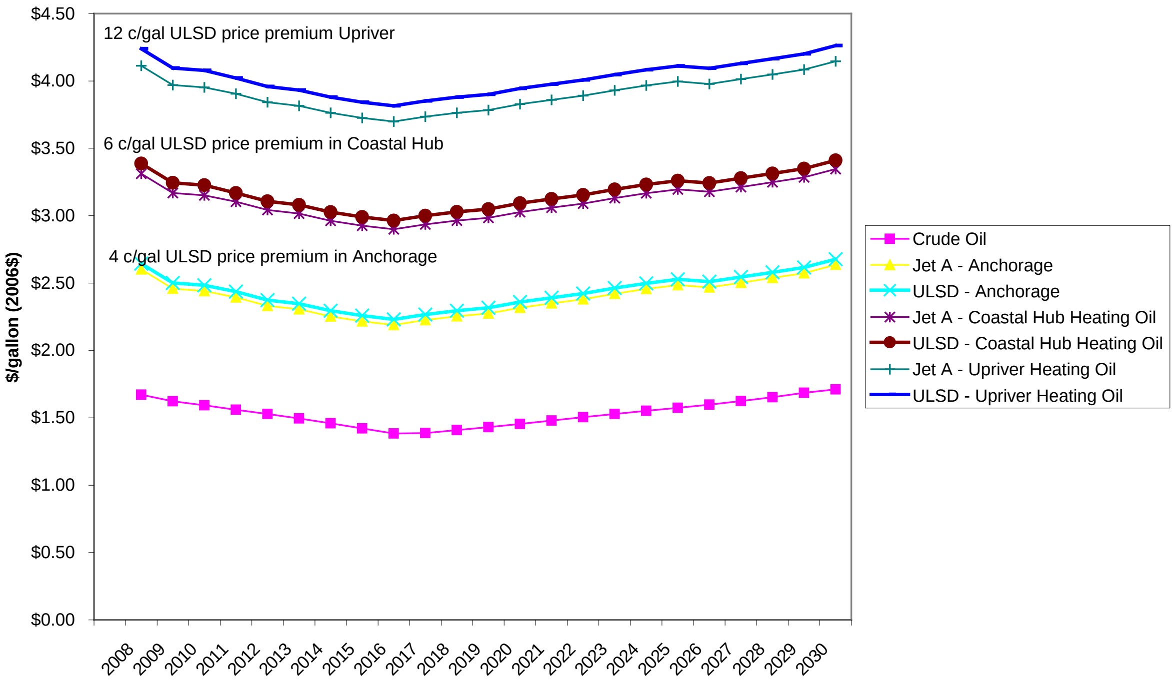
At the refinery, and with microbial testing (there is only one set of test equipment in the state), the cost of lubricity additives may approach one-half cent ($0.005) per gallon. Without testing equipment, and to ensure that the fuel meets the lubricity specification, the costs for injecting additives from a barge into the fuel stream are estimated at $0.01 per gallon.

Table 35. Projected Long Term Fuel Prices of Crude Oil, Jet A, ULSD, and the Price Premiums in Anchorage, Coastal Hub, and Upriver Locations, 2008-2030, in 2006$.

Fuel	Units	2010	2015	2020	2025	2030
Crude Oil	$/bbl	$66.89	$59.70	$61.05	$66.11	$71.87
Crude Oil	$/gallon	$1.59	$1.42	$1.45	$1.57	$1.71
Jet A – Anchorage	$/gallon	$2.44	$2.22	$2.32	$2.49	$2.64
ULSD – Anchorage	$/gallon	$2.48	$2.26	$2.36	$2.53	$2.68
ULSD - Anchorage Premium	$/gallon	**$0.04**	**$0.04**	**$0.04**	**$0.04**	**$0.04**
Jet A - Coastal Hub Heating Oil	$/gallon	$3.15	$2.93	$3.03	$3.20	$3.35
ULSD - Coastal Hub Heating Oil	$/gallon	$3.23	$2.99	$3.09	$3.26	$3.41
ULSD - Coastal Hub Premium	$/gallon	**$0.07**	**$0.06**	**$0.06**	**$0.06**	**$0.06**
Jet A - Upriver Heating Oil	$/gallon	$3.95	$3.73	$3.83	$4.00	$4.15
ULSD - Upriver Heating Oil	$/gallon	$4.08	$3.84	$3.94	$4.11	$4.26
ULSD - Upriver Premium	$/gallon	**$0.13**	**$0.12**	**$0.12**	**$0.12**	**$0.12**

Source: SAIC, MAFA, Northern Economics Analysis, adopted from EIA, AEO, 2008.

Figure 36. Long Term Fuel Price Forecast – Alaska Distillate Fuel Prices (2006$)



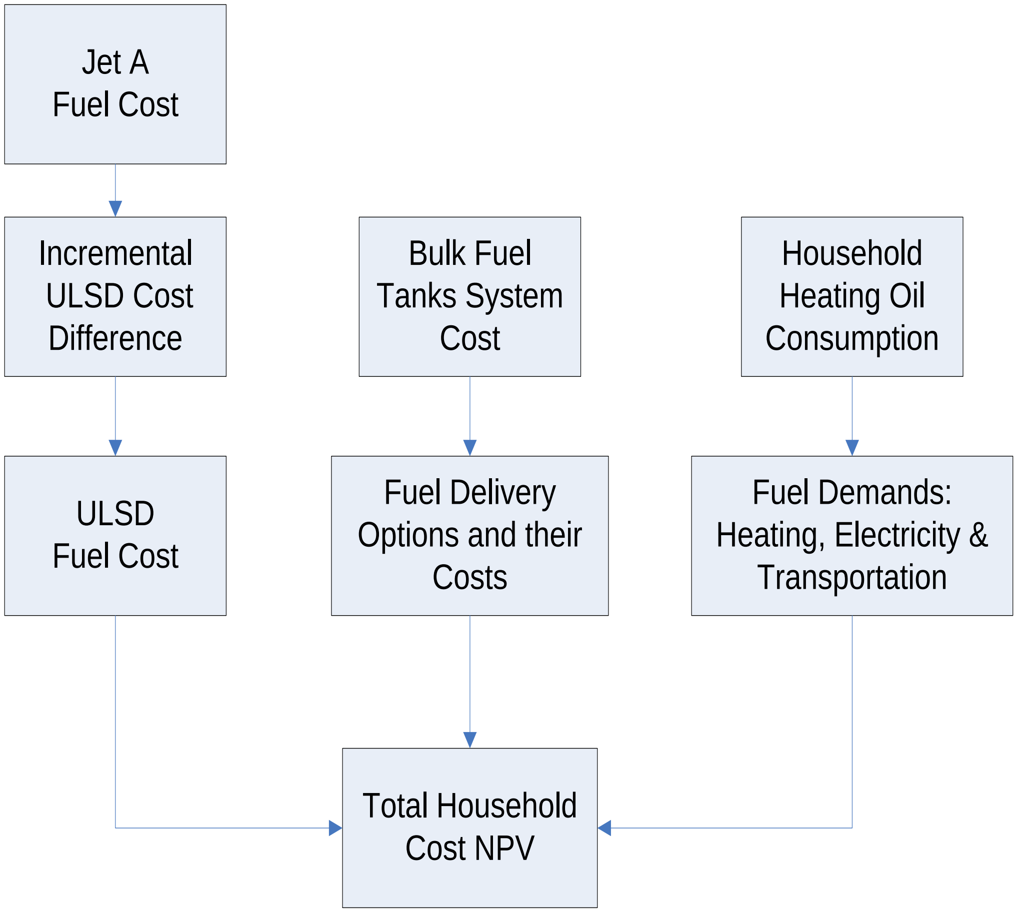
Source: MAFA, 2007.

However, at any given time a market shortage can have a significant impact on the prices shown. These shortages could be the result of a loss of crude supply (pipeline shutdown), a refinery disruption, or problems in the delivery supply chain.

8.3 Cost Model

Project requirements included development of a cost model, using forecasts to 2030, to estimate economic impacts on communities in the project area. The model, developed by Mark A. Foster Associates is shown as a flow chart in Figure 37

Figure 37. Cost Model Flow Chart.[14]



Source: Northern Economics adaptation, MAFA source data.

8.3.1 Fuel Supply Chain Focus

The model attempts to mimic the fuel supply chain and capture the cost to delivery refined fuel to end-users from the acquisition of crude oil through refining, transportation, storage, ocean transport, lightering, regional fuel terminals, lightering, river barge, delivery to upriver bulk fuel storage facilities, local storage, and final delivery to local end-users, including residential heating oil, diesel generating unit day tanks, and vehicles and marine engine dispensing.

8.3.2 Assumptions

Project scenarios were used to develop four key assumptions, listed below:

- Scenario 1 – ULSD fuels would be required to meet new engine requirements from 2007 on, representing a gradual growth in ULSD needs as new engines with ULSD warranty requirements come into the market.

[14] See Appendix C.

- Scenario 2A – Mobile Sources + Stationary Power adding a new unit engine-generator set in 2013.
- Scenario 2B – Mobile Sources + Stationary Power + Begin Blend Down in 2008
- Scenario 3A – Mobile Sources + Stationary Power + Heating Oil + Begin Blend Down in 2008.

The cost of each scenario is analyzed over the time period 2008 to 2030, and the results are discounted back to the present using a 5.0 percent discount factor, based on Alaska Municipal Bond Bank rates over the past several years. The discount factor is a variable input to the model and may be varied to test impacts of changing interest rates.

Basic fuel demand per year was projected at 300,000 gallons for a typical upriver village community, with a projected 75,000 gallons of ULSD required for each new power generator (per year).

8.3.3 Basic Electrical and Heating Demand

The cost model assumes an average of 5,400 kWh per household, 800 gallons per year of heating oil, and a nominal amount of diesel transportation fuels for upriver communities. The model also assumes an average of 6,000 kWh per household per year, 1,000 gallons per year of heating oil, and a slightly larger, but likewise nominal amount of diesel transportation fuels for coastal hub communities.

8.4 Results

Table 36 summarizes results for each scenario.

Table 36. Estimated incremental cost of ULSD compared to Jet A for rural Alaska households – Selected Scenarios

	Units	**Scenario 2A:** Gradual Transition to ULSD (excluding heating oil)	**Scenario 2B:** Rapid Transition (excluding heating oil) with blend down	**Scenario 3:** Rapid Transition (including heating oil) with blend down
Household Cost 2010	$/household/year	$300	$278	$189
Household Cost (2008-2030)	$/household (NPV 2006$)	$2,902	$2,361	$2,091
Households	Number of households in Study Area	14,700	14,700	14,700
Aggregate Household Cost	$ (2008-2030, NPV 2006$)	$42,666,368	$34,713,598	$30,744,452

Source: ULSD Economic Model. The household costs represent an aggregate weighted average of coastal hub and upriver community costs.

Net Present Value

NPV stands for Net Present Value, an economic and financial technique that reflects the time value of money, also referred to as compound interest calculations. NPV is a useful way to compare alternatives with different cash flows at different time periods.

A key factor for calculating the time value of money is the discount rate (i.e. interest rate) used for calculating the current or present value (PV) of future cash flows. Future cash flows can be positive or negative, reflecting income or expense; when these cash flows are calculated at the present time (i.e. present value) they are termed "net" present value to reflect the difference between cash inflows and outflows. For example, if the present value (PV) of a series of future cash flows is $250 and the PV of cash outflows is $100, the net amount of $150 ($250 - $100 = $150) is termed the Net Present Value.

The estimated cost of using ULSD instead of Jet A in the study area households averages between $189 and $300 a year per household with an aggregate household cost over the study period (2008 to 2030) of $30 to $40 million (2006$).

A rapid transition from Jet A to ULSD that includes heating oil appears to be the least expensive transition to ULSD due to:

1) Economies of scale: higher volumes decrease the unit cost of delivering fuel (e.g., it is cheaper to deliver fuel in larger barges than in 55 gallon drums);
2) Less need for transitional storage (e.g., 55 gallon drums and ISO containers); and
3) More efficient use of existing infrastructure (e.g., a rapid transition using a blend-down approach makes the best use of existing bulk fuel tank farms by reducing the risk of un-used capacity in existing tanks).

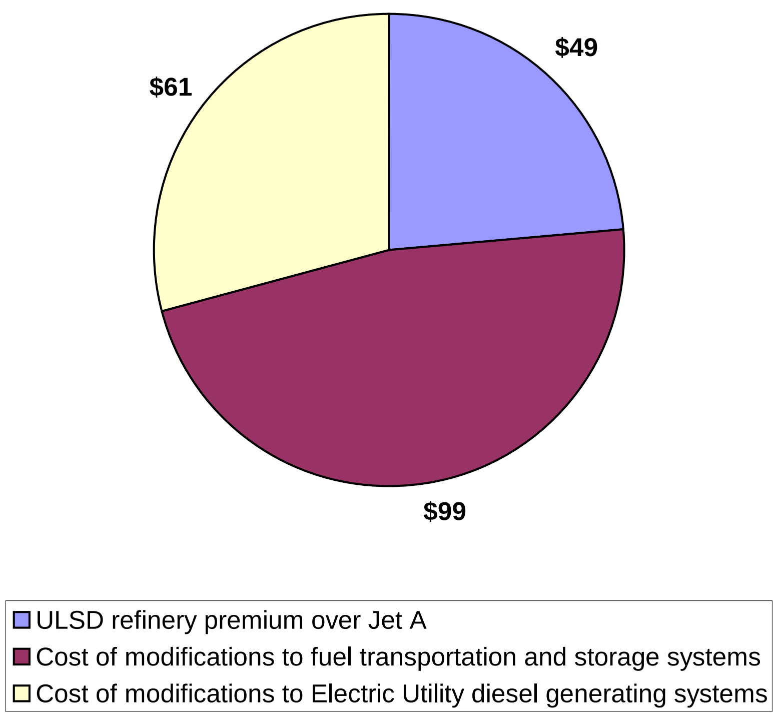
Even an efficient rapid transition to ULSD will incur significant costs for rural households in the study area—on the order of $190 per household per year—roughly $16 per month. This reflects the costs associated with:

1) The price premium for ULSD over Jet A;
2) The costs associated with changes in fuel filters, fuel pump seals, finding a new way to dispose of used oil, and a slight loss in fuel economy at the electric utility using diesel generating units; and
3) The costs associated with modifications to ocean barges and river barges to segregate, label, and operate the new ULSD fuel stream including a new lubricity additive system. Due to the smaller scale and additional lightering associated with fuel deliveries to upriver communities, households in upriver communities may pay on the order of 20 percent more for the transition to ULSD than households in coastal hub communities.[15]

The relative proportion of the incremental costs for the delivery of ULSD fuel compared to Jet A to an *upriver* community breaks down roughly along the lines described in Figure 38.

[15] See Appendix C, tab "Household Impact."

Figure 38. Breakdown of Incremental Costs to Supply ULSD to Upriver Community compared to Jet A



Source: MAFA, 2007.

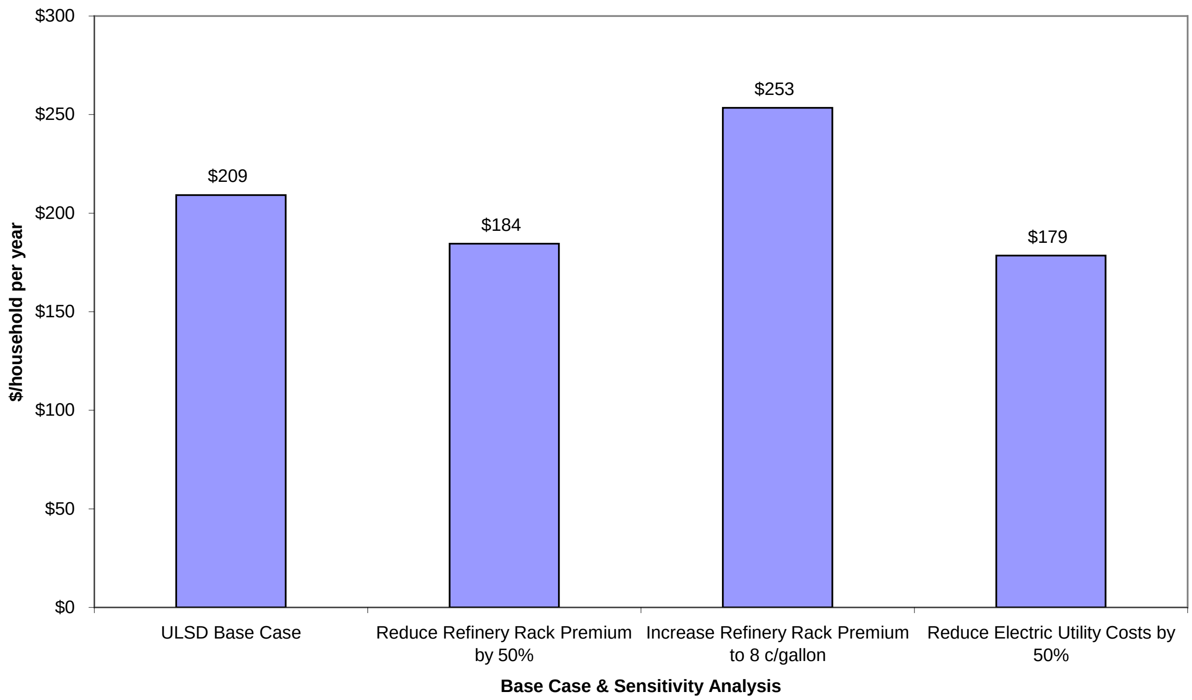
8.5 Sensitivity Analysis

The sensitivity analysis consists of two parts: 1) basic sensitivity testing of key variables and 2) probability weighted Monte Carlo simulation.

8.5.1 Basic Testing of Key Variables

Two key assumptions with the greatest uncertainty (refinery premium and electric utility costs) were varied to analyze their relative importance on the cost analysis from the perspective of upriver households. The results of varying the refinery premium and the electric utility costs compared to the base case are presented below in Figure 39 on a cost per household per year basis.

Figure 39. Sensitivity Analysis of ULSD Costs – Upriver Community



Source: MAFA, 2007.

8.5.2 Probability Weighted Monte Carlo Simulation

Specific cost variables were set to vary in a spreadsheet simulation:

- Jet A fuel
- the incremental cost of ULSD
- gallons of fuel consumed per household for heating
- the cost of a new bulk fuel tank system

The simulation was used to determine which variable has the greatest effect on the NPV of total cost to each household for the four scenarios used by MAFA (note Scenario 1 had two slightly different variations in ULSD fuel quantity and the timing for new engines—2008 versus 2010).

For this analysis, the price of Jet A fuel was varied using a triangular distribution with a minimum of $2.5985 per gallon ($70 per barrel crude) to a maximum value of $3.7121 per gallon ($100 per barrel crude) with an expected value increasing each year based on estimated fuel costs at the Anchorage Rack.

The incremental difference in price between Jet A fuel and ULSD No. 1 with lubricity additive was varied using a normal distribution with a mean of 1.0516 and a standard deviation of 0.0236 resulting in the value being between 1.0083 and 1.0949 over 90 percent of the time based on a statistical evaluation of indexing information (Anchorage)[16].

The number of gallons of fuel consumed per household for household heating was varied using a triangular distribution from a minimum value of 700 gallons per year to a maximum value of 1,100 gallons per year with an expected value of 1,000 gallons per year. The cost of a new bulk fuel tank system was varied using a triangular distribution from a minimum value of $280,000 to a maximum value of $410,000 with an expected value of $380,000. These variables were the basis for Northern Economics' analysis.

Northern Economics performed the sensitivity analysis by running the model for 5,000 iterations using @RISK software and monitored the NPV sensitivity of total cost by household for the four scenarios (outputs). The sensitivity of an output to the variable input is measured on scale from zero to one, with one indicating the strongest possible sensitivity.

Table 37 shows the sensitivity of the Total Household NPV Cost for the full engine conversion by 2010 scenario to the four input variables. The simulation indicated that the each of the four scenarios were extremely sensitive to the incremental cost *difference* between Jet A fuel and ULSD with the sensitivity at one.

The cost of Jet A fuel showed a sensitivity of 0.013 indicating a very small effect on the output. The average household use variables showed a sensitivity of 0.002 indicating virtually no effect. Finally, the cost of Bulk Fuel Tank Systems showed no effect on the outputs.

Table 37. Sensitivity of Input Variables for Total Household NPV Cost

Input Variable	Input Range	Sensitivity for Full Conversion by 2010 Scenario
Incremental ULSD Cost Difference	1.0083 to 1.0949 factor per gallon	1
Jet Fuel Cost	$2.5985 to $3.7121 per gallon	0.013
Household Heating Oil Consumption	700 to 1,100 gallons per year	0.002
New Bulk Fuel Tank System	$280,000 to $410,000 per tank system	0

Source: MAFA, Northern Economics

Table 38 shows the statistical results for the Total Household Cost NPV of the @RISK simulation for each of the four conversion scenarios. The second column shows the most likely or mean value of the simulation and the third column shows the bounds of the simulation results at a 90 percent confidence interval. These results indicate that the New Engine Warranty in 2008 has the lowest cost per household and the Diesel Engine and Heating Oil conversion in 2010 scenario has the highest cost per household. A prudent conversion appears to be the blend-down process, delivering ULSD in 2008 and reducing average sulfur ppm over three years to the end of 2010.

[16] The cost of the lubricity additive was added after the incremental difference between Jet A and ULSD was sampled.

Table 38. Simulation Results for Total Household NPV Cost

Output	Mean Value ($)	90% Confidence Range ($)
New Engine Warranty – 2008	456	375 - 535
New Engine Warranty – 2010	523	432 - 615
All Diesel Engines converted in 2010	523	402 - 643
Diesel Engines and Heating Oil converted in 2010	2,605	854 - 4,373

Source: MAFA, Northern Economics

9 Potential Environmental Justice Effects of ULSD Transition

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," issued in 1994, directs federal agencies to make achieving environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies and activities on minority and low-income populations. This analysis examines the potential environmental justice implications of transitioning to ULSD fuel in the project area.

The analysis is divided into three parts. The first part describes the project area in terms of its race/ethnicity and poverty characteristics. Data collected by the U.S. Bureau of the Census are used to determine the number and proportion of individuals residing in the area who are members of a minority group or who have incomes falling below the federal government's poverty threshold. A demographic comparison to Alaska's entire population is presented to place the race/ethnicity and poverty characteristics of western and northern Alaska in context.

The second part of the analysis examines the potential for communities in the project area to experience a disproportionately high and adverse impact by a transition to ULSD fuel. In addition, the analysis determines whether characteristics of project area communities could amplify possible adverse economic effects of transitioning to ULSD fuel.

In the final part of the analysis, various mitigation measures are discussed, should disproportionately high and adverse impacts occur.

9.1 Environmental Justice Populations in Project Area

To sufficiently provide environmental justice to minority and low-income communities that may be disproportionately impacted by a transition to ULSD fuel, it is critical to define affected populations. Standard definitions related to such terms as minority, low-income, and minority population have been provided by the Council on Environmental Quality (1997):

Minority: Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

Low-income population: Low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the Bureau of the Census' Current Population Reports, Series P-60 on Income and Poverty.

Minority population: Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

The Council on Environmental Quality notes that a minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds.

9.1.1 Minority Populations in Project Area

Demographic data for the project area were evaluated to determine whether the minority population percentages are greater than the State of Alaska average. According to the 2000 U.S. Census, minorities account for 85 percent of the project area population, with American Indian and Alaska Native constituting the largest minority group (Table 39).

Consequently, the Council on Environmental Quality's threshold of 50 percent is exceeded. In addition, the total minority population percentage of the project area is greater than the minority population percentage in the general population of the state. The difference was calculated by subtracting the state percentage from the project area percentage. The Council on Environmental Quality does not define the term "meaningfully greater," but a difference of 53 percent would appear to meet this threshold.

Table 39. Minority Populations in Project Area and State of Alaska, 2000

Minority Group	Project Area (%)	State of Alaska (%)	Difference (%)
American Indian and Alaska Native alone or in combination with one or more other races, not Hispanic or Latino	84.0	18.6	65.4
Asian alone or in combination with one or more other races, not Hispanic or Latino	0.4	5.2	-4.8
Native Hawaiian and Other Pacific Islander alone or in combination with one or more other races, not Hispanic or Latino	0.1	0.7	-0.6
Black or African American alone or in combination with one or more other races, not Hispanic or Latino	0.2	4.1	-3.9
Hispanic or Latino (of any race)	0.8	4.1	-3.3
Total minority population	**85.5**	**32.7**	**52.8**

Source: U.S. Census Bureau, Census 2000 Summary File 4 (SF 4) - Sample Data and Census 2000 Summary File 1 (SF 1) 100-Percent Data.

9.1.2 Low-Income Populations in Project Area

The second criterion for environmental justice analysis is income. As in the case of minority populations, demographic data for the project area were evaluated to determine the percentage of individuals with incomes below the poverty threshold. These data were then compared to the percentage of individuals with incomes below the poverty threshold in the general population of the state. Table 40 shows that the low-income population percentage of the project area is greater than the low-income population percentage in the general population, with a level approximately twice the statewide figure.

Table 40. Low-Income Populations in Project Area and State of Alaska, 2000

	Project Area (%)	State of Alaska (%)	Difference (%)
Income in 1999 below the poverty level	19.6	9.4	10.2

Source: U.S. Census Bureau, Census 2000 Summary File 3 (SF 3) - Sample Data and US Census Bureau, Census 2000 Summary File 4 (SF 4) - Sample Data.

Table 41 shows the estimated median household income in the project area for 2006. The median income in project area villages is about 59 percent of the statewide median income.

Table 41. Median Annual Household Income in Project Area by Community Type, 2006

Regional Hubs	Sub-Regional Hubs	Towns	Villages	State of Alaska
$63,954	$45,829	$37,761	$33,083	$56,390

Source: Northern Economics, Inc. from U.S. Census Bureau, Census 2000 Summary File 3 (SF 3) - Sample Data.

Another indicator of the income status of households in the project area is the number of communities considered "distressed" by the Denali Commission based on employment and earnings information. The Commission uses distressed community criteria to guide economic development assistance. As shown in Table 42, a substantial proportion of the project area sub-regional hubs, towns and villages meet the Commission's distressed criteria.

Table 42. Number of Distressed Communities in Project Area by Community Type, 2007

Regional Hubs		Sub-Regional Hubs		Towns		Villages	
Number	Percent	Number	Percent	Number	Percent	Number	Percent
0	0	4	44	29	78	51	51

Source: Denali Commission, 2007

9.1.3 Conclusion

Based on this screening analysis, it is concluded that the project area contains a high minority population and low-income population relative to the state as a whole.

It is important to note that high concentration "pockets" of low-income and/or minority populations are evidenced in specific parts of the project area; these pockets have minority or low-income populations considerably higher than the regional averages. For example, the population of Karluk is entirely minority, and 64 percent of the residents of Grayling have incomes below the poverty level.

9.2 Disproportionately High and Adverse Impacts in Project Area

The prior analysis demonstrates that the project area contains a significant minority and low-income population, but the existence of an environmental justice impact has not yet been shown. A determination of an environmental justice impact would be made if the economic effects of transitioning to ULSD fuel are especially high and adverse in areas where there is a substantial presence of low-income or minority residents, based on proportionality, and no reasonable and feasible mitigation for these effects is available.

9.2.1 Adverse Economic Effects on Households

In order to probe for the presence of an environmental justice impact, interrelationships between the identified concentrations of minority and low-income individuals and the household economic effects of transitioning to ULSD fuel, as identified through the other analyses of this document, were assessed.

The major impacts on rural villages and households in the overall project area will be in the areas of home heating and cost-to-consumers for electricity. With respect to electricity price effects, the Alaska Department of Environmental Conservation (2007a) notes that power systems in rural Alaska are operated as non-profits by city governments or regional cooperatives. Remote local economies generate little cash to support utility operations, and many, if not most, of these power systems are not self supporting (Colt et al. 2003). Revenue is slim and operations are tightly controlled for costs. There is little revenue cushion to shield customers from increased operating costs like a rise in fuel prices (DCCED, 2007c).

As discussed in prior report sections, residents of larger population centers in the project area, such as the regional hubs of Dillingham, Nome, Kotzebue, Bethel and Barrow, may see little, if any, change in heating or power costs as a result of the transition to ULSD fuel. However, the 100 villages within the project area will see more impact due to their distance from hubs, smaller market size and fewer deliveries per year.

Table 43 indicates households in rural villages may experience up to $209 of increased cost due to ULSD requirements, within the three categories shown.

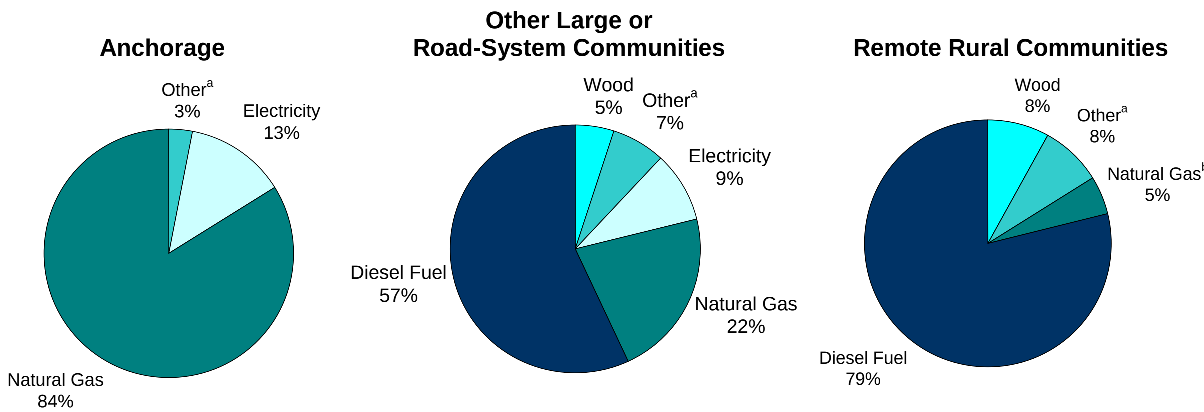
Table 43. Estimated Annual Household Incremental Costs, by Category

Cost Category	$/Year	Percent
Cost of modifications to electric utility diesel generating systems	$61	29.2
ULSD refinery premium over Jet A	$49	23.4
Cost of modifications to fuel transportation and storage systems	$99	47.4
Total	$209	100.0

Source: Northern Economics, MAFA

It would appear that communities in the project area would be disproportionately affected by these ULSD transition costs due to their greater reliance on diesel for heating and power generation in comparison to the rest of Alaska. As shown in Figure 40, the large majority of households in Anchorage and many residences in other large or road-system communities have access to natural gas for space and water heat. A negligible proportion of Anchorage households rely on diesel fuel, while an estimated 57 percent of households in other large or road-system communities use this fuel source for heating. In contrast, more than three-quarters of the residences in remote rural communities depend on diesel fuel.

Figure 40. Share of Alaska Households Using Various Energy Sources for Heating, 2000.



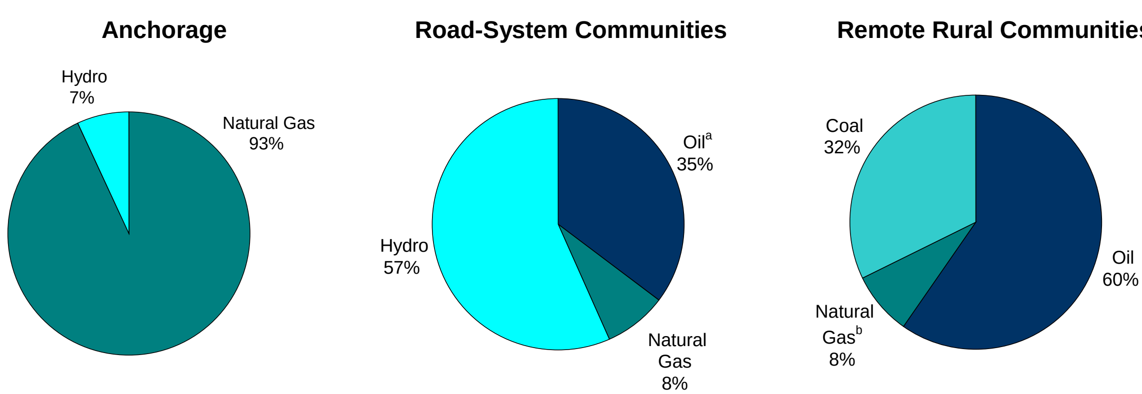
[a] Other = any fuel type not specified. Specific sources of heat include natural gas, propane, electricity, diesel fuel, coal, wood, and solar energy.

[b] Barrow has access to natural gas from local wells.

Source: Saylor and Haley, 2007.

Figure 41 shows that most electricity for Anchorage and other road-system communities is generated from natural gas or with hydro-power. In comparison, 60 percent of the electricity produced in remote rural communities is from diesel-powered generators.

Figure 41. Utility Net Generation (MWh) by Fuel Type, 2001



[a] Fairbanks and North Pole use No. 5 and No. 6 Fuel Oils and Bunker C Fuel Oil.

[b] Barrow has access to natural gas from local wells.

Source: Institute of Social and Economic Research, 2003.

9.2.2 Community Characteristics That Could Amplify Adverse Effects

There are distinct economic characteristics of communities in the project area that could amplify the adverse economic effects of transitioning to ULSD fuel. Firstly, the unemployment rate in the project area is relatively high. According to Alaska Department of Labor and Workforce Development employment data, an estimated 11.1 percent of the civilian labor force in the project area was unemployed in 2006; in comparison, the unemployment rate for the entire state was 6.7 percent. It is important to note that the official unemployment rate may underestimate the full extent of employment difficulties in rural Alaska by excluding those who have given up looking for work. With the high unemployment in the project area, many households are struggling for basic needs.

Population changes in the project area reflect the lack of employment opportunities in the area. As discussed in Section 3, communities in the project area with a population of less than 1,000, which represents 97 percent of all project area communities, experienced an overall population decline of 0.8 percent between 2000 and 2006. The population decline in villages with less than 100 inhabitants was more dramatic; they saw an overall outward migration of almost 20 percent between 2000 and 2006. In contrast, the state population increased by 7 percent during that time period.

A second characteristic of project area communities that could magnify the adverse economic effects of transitioning to ULSD is that fuel utility costs are higher to start with in rural Alaska communities because they rely mostly on diesel for heating houses and generating power (Saylor and Haley 2007). Both diesel and natural gas prices have increased sharply in recent years. Between 2000 and 2007, the cost of diesel for home heating in the project area increased an estimated 80 percent, while residential natural gas prices in Alaska increased 144 percent. Nevertheless, diesel is still more expensive when measured by heat or energy content. Assuming that natural gas and oil furnaces have the same seasonal heating efficiencies, households in the project area that use diesel fuel for heating pay on average about three and a half times more than Alaska households that use natural gas (Figure 42).

Figure 42. Comparison of Heating Costs of Natural Gas and Diesel Fuel, 2007

Source: Northern Economics, Inc., from AIDEA, 2007; Larsen et al., 2006.

Because most of the electric generators in rural Alaska run on diesel, escalating diesel prices have also resulted in substantial electric rate increases. Table 44 shows population-weighted averages of price per kilowatt-hour. Electric rates have increased throughout Alaska, but especially in remote rural places. Many remote communities receive Power Cost Equalization (PCE), a state program that subsidizes electricity cost in places that generate electricity mainly with diesel.

Table 44. Average Electric Prices Per kWh, 1999 and 2005

Region	1999 ($)	2005 ($)	Increase (%)
Anchorage (based on cost of 1000 kWh)	0.092	0.116	26
Kenai & Mat-Su (based on cost of 1000 kWh)	0.111	0.129	16
Mid-Size & Roaded (based on cost of 1000 kWh)	0.113	0.152	34
Remote Rural (based on PCE effective rates)	0.172	0.237	38

Source: Saylor and Haley (2007)

As a result of the relatively high utility costs and low incomes in rural Alaska, utilities take a much larger share of income among households. Saylor and Haley (2007) estimated that remote households paid a median of nearly 10 percent of their income on utilities, more than triple the share of Anchorage households.

Utility costs amount to more than a third of income among low-income households in remote places. These figures take into account the PCE program subsidy. The aforementioned high out-migration from small villages in the project area is particularly significant with respect to these disproportionate energy costs, as there are fewer people to pay ongoing capital and operating costs.

Another consideration is that utility costs are not only higher in the project area than in other areas of Alaska because of a greater dependence on diesel fuel, they are also more variable. Saylor and Haley (2007) note that the high volatility of diesel oil prices transfers over to heating oil costs and electric rates. Volatility and unpredictability in heating oil costs and electric rates is a problem for budgeting and planning for households. The problem is compounded when household incomes also vary month to month and year to year, as they do in seasonal and highly variable industries such as fishing, tourism, and construction—industries that dominate the economies of many areas of rural Alaska.

A fourth factor that could amplify the adverse economic effects on project area communities of transitioning to ULSD is the high cost of living in these communities. High fuel prices not only affect heating and electricity costs in the project area; they also indirectly affect many other costs. The high cost of living in rural Alaska is largely due to the absence of low cost transportation links to the outside world or between communities. Air transportation and summer barge service represent the only transportation options for bringing goods to most residents. Few goods or services escape a substantial transportation premium. For example, food costs in rural Alaska are twice those in the state’s more urban and accessible areas (Fried and Robinson 2007). Moreover, the rural/urban differential in food costs appears to be increasing. In 1997, for instance, food costs for a week for a family of four in Bethel were 147 percent of Anchorage costs (Boucher 1999); a decade later Bethel costs are 192 percent of Anchorage costs (Fried and Robinson 2007).

Finally, it is important to note the effects of the importance of subsistence activities for rural Alaskans. Harvesting and consuming fish, game and other natural foods for subsistence is the cornerstone of life in rural Alaska (Colt et al. 2003). These resources have considerable nutritional, economic, cultural and spiritual importance. Rural Alaskans often face difficult trade-offs between the need for cash income and the need to participate in subsistence. This trade-off means that rural villages may not wish to generate as much cash income as they could, because their scarce time is better spent on subsistence. With less cash income, customers have a harder time paying utility bills (Colt et al. 2003).

9.2.3 Conclusion

In summary, the present analysis suggests that the household costs of transitioning to ULSD fuel are highest for the regions of the state with the highest concentrations of minority and low-income populations. This disproportionate impact is due to the greater reliance of project area communities on diesel for heating and power generation in comparison to the rest of Alaska. The analysis further indicates that several characteristics of project area communities would exacerbate this disproportionate adverse economic effect.

9.3 Mitigation of Disproportionately High and Adverse Impacts in Project Area

If it is demonstrated that a transition to ULSD fuel will have a disproportionately high and adverse effect on a minority or low-income population, Executive Order 12898 requires that measures be developed in consultation with affected communities to mitigate these effects. Mitigation measures include steps to avoid, mitigate, minimize, rectify, reduce, or eliminate the impact associated with a proposed agency action (Council on Environmental Quality 1997). For example, among the potential mitigation measures the EPA identifies in its environmental justice guidance for Clean Air Act 309 Reviews are the following:

- Planning for and addressing indirect impacts prior to project initiation
- Providing assistance to an affected community to ensure that it receives at least its fair (i.e., proportional) share of the anticipated benefits of the proposed action
- Changing the timing of impact-causing actions to reduce effects on minority communities and low-income communities

It is beyond the scope of this analysis to determine the practicability of a mitigation measure in terms of the social, economic (including costs) and environmental effects of avoiding or mitigating the adverse economic effects of a transition to ULSD fuel. However, it is instructive to briefly describe possible mitigation measures and constraints in the implementation of those measures.

EPA's rules for fuel sulfur levels in rural Alaska require a transition of new, modified, or reconstructed stationary diesel internal combustion engines to ULSD fuel by 2010. One possible mitigation measure would be to extend the target date for implementation of the new fuel requirements in order to give affected communities, organizations, and other groups' additional time to upgrade fuel distribution and storage facilities. A drawback of this mitigation measure is the potential health impact of the air pollution caused by continued use of conventional diesel fuel for power generation.

Attempts to study the health implications of diesel use in Alaskan villages have not been successful (Alaska Department of Environmental Conservation 2007b). However, adverse health impacts associated with diesel exhaust exposure is well established. The current rules require use of ultra low sulfur diesel in 2011 and later model year stationary source engines. If the state stays with the current recommendation, rural power generators will come under the same rules as the diesel internal combustion engines in the rest of the nation. Thus the state does not currently recommend pursuing further health studies. In the event of an extended target date for the transition of stationary sources to ULSD, the Alaska Department of Environmental Conservation recommends further study to determine health effects of long term exposure to large stationary source diesel exhaust.

Another possible mitigation measure would be the development and application of a new energy assistance program or expansion of an existing one. Saylor and Haley (2007) list a variety of state, federal, and private programs that currently provide energy assistance to Alaska households and communities. These programs include the Low Income Energy Assistance program, which provides grants to qualifying households to assist with winter home heating costs; the Power Cost Equalization Program, which subsidizes electric costs for rural Alaska; and the RuralCAP's weatherization program, which helps poor households conserve home heating.

Energy assistance programs have substantially reduced energy costs in some rural Alaska villages. For example, North Slope communities report the lowest average heating fuel retail price ($1.64 per gallon) in the state because the North Slope Borough provides free heating fuel for residential use through village corporations who distribute fuel to borough community residents, charging only a delivery fee on a per gallon basis (Alaska Department of Commerce, Community and Economic Development 2005).

Subsidies provided through energy assistance programs could assist in updating village infrastructure to accommodate ULSD (Alaska Department of Environmental Conservation 2002). This may include new tanks, cleaning of existing tanks, barge modifications, engine overhauls, and other activities. The mitigation levels of energy assistance programs are dependent on the funding allocated to the programs. Funding levels, in turn, are at least partially dependent on the fiscal situation of the federal and State of Alaska governments. Funding for federal programs such as the Low Income Energy Assistance program have faced increasing pressure in recent years as the wars in Afghanistan and Iraq continue, the current administration cuts taxes, and social programs such as Medicare, Medicaid, and Social Security grow with an aging population. With respect to funding for state energy assistance programs, high oil prices have temporarily restocked the state treasury and removed fiscal pressures; however, the state's long-term fiscal situation is highly uncertain.

A third possible mitigation measure is to develop alternative energy sources for rural Alaska communities and thereby reduce their dependence on diesel fuel to generate electricity and to heat homes and buildings (Alaska Department of Environmental Conservation 2002). Saylor and Haley (2007) indicate that there are many promising alternative energy projects in progress or under study, drawing on wind, hydroelectric, geothermal, biomass, and tidal resources. The author's note, however, that many of these alternative technologies depend on location, and none are likely to occur on a large enough scale over the next decade to displace natural gas in urban Alaska or diesel fuel in rural Alaska as the primary energy sources.

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11 Appendices

Appendix A – EPA Regulatory Announcement May 2006

Appendix B – ADEC, air Non-Point and Mobile Sources, April 2002

Appendix C – ULSD Cost Model, Mark A. Foster Associates