IN-STATE PROPANE UTILIZATION STUDY FOR THE ALASKA GASLINE DEVELOPMENT CORPORATION

JULY 1, 2011

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IN-STATE PROPANE UTILIZATION STUDY

ALASKA GASLINE DEVELOPMENT CORPORATION

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KEY CONVERSIONS

Propane

1 gallon = 91,033 Btu

1 MMBtu = 10.99 gallons

Heating Oil/Diesel/Distillate

1 gallon = 138,690 Btu

1 MMBtu = 7.21 gallons

Diesel Gallon Equivalent (DGE)

1 DGE = 138,690 Btu

1 MMBtu = 7.21 DGE

1 DGE = 1 gallon heating oil/diesel/distillate

1 DGE = 1.52 gallons propane

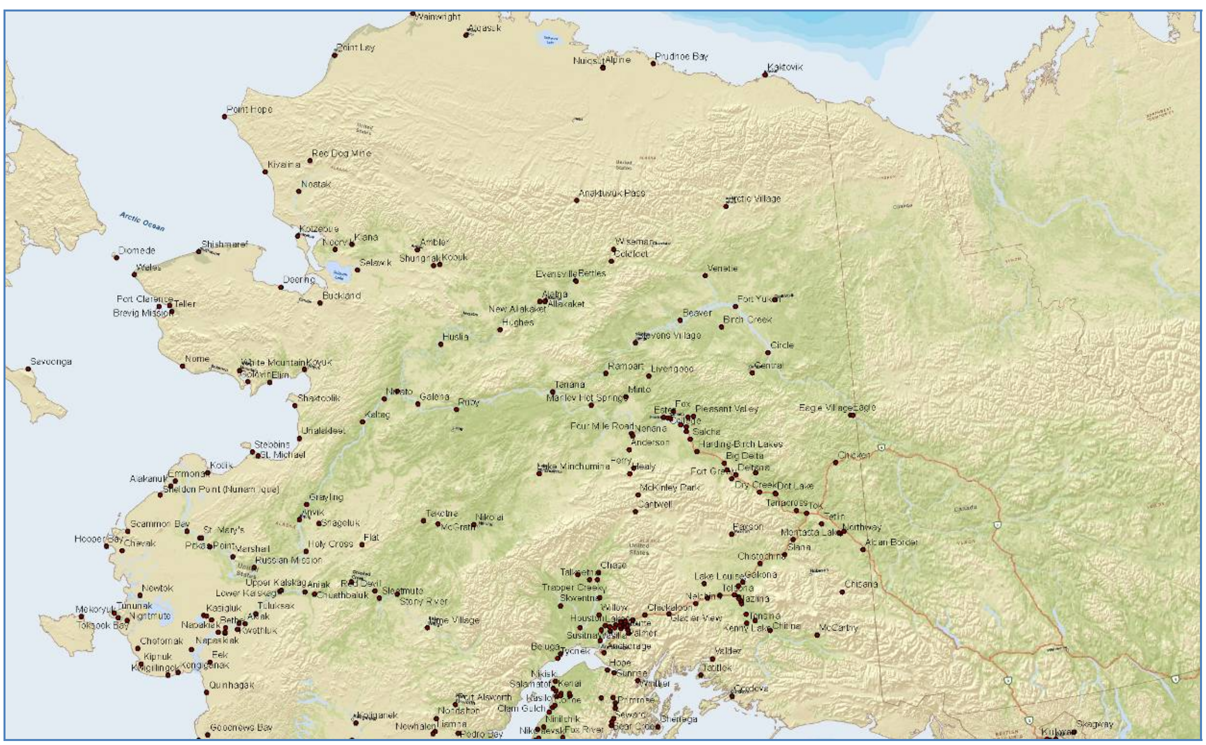
1.0 - INTRODUCTION

SAIC has been engaged by Alaska Gasline Development Corporation (AGDC) in accordance with Request for Proposal ("RFP") #2010-AGDC-003 (and Addendum #1) for development of a supplemental study (the "Propane Study") associated with the benefits that a Greenfield Natural Gas Liquids (NGL) Extraction, Fractionation, Storage, and Export Facility (the "NGL Process Facility") could bring to marine coastal towns and river-based villages without highway access in rural Alaska. The general assumption of these benefits is that lower unit rate costs and improved economies of scale would make propane a more desirable heat source than diesel fuel in these communities. For purposes of this study diesel fuel, # 2 diesel, and fuel oil while unique products will be collectively referred to as "diesel fuel."

An initial challenge with the substitution of propane for diesel fuel is the cost and availability of infrastructure for moving the larger quantities of propane required to achieve economies of scale. Alaska currently consumes low volumes of natural gas liquids (NGLs), whether propane, butane, or ethane. Although NGLs could be extracted from liquids-rich North Slope gas production, these supplies are stranded from potential demand centers in the southern part of the State. Currently North Slope gas production (and the NGLs entrained in these production streams) has been re-injected into oil wells for enhanced oil recovery. The result is a "chicken or the egg" dilemma in which propane demand markets don't exist due to the absence of cost-effective supplies and potential suppliers do not develop propane extraction and transportation infrastructure due to the absence of a demonstrated market.

For purposes of this study, the City of Tanana was selected as the representative river based village and Seldovia was selected as the representative marine coastal town. The City of Tanana is the first town on the Yukon River for shipping fuel from the Port of Nenana. Seldovia is the closest marine access only community to the upper Cook Inlet fuel distribution infrastructure. If lower costs for propane utilization as compared to diesel fuel cannot be derived in these locations, then it is doubtful that savings can be realized at villages with higher transportation costs.

Figure 1.1: Customer Locations in Alaska



Source: (Schworer, 2010) (See Table 1.2)

In the past, developing in-state propane production and distribution capacity has been hampered by relatively higher propane costs compared to diesel fuel and heating oil. In the last several years, however, higher oil prices have led to higher prices for diesel and heating oil, thus raising the cost of cooking heat and home heating for many Alaskans. Furthermore, environmental regulations and economic incentives designed to spur alternatives to conventional diesel and fuel oil have recently gone into effect in Alaska. **Error! Reference source not found.** below shows Alaskan energy demand by type in 2009.

Table 1.1
Alaska Energy Consumption 2009

Source	**Amount**	**Units**
Coal*	500,000	Short tons
Natural Gas	352.3	Billion cubic feet
Petroleum	45.4	Million barrels
• **Distillate**	14.5	Million barrels
• **Jet fuel**	18.7	Million barrels
• **LPG**	0.4	Million barrels
• **Motor gasoline**	6.7	Million barrels
• **Residual fuel oil**	0.4	Million barrels
• **Other**	5.0	Million barrels
• **Subtotal**	49.1	Million barrels
Ethanol*	0.5	Million barrels
Hydroelectric power	1.2	Billion kWh

*2008 data
Source: EIA, State Energy Data System: http://www.eia.doe.gov/state/state-energy-profiles-data.cfm?sid=AK

Currently in-state diesel fuel is supplied from refineries in the greater Fairbanks region and Kenai area on the eastern side of the Cook Inlet. Diesel fuel is then distributed via surface highway, trains, and barges to regional consumers throughout Alaska. In-state propane is currently supplied from Canada, Kenai, and the Northwest United States. Propane is primarily moved by barge, truck, train, and in limited quantities by air throughout Alaska.

1.1 Potential In-State Propane Demand

Interest in developing propane extraction and transportation has increased markedly in recent years as the price of petroleum products has increased dramatically with the price of crude oil. **Error! Reference source not found.** lists several recent studies and presentations pertaining directly or indirectly to the potential future in-state market for NGLs including propane. A very large body of data on potential NGL demand and pricing, as well as interpretations of the results, is contained in these studies.

Table 1.2
Recent Studies and Presentations Regarding the Alaskan In-State Market for NGLs

Author	Title	Agency	Date	Remarks
Roger Ridlehoover and Barry Pulliam (Econ One Research)	Alaska Gas and NGL; Economic Analysis of Value and Royalty	Alaska Department of Natural Resources Oil & Gas Div	January, 2002	
ANGDA Staff	Extract 20 Percent of NGLs Transported via the ANG Pipeline	ANGDA	February, 2007	One of two scenarios
ANGDA Staff	Propane Extraction Facility at the Yukon River	ANGDA	February 2007	The second of two scenarios
Northern Economics, Mark Foster & Assoc., SAIC, Sierra Research	Cost Assessment for Diesel Fuel Transition in Western and Northern Alaska Communities	Alaska Dept of Environmental Conservation Division of Air Quality	December, 2007	Focuses on Ultra Low Sulfur Diesel as a substitute for conventional distillate to comply with EPA requirements
CMAI Global	Alaska Petrochemical Development Study	Anchorage Economic Development Corp. and ANGDA	November, 2009	
ANGDA	North Slope Propane Extraction Facility	ANGDA	December 2009	Accompanied by financial assessment by First Southwest deriving and forecasting delivered propane costs per MMBtu
Tobias Schworer and Ginny Fay, Institute of Social and Economic Research, University of Alaska Anchorage	Economic Feasibility of North Slope Propane Production and Distribution to Select Alaska Communities	ANGDA	June, 2010	Analyzes potential savings for electric utilities and residential space heating from converting from fuel oil to propane
Heinze, Harold	In-State Natural Gas & Value Added Manufacturing	ANGDA	October, 2010	Presentation in Seattle

The potential in-state Alaska market for propane as described in these studies consists of at least three elements:

- The development of an in-state petrochemical industry, based on the availability of methane, ethane, propane, butane and pentane extracted from North Slope natural gas. One current proposal involves 1.4 billion cubic feet per day (Bcfd) of these NGL components to be made available to foreign investors.

- The development of a propane distribution system for residential and commercial customers throughout Alaska that displaces some consumption of distillate and jet fuel as well as residual fuel oil for heating and hot water.

- The use of propane to displace consumption of expensive petroleum-based fuels for power generation in remote Alaskan communities that currently rely on generators fueled by residual fuel oil or distillates.

1.2 Potential Cost Savings from Propane Usage

Price assumptions and forecasts are central to the complex comparisons that are required to identify the potential size of the propane market in Alaska. Alaskan consumers are likely to adopt propane only if doing so offers a significant price advantage over the fuels that they currently use.

Propane as a new fuel for electric utilities and residential space heating, water heating, and cooking is analyzed in Schwoerer, 2010, for 14 selected communities along the Yukon and Kuskokwin Rivers, coastal Alaska, and Fairbanks. They conclude:

- Annual savings to households associated with converting to propane from fuel oil can be up to $1,700 at $60/bbl of crude oil, and up to $5,300 at $140 per barrel.
- Fairbanks residents would benefit from switching to propane for all applications at crude oil prices of $60/bbl.
- Switching to propane for domestic water heating makes more sense at lower oil prices than for conversions to home space heating.
- Three of the 14 communities are projected to benefit from switching to propane for home heating at crude oil prices greater than $80/bbl, and four communities at crude oil prices of more than $110/bbl.
- Savings are sensitive to assumptions surrounding operating cost of the production facility.
- Only Fairbanks (of the communities studied) would experience benefits from switching from fuel oil to propane for electric power sector.

The Northern Economics December 2007 study "Cost Assessment for Diesel Fuel Transition in Western and Northern Alaska Communities" summarized EPA's new regulations as they are applied to rural Alaska. As of June 1, 2010, all areas of Alaska, rural and urban, began transitioning diesel fuel supply to conform to EPA regulations restricting chemical and particulate matter in diesel exhaust from mobile sources, construction equipment, locomotives, boats and ships and stationary engines. The transition is required to be complete by 2012.

More analysis of the in-state market for propane is required to define its likely size and characteristics. However, sufficient analysis has been done, to perform additional study of a new propane supply for home heating, clothes drying, and hot water heating in some communities throughout Alaska. SAIC will use information and methodologies from previous studies where appropriate to estimate costs given the current 2011 price levels. These levels will be tested through a sensitivity analysis that compares propane's cost advantage (or disadvantage) to existing energy sources under a range of oil prices and different locations.

2.0 - EXECUTIVE SUMMARY

The construction of NGL/LPG facilities to extract propane at either Fairbanks (Dunbar) or Big Lake/Nikiski has the potential to displace distillate fuel consumption in both the general vicinity of the plant and in rural Alaskan communities that can be accessed by truck and/or barge. If propane economics are positive, residential and commercial consumers in Alaska will have an incentive to utilize propane for heating purposes rather than diesel and other distillate fuel oils, which have grown increasingly expensive in recent years. This report utilizes SAIC's previously submitted NGL/LPG export study and several recent propane studies conducted by other consultants to estimate the potential size of Alaskan propane markets, analyze the economics of propane use versus distillate for heating, assess the value chain economics of delivering propane to both urban and rural consumers, and provide suggestions for the encouragement of rural propane consumption.

2.1 Propane Scenarios Defined

Propane prices in this report were estimated based on the two scenarios from the NGL/LPG export study and are defined below.

1. **Big Lake/Nikiski (Case NGL 3.1.2):** Propane entrained in natural gas is produced on the North Slope and transported via a wet gas pipeline from Prudhoe to Fairbanks and onto Big Lake. At Fairbanks, a spur with 60 MMSCFD of capacity feeds a straddle plant for meeting local dry gas requirements. NGLs extracted at the Straddle Plant are re-injected into the wet gas pipeline for transport to Big Lake. An export-scale NGL extraction facility is located in the greater Big Lake area sufficiently close to the existing Beluga Pipeline so that the dry residual gas pipeline distance and interconnection cost is minimized. NGLs extracted at Big Lake are then transported via a 12-inch, 180-mile liquids pipeline from Big Lake to Nikiski, where a fractionation facility separates propane from the NGL stream. From Nikiski, LP Gas is exported from Nikiski to East Asian customers.

    - **Local-Scale Fairbanks Fractionation.** For this propane study an alternate scenario will occasionally be referenced that involves the installation of a local-scale fractionation facility at the 60 MMSCFD straddle plant. Under this scenario, propane is produced in Fairbanks at a level sufficient to meet local demand, while excess NGLs are re-injected into the wet gas pipeline to Big Lake.

2. **Fairbanks/Dunbar (Case NGL 2.1):** Propane entrained in natural gas is produced on the North Slope and transported via a wet gas pipeline from Prudhoe to Fairbanks, where export-scale NGL extraction and LP Gas fractionation facilities are located. From the NGL extraction facility, dry gas is supplied directly to Fairbanks-area consumers and a dry residual gas pipeline is run south to the Beluga pipeline interconnection to serve consumers in South Central Alaska. Propane produced in Fairbanks is transported by rail to either Port MacKenzie or Seward. The Port MacKenzie option requires a rail spur to be constructed from the Big Lake area to the port area. From Port MacKenzie or Seward, propane is exported from to East Asian customers.

2.2 Potential Demand

For this study, volumetric propane markets in the vicinity of Fairbanks and Big Lake/Nikiski were estimated using distillate consumption data from the EIA, home heating characteristics from the U.S. Census Bureau, regional weather information, and approximation methods developed by PND Incorporated. The potential propane market around Fairbanks was estimated to be approximately 37.8 million gallons per year, or nearly 2,500 barrel per day. The potential market around Big Lake was estimated to be 14.6 million gallons per year or about 1,000 barrels per day. Due to the dominance of utility gas use for heating in Anchorage, potential demand for propane in the vicinity of Big Lake (near Anchorage) was significantly less than the potential demand in the Fairbanks area despite a much larger population in the Big Lake vicinity.

Table 2.1
Potential Propane Demand by Market Area

Market	Gallons per Year	Barrels per Day
Big Lake/Nikiski	14.6	954
Fairbanks	37.8	2,467

Note: fluctuations due to weather is +25% and -12.5%

2.3 Wholesale Propane Economics

The potential for propane conversion in Alaska depends on the economics of propane versus competing fuels for heating, primarily diesel, distillate fuel oil, and kerosene (collectively called "heating oil"). A regression analysis was performed to estimate Alaska North Slope crude oil, wholesale No. 2 distillate (a proxy for heating oil), and "burner tip" No. 2 distillate prices in Alaska based on a West Texas Intermediate (WTI) crude price assumption. Using this analysis, a WTI oil price of $82.40 per barrel would correspond with an Alaskan wholesale distillate price of approximately $2.61 per gallon or roughly $18.84 per MMBtu. By comparison, the wholesale price of propane is expected to be $10.45 per MMBtu in Big Lake/Nikiski and $8.69 per MMBtu in Fairbanks based on a value chain assessment of costs from the North Slope production site to the fractionation outlet from the previous NGL/LPG export study. This equates to potential wholesale savings of $8.39 and $10.15 per MMBtu in Big Lake/Nikiski and Fairbanks respectively. These results are summarized in both $ per MMBtu and $ per diesel gallon equivalent (DGE) in Table 2.2 below.

Table 2.2
Estimated Wholesale* Propane and Distillate No. 2 Prices (2011 $)

Fuel	Big Lake/Nikiski (NGL 3.1.2)		Fairbanks (NGL 2.1)**	
	$/MMBtu	$/DGE	$/MMBtu	$/DGE
Distillate No. 2**	18.84	2.61	18.84	2.61
Propane	10.45	1.45	8.69	1.21
Potential Savings	**8.39**	**1.16**	**10.15**	**1.41**

*Wholesale prices are at the fractionation or refinery outlet and do not include transportation, storage, and distribution costs or. Propane prices do not include a 10% efficiency adjustment.
**Propane prices in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
***WTI price is assumed to be $82.40/bbl.

The results in Table 2.2 do not necessarily mean that propane will have a significant price advantage over heating oil at the "burner tip." Furthermore, the potential savings are sensitive to the price of crude oil. At higher oil prices, the wholesale price advantage of propane over heating oil is larger and at lower crude oil prices the advantage is smaller. This report estimates that the wholesale price of propane on an energy equivalent basis would be lower than wholesale distillate at WTI prices above $43 per barrel in Nikiski and at WTI prices above $36 per barrel in Fairbanks.

2.4 Burner Tip Propane Economics

The comparison of propane and distillate prices at the burner tip required estimating transportation, storage, and distribution costs from the wholesale distribution points to highway-accessible and rural end users in the general vicinity of Big Lake/Nikiski and Fairbanks.

2.4.1 Urban Consumers

Based on discussions with fuel distributors, a $0.25 per gallon ($1.80 per MMBtu) transportation surcharge was added to the wholesale distillate price to estimate the burner tip cost to urban consumers and a $0.50 per gallon ($5.47 per MMBtu) truck loading and transportation surcharge was added to the wholesale propane price to estimate the delivered cost to urban end users. Table 2.3 below compares estimated burner tip distillate and propane prices based on these transportation cost assumptions plus a 10% efficiency adjustment to account for propane's less efficient combustion characteristics.

Table 2.3
Burner-Tip Cost Comparison of No. 2 Distillate and Propane in Highway-Accessible Markets (2011 $)

	Big Lake/Nikiski (NGL 3.1.2)		Fairbanks (NGL 2.1)*	
Fuel	**$/MMBtu**	**$/DGE**	**$/MMBtu**	**$/DGE**
No. 2 Distillate**	20.64	2.86	20.64	2.86
Propane***	17.52	2.43	15.58	2.16
Potential Savings	**3.12**	**0.43**	**5.06**	**0.70**

*Propane prices in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
** WTI price is assumed to be $82.40/bbl.
***Includes 10% efficiency adjustment.

Table 2.3 shows that potential savings from switching from distillate to propane are $3.67 per MMBtu in the Big Lake/Nikiski area and $5.44 per MMBtu in the Fairbanks area. This equates to a savings of 51 and 76 cents per diesel gallon equivalent (DGE) respectively.

2.4.2 Rural Consumers

Estimating transportation, storage, and distribution costs to rural consumers required a more complicated value chain analysis. Two rural communities were chosen as representative rural markets: Tanana, a rural village along the Tanana River west of Fairbanks, and Seldovia, a rural community on the Kenai Peninsula south of Nikiski. Both these communities lack access to Alaska's highway system and rely on river or marine transport for fuel deliveries. Estimated burner tip distillate costs in Tanana and Seldovia were based on data collected and analyzed by the Institute of Social and Economic Research (ISER).

To estimate the burner tip price of propane in Tanana and Seldovia, SAIC used transportation, storage, and distribution costs gathered from site visits to companies that currently transport propane to these markets. To deliver propane to Seldovia, the propane would first be shipped via bobtail truck from Nikiski to Homer. From Homer, the bobtail trucks would be loaded on to landing craft barges and shipped to Seldovia. Upon arrival in Seldovia, the trucks would drive off the barges and deliver fuel to end consumers. To deliver propane to Tanana, propane would first be shipped by truck in 6,400-gallon ISO containers from the LPG fractionation facility in Fairbanks (Dunbar) to Nenana. From Nenana, the containers would be loaded on to barges and shipped by river to Tanana. 6,400-gallon ISO containers (rather than 100-pound bottles) are required in Tanana because of the need for larger-scale local storage during the part of the year when barge deliveries are not possible due to river icing.

Table 2.4 below compares the burner tip cost of distillate and propane in Seldovia and Tanana based on the previously stated transportation, storage, and distribution cost assumptions, plus a 10% adjustment to account for propane's less efficient combustion characteristics. In order to comply with EPA regulations, many rural communities likely have switched or are in the process of switching to ultra low sulfur diesel (ULSD) for all fuel uses, including home heating. The status of this transition is currently unclear. Using ULSD rather than other arctic-suitable fuels (typically Jet A) would add approximately 5 cents per gallon to the burner tip price of heating oil.

Table 2.4
Burner-Tip Cost Comparison of Heating Oil and Propane in Rural Markets
(2011 $)

	Tanana (NGL 2.1)*		Seldovia (NGL 3.1.2)	
Fuel	**$/MMBtu**	**$/DGE**	**$/MMBtu**	**$/DGE**
Heating Oil**	25.44	3.53	25.32	3.51
Propane***	42.44	5.89	52.08	7.22
Potential Savings	**(17.00)**	**(2.36)**	**(26.76)**	**(3.71)**

*Propane prices in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
** WTI price is assumed to be $82.40/bbl. Using ULSD would add ~5 cents per DGE to the burner tip price.
***Transported by ISO containers. Includes 10% efficiency adjustment.

Error! Reference source not found. shows that propane economics to rural communities in both Seldovia and Tanana would be very unfavorable compared to the price of distillate assuming a WTI crude oil price of $82.40 per barrel. This is because the intermodal transportation, storage, and distribution costs are significantly more expensive for propane than for distillate per unit of energy delivered.

2.4.3 Potential for Propane Conversion

Whether or not it is economically viable for an individual household or business to switch from heating oil to propane depends on a number of factors including the relative "burner tip" prices of the two fuels, the capital cost of installing propane heating systems, annual fuel consumption estimates, and the number of years over which the consumer wishes to "pay back" the initial investment in propane conversion. This report estimated the minimum WTI oil price at which the price differential between propane and heating oil was favorable to propane conversion based on capital cost estimates on propane conversion for space and water heating from previous studies, annual fuel consumption estimates based on average fuel consumption and average heating degree days by market, and a payback period of 10 years. These minimum oil prices are presented for both space and water heating systems in Table 2.5 below.

Table 2.5
Minimum WTI Oil Price to Make Propane Conversion Economically Viable*
by Heating Type (2011 $/bbl)

	Space Heating	**Water Heating**
Fairbanks (NGL 2.1)**	68	92
Fairbanks (NGL 3.1.2)***	76	100
Big Lake (NGL 3.1.2)	79	109
Tanana (NGL 2.1)	165	186
Seldovia (NGL 3.1.2)	215	246

*Assuming a 10-year payback on propane conversion investments.
**Under this scenario, Fairbanks propane markets are served by an export-scale fractionation plant (see scenario NGL 2.1).
***Under this scenario, Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario).

Table 2.5 above shows that propane conversion is economically viable for space heating in Fairbanks and Big Lake at relatively moderate oil prices. Propane conversion in rural communities, such as Tanana and Seldovia, only makes economic sense under very high oil prices scenarios.

2.5 Conclusion

Economics at the "burner tip" will be the primary force that drives propane conversion for residential and commercial consumers in Fairbanks, Big Lake/Nikiski, and rural Alaskan communities. Consumers that currently use diesel, fuel oil, or kerosene for heating in the highway-accessible areas around Fairbanks and Big Lake/Nikiski could realize significant savings by switching to propane under moderate oil price scenarios. Rural consumers that lack highway access are only likely to switch fuels under extreme oil price due to very high intermodal transportation, storage, and distribution costs for propane.

Many Alaskan consumers should be able to take advantage of lower propane prices at the wholesale level. Remote river villages that wish to utilize propane for heating need to have the ability to receive and store propane in 6,400-gallon ISO containers rather than the 100-pound bottles that are currently used. Although ISO containers do not reduce per-unit transportation costs, the use of ISO containers allows villages to continue consuming propane during the portion of the year when barge deliveries are impossible due to river icing, and allows villages to strategically purchase bulk quantities of propane at seasonally lower prices. By having a large propane inventory available year-round, rural consumers also avoid having to fly in full 100-pound bottles in emergency situations. Unfortunately, equipping river villages to receive ISO containers will involve significant infrastructure improvements, including the construction of cranes for offloading the containers from delivery barges and facilities for storing the containers.

Based on discussions with several rural propane and diesel fuel consumers in Alaska, the majority of their annual fuel requirements are purchased at one time. This does not allow market timing to be used to reduce fuel costs. Regardless of whether propane or diesel fuel is purchased, remote villages should form fuel purchasing cooperatives to maximize bulk purchase discounts and to hedge against seasonal price spikes.

Only those communities that can access propane deliveries directly from inventory located close to the fractionation facility should see savings by replacing diesel fuel with propane. Where propane delivery is accomplished by barge or requires multiple handlings, propane will be more expensive than fuel barge delivered diesel fuel due to the substantially lower transportation costs per gallon for diesel. For Alaskan power utilities, purchase or upgrade of power plant equipment capable of utilizing both propane and fuel oil may be to their advantage, especially if reducing carbon emissions becomes a higher priority in future years.

3.0 - POTENTIAL ALASKA PROPANE DEMAND

This section will seek to estimate the volumetric size of the heating oil markets in the general vicinity of the NGL/LPG facilities in Big Lake/Nikiski and Fairbanks/Dunbar, and estimate the percentage of this demand that could be converted to propane use. The statement of work narrowly specified that SAIC study diesel markets for conversion to propane. However, if propane is introduced in Alaska markets on a large scale, it will primarily compete with a range of heating oil products, including distillate fuel oil (No. 1 and No. 2 including diesel) and kerosene. These products, when used for residential and commercial heating, will be referred to together as "heating oil." The statement of work also suggested utilizing the "Feasibility Study of Propane Distribution throughout Coastal Alaska" prepared by PND Incorporated, August 2005 to estimate the volumetric demand for heating oil. However, the PND report only provides diesel demand for coastal Alaska communities and does not provide demand estimates for the areas specified in the statement of work (Big Lake and Fairbanks). This chapter will adopt assumptions and methodologies from the PND study where appropriate to estimate potential propane demand. Key assumptions that will be adopted from the PND study include:

- Demand for propane – expressed in MMBtus – is equal to the total Btus provided by heating oil plus an estimated 10 percent efficiency loss due to propane's combustion characteristics.

- If economics are positive, approximately 50 percent of Alaskan demand that could be economically converted from heating oil to propane would occur within 10 years.

Per the directions in the statement of work, SAIC will evaluate the potential for propane conversion only for the residential and commercial heating segments. The use of propane for electric power generation will not be covered in depth and the use of propane as a transportation fuel will also not be evaluated.

3.1 Existing Market for Heating Oil in Alaska

The residential and commercial heating oil markets that propane could compete with in Alaska are currently served by distillate fuel oil and kerosene. Table 3.1 shows Alaska's consumption of distillate fuel oil and kerosene by sector in 2009. Overall, Alaska consumed 602.1 million gallons (roughly 39,300 barrels per day) of these fuels in 2009. Of this consumption, residential and commercial use (for heating purposes) accounted for a combined 106.7 million gallons, or roughly 18 percent of Alaska's total demand for distillate fuel oil and kerosene.

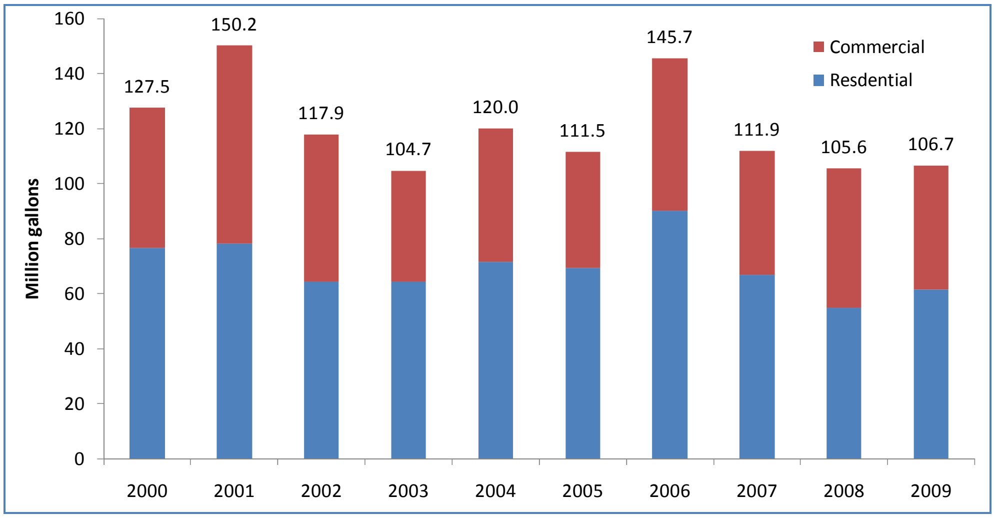
Table 3.1
2009 Alaska Consumption of Distillate Fuel Oil and Kerosene by Market Segment

Market Segment	Consumption (MM gallons)	Percent of Total
On-Highway	202.1	34%
Vessel Bunkering	93.0	15%
Oil Company	66.7	11%
Residential	61.7	10%
Industrial	52.9	9%
Electric Utility	47.1	8%
Commercial	45.0	7%
Off-Highway	14.2	2%
Military	13.3	2%
Railroad	5.9	1%
Farm	0.2	0%

*Distillate fuel oil (No. 1 and No. 2) and kerosene.
Source: Energy Information Administration, http://www.eia.doe.gov/dnav/pet/pet_cons_821dst_dcu_SAK_a.htm

Consumption of heating oil (distillate fuel oil and kerosene used for heating) has shown no clear trend in Alaska over the past ten years and demand fluctuates considerably from year to year as colder, longer winters are typically associated with higher consumption levels. Figure 3.1 below shows residential and commercial heating oil consumption between 2000 and 2009. The absence of a clear trend in this figure suggests that the number of residential and commercial units that rely on heating oil has not changed significantly since 2000. The average consumption of these fuels over this 10-year span was 120 million gallons per year (70 million gallons for residential consumers and 50 million gallons for commercial consumers).

Figure 3.1. Alaska Consumption of Heating Oil*, 2000-2009



*Distillate fuel oil (No. 1 and No. 2) and kerosene used for heating purposes
Source: Energy Information Administration

3.2 Existing Market for Heating Oil in Fairbanks and Big Lake

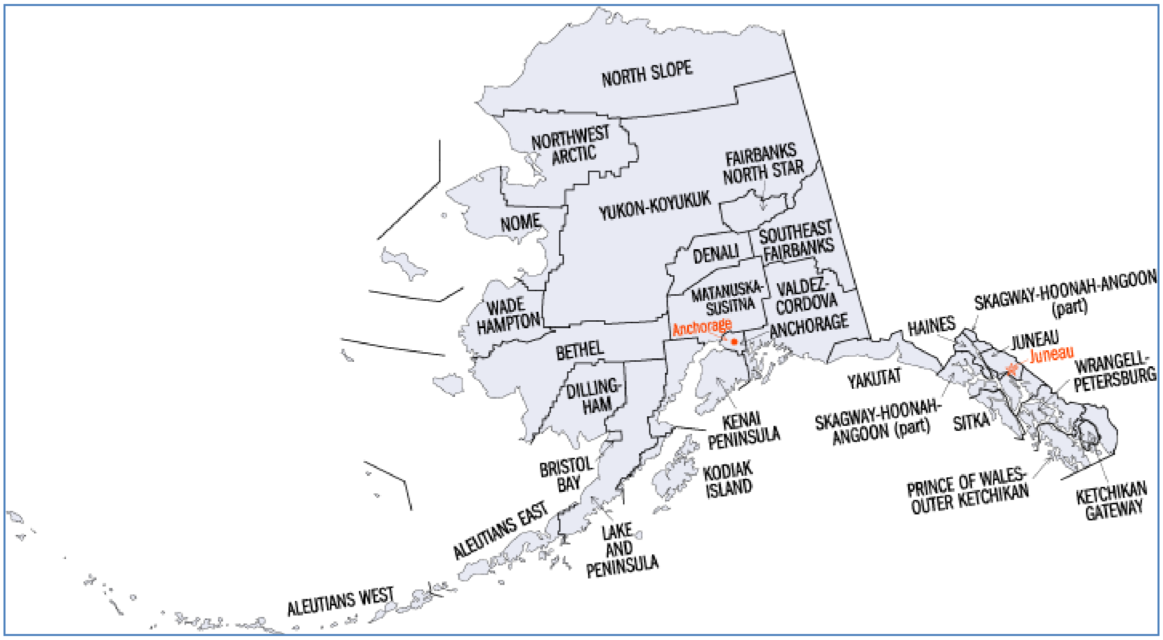
This study will focus on two markets within Alaska:

1. The market around Big Lake, which is defined as the Anchorage, Kenai Peninsula, and Matanuska-Susitna boroughs; and

2. The market around Fairbanks, which is defined as the Fairbanks North Star, Southeast Fairbanks, and Denali boroughs.

Figure 3.2 provides a map of Alaska's boroughs.

Figure 3.2. Map of Alaska Boroughs



Source: U.S. Census Bureau

Demand in the general vicinity of Big Lake and Fairbanks was approximated by utilizing data from a U.S. Census Bureau survey that tracks the number of residential housing units by heating fuel type. Table 3.2 below presents the total number of occupied housing units by borough and the number of these units that use fuel oil or kerosene as their primary source of home heating. This data is current as of the 2000 census. At the time of this analysis, similar data from the 2010 census has not been released.

Table 3.2 indicates that despite a lower number of total residential units, more units used heating oil in Fairbanks than Anchorage in both absolute terms and as a percentage of total units. The estimates in Table 3.2 are based on the number of housing units in the year 2000. Between 2000 and 2009, the State of Alaska added approximately 13,179 occupied residential units, some of which were in the Fairbanks and Big Lake areas. However, for the purpose of this study, it will be assumed that new residential additions anywhere in Alaska during this time period utilized an energy source other than heating oil for home heating (e.g. utility gas, electricity, etc.).

Table 3.2
Housing Units Using Fuel Oil for Home Heating by Borough, 2000

Big Lake Area	Total Occupied Housing Units	Housing Units Using Heating Oil*	Heating Oil Share of Market
Anchorage	100,368	939	1%
Kenai Peninsula	18,438	6,525	35%
Matanuska-Susitna	20,556	4,971	24%
Big Lakes Area Total	**139,362**	**12,435**	**9%**
Fairbanks Area			
Fairbanks North Star	29,777	22,851	77%
Southeast Fairbanks	2,098	1,386	66%
Denali	785	563	72%
Fairbanks Area Total	**32,660**	**24,800**	**76%**
Alaska Total	**221,600**	**79,429**	**36%**

*Fuel Oil, kerosene, etc.
Source: U.S. Census Bureau, http://censtats.census.gov/cgi-bin/pct/pctProfile.pl

To convert the numbers of residential units using heating oil in Table 3.2 into volumetric estimates of heating oil demand, it is first necessary to obtain an estimate of heating oil consumption per unit. Alaska's average annual residential heating oil consumption was approximately 70 million gallons per year from 2000 to 2009 according to EIA data (See Figure 3.1). In 2000 there were nearly 80,000 residential units in Alaska that used heating oil for home heating (See Table 3.2). Assuming that no occupied units that use heating oil were added or subtracted between 2000 and 2009, annual average consumption per residential unit would be about 875 gallons.

Residential heating oil consumers in Alaska are likely to consume fuel at different rates due to differences in local weather patterns. For instance, housing units located in areas with longer, colder winters are likely to have higher heating oil consumption rates than housing units located in milder climates. Heating degree days (HDDs) are a key measurement designed to reflect the demand for energy needed to heat homes or businesses in a particular area. Table 3.3 below compares the number of HHDs by borough in the vicinity of Big Lake and Fairbanks, as well as the Alaska state average. Table 3.3 also estimates the rate of heating oil consumption per residential unit by adjusting Alaska's average per-unit heating oil demand (879) by an adjustment factor that captures the difference between the boroughs's HDDs and the state average HDDs.

Table 3.3
Average Annual Heating Degree Days and Estimated Per-Unit Heating Oil Consumption by Borough

Big Lake Area	**Avg. Heating Degree Days***	**Adjustment Factor****	**Est. Per Unit Heating Oil Consumption*** (gallons/year)**
Anchorage	10,570	0.92	1,065
Kenai Peninsula	10,054	0.87	1,034
Matanuska-Susitna	11,606	1.01	976
Weighted Average******	**10,713**	**0.93**	**1,061**
Fairbanks Area			
Fairbanks North Star	13,940	1.21	807
Southeast Fairbanks	13,535	1.18	768
Denali	12,773	1.11	887
Weighted Average******	**13,891**	**1.21**	**818**
Alaska Weighted Average*********	**11,511**	**1.00**	**879**

*Measured at 65 degrees Fahrenheit.
**This factor is used to estimate each borough's heating oil consumption per housing unit relative to the Alaska average. This measure is calculated by taking the average heating degree days for each borough and dividing it by the Alaska average HDDs weighted by heating oil housing units (11,511).
***Alaska state average per unit heating oil consumption (879 gallons per year) multiplied by the adjustment factor.
****Weighted by number of housing units using heating oil in the boroughs listed above (See Table 3.2 for weights).
*****Weighted by number of housing units using heating oil in Alaska.
Sources: Appendix C, Figure 3.1, Table 3.2

Table 3.3 shows that HHDs are 21 percent greater in the Fairbanks area than the Alaska state average while HDDs are 7 percent lower in Big Lake area than the state average. As a result, it will be assumed that per unit heating oil consumption in the Fairbanks area will be 21 percent greater than the state average, or roughly 1,061 gallons per year and Big Lake area heating oil consumption will be 7 percent lower, or roughly 818 gallons per year.

By multiplying the estimated consumption rates from Table 3.3 by the number of residential units using heating oil from Table 3.2, it is possible to approximate residential demand for heating oil in the general vicinity of Big Lake and Fairbanks. Table 3.4 below presents these estimates by market area. Table 3.4 also approximates commercial demand for heating oil by assuming that each market's share of total commercial demand in Alaska is equal to its share of residential heating oil demand.

Table 3.4
Estimated Residential and Commercial Annual Heating Oil* Demand by Market
(Million Gallons)

Market	**Residential**	**Commercial**	**Total**	**% of AK Total**
Big Lake	10.2	7.3	17.5	15%
Fairbanks	26.3	19.0	45.3	38%
Alaska Total	69.8	50.3	120.2	

*Distillate fuel oil (No. 1 and No. 2) and kerosene used for heating purposes
Note: fluctuations due to weather is +25% and -12.5%

Table 3.4 above shows that total residential and commercial demand for heating oil in the Fairbanks market area is estimated to be 45.3 million gallons or 38% of Alaska's total heating oil demand. The market in the vicinity of Big Lake is estimated to be approximately 17.5 million gallons or roughly 15% of total Alaska demand. It should be noted that these demand estimates are very sensitive to the length and coldness of the winter heating season. Between 2000 and 2009, Alaskan heating oil demand fluctuated between 105 and 150 million gallons – a window of 12.5 percent below or 25 percent above the average over this time period.

3.3 Potential Propane Demand in Fairbanks and Big Lake

According to the PND Incorporated Study, the potential demand for propane is equal to the total Btus provided by heating oil plus an estimated loss of 10 percent due to propane's combustion characteristics. PND Incorporated study also estimates that if propane economics are advantageous, approximately 50 percent of heating oil demand could be converted to propane within 10 years. Given these assumptions, it is possible to approximate the volumetric size of potential propane market. Table 3.5 below presents the potential annual propane demand by market area and market segment.

Table 3.5
Potential Propane Demand by Market Area and Market Segment
(Million Gallons per year)

Market	Residential	Commercial	Total	Total (bpd)
Big Lake	8.5	6.1	14.6	954
Fairbanks	22.0	15.8	37.8	2,467

Note: fluctuations due to weather is +25% and -12.5%

Table 3.7 above shows that the total demand market around Fairbanks is more than 2.5 times the size of the market around Big Lake. These demand figures are relatively small compared to the overall production capacity of the planned NGL fractionation facility at either site.

3.4 Potential Propane Demand by Power Projects

For power plants utilizing diesel fuel or naphtha as the primary fuel, the potential for conversion to propane is an analysis that each facility will have to make based on current investments in capital equipment and existing fuel off take contracts. Reciprocating diesel engines and combustion turbines are capable of operating on propane. However, some diesel engines and combustion turbines may not be able to convert to propane due to original design configuration of the fuel introduction system and combustor design. Instead, this may involve modifications to the combustion systems or require complete replacement. Diesel engines and combustion turbines typically require less intensive maintenance cycles when operating on propane as compared to diesel fuel. Carbon emissions are also lower especially with regard to sulfur oxide emissions. Coal-fired power projects have also successfully used propane as a start-up fuel.

The ideal candidate for propane conversion would be aging reciprocating diesel engines due for capital replacement plus diesel storage facilities that are in need of upgrades to stay in compliance. Unfortunately, based on conversations with AGDC personnel, many diesel storage tank farms have recently been upgraded to meet environmental standards, so this becomes less of a reason for conversion of diesel engines to propane.

4.0 - NO. 2 DISTILLATE PRICE BUILD UP

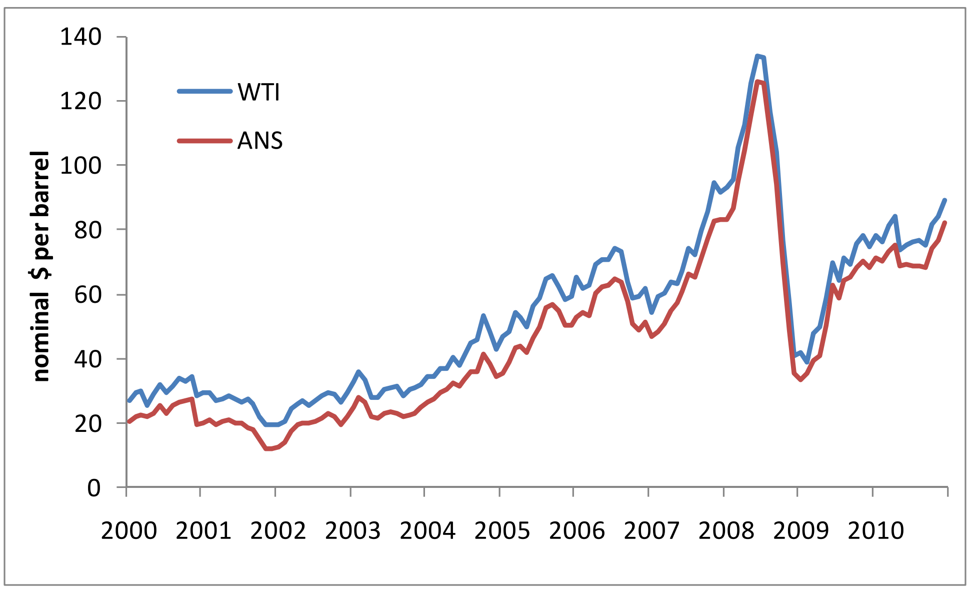
Propane produced in either the Fairbanks/Dunbar or Big Lake areas would compete with both distillate fuel oil (No. 1 and No. 2) and kerosene for heating uses among residential and commercial consumers. The Energy Information Administration (EIA) does not provide individual product price series for Alaska heating oil. As a result, the EIA price category "No. 2 Distillate" will be used to as a proxy for heating oil. Alaska-specific data from the EIA will be used in this section to provide "build up" of No. 2 distillate prices. The term "heating oil" will be used interchangeably with "No. 2 distillates". Rural communities are most likely to be impacted by use of ultra low sulfur diesel for heating and power generation as discussed further in Section 4.5.

Throughout this chapter, prices will be presented in \$ per gallon or \$ per barrel. In some places, prices will also be presented on an energy content-basis; in \$ per million British Thermal Units (MMBtu). A gallon of distillate heating oil contains 138,690 Btu.[1] Conversely, 1 MMBtu contains 1,000,000/138,690 = 7.21 gallons of heating oil. Thus, a heating oil price of \$3.00 per gallon is equal to a price of roughly \$21.63 per MMBtu. These conversions refer to the gross energy content of the heating oil but not the net energy output. Net energy output – the energy content actually utilized – will vary by household and business depending on fuel utilization efficiency of the consumer's furnaces or boilers. Older heating systems have low efficiencies in the range of 68-72%, while newer furnaces and boilers have ratings of 80-83% for mid-efficiency systems and 90-97% for high efficiency systems.[2] No data on Alaska heating system efficiencies was available for the production of this report. As a result, burner tip prices for heating oil will be presented on a gross energy, or higher heating value (HHV), basis.

4.1 Crude Oil Costs

Petroleum products consumed in Alaska are primarily produced at refineries in Kenai and near Fairbanks. These refineries purchase crude oil produced on the Alaskan North Slope (ANS) and transported via the Trans-Alaska Pipeline System (TAPS) plus, in the case of the Kenai refinery, crude oil from the Cook Inlet. As a result, petroleum product prices are highly correlated with the ANS oil price. The spot price of ANS crude is typically calculated by subtracting a market differential from West Texas Intermediate (WTI) crude oil price marker at the oil trading hub in Cushing, Oklahoma. Figure 4.1 below plots the ANS price against the WTI price from 2000 to 2010.

Figure 4.1. Alaska North Slope (ANS) vs. West Texas Intermediate (WTI) Oil Prices, 2000-2010



Source: Energy Information Administration

[1] http://www.eia.gov/energyexplained/index.cfm?page=about_energy_units
[2] http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12530

According to regression analysis conducted by SAIC, the ANS oil price can be estimated given the following equation:

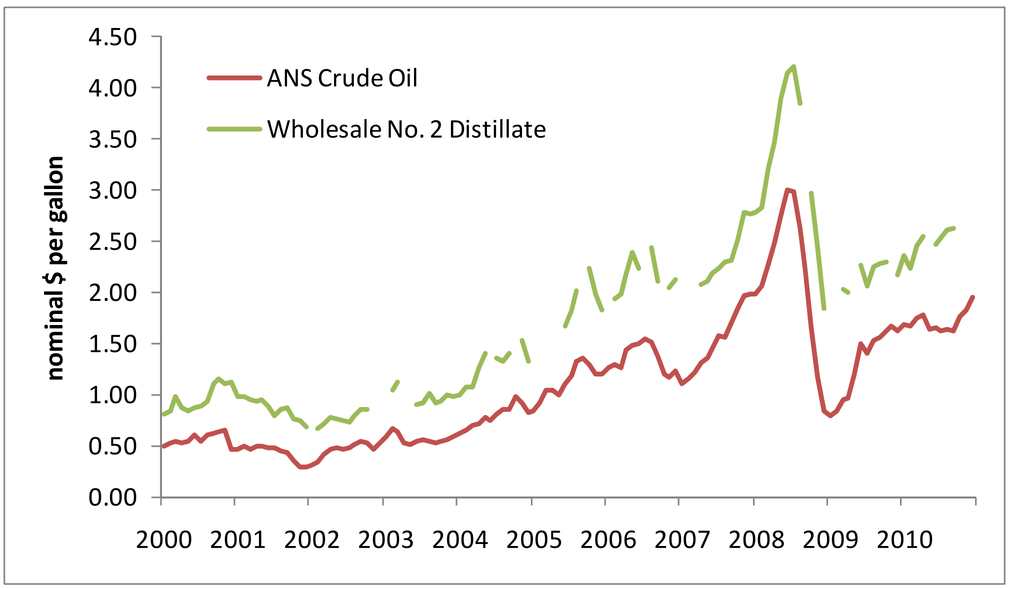
$$ANS = 0.9916 \times WTI - 7.4199$$

In the above equation the ANS and WTI price variables are reported in dollars per barrel. Thus, at a WTI price of $82.40 per barrel, the ANS price would be approximately $72.30 per barrel. As there are 42 gallons in a barrel of crude oil, this price would equate to roughly $1.77 on a per-gallon basis. In theory, the price of crude oil delivered to the North Pole refinery outside Fairbanks is likely to be less expensive than the price of crude oil delivered to Kenai-area refineries due to the closer proximity of the former to the Alaskan North Slope and thus lower shipping costs via TAPS. However, crude acquisition costs by refinery are propriety and were not available to SAIC for analysis.

4.2 Refinery Wholesale Prices

Wholesale distillate fuel prices at the refinery rack incorporate the cost of crude oil acquisition plus a margin that includes the cost of refining and the refiner's profit margin. This margin is measured as the difference between the wholesale price of the fuel at the refinery rack and the cost of crude inputs. Figure 4.2 plots the wholesale No. 2 distillate fuel price against the ANS price of crude oil on a per-gallon basis.

Figure 4.2. Wholesale No. 2 Distillate Price vs. ANS Crude Oil Price, 2000-2010



Source: Energy Information Administration

Figure 4.2 shows that the refiner margin in Alaska varied from a high of $1.32 to a low of $0.24 per gallon between 2000 and 2010. The average spread over this time period was $0.62 per gallon. Gaps in the heating oil price series above are due to some data being withheld for proprietary reasons. Regression analysis conducted by SAIC shows that the wholesale price of heating oil in Alaska can be reasonably estimated given an ANS crude price using the following relationship:

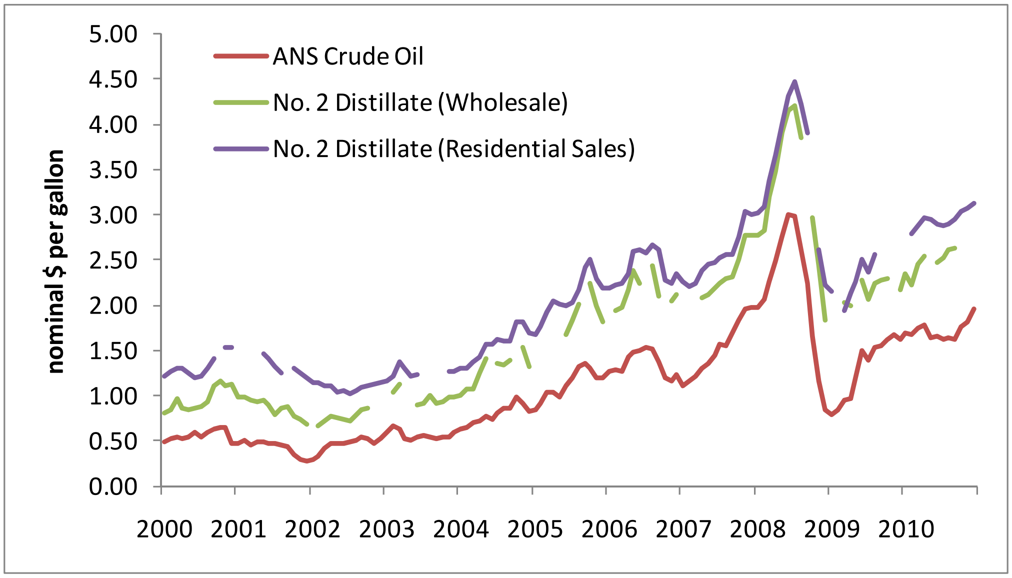
$$\text{Wholesale No. 2 Distillate} = 1.3249 \times ANS + 0.2689$$

In the above formula, the ANS and the No. 2 distillate prices are represented in dollars per gallon. Thus, at an ANS oil price of $1.77 per gallon (corresponding with WTI at $82.40 per barrel), the wholesale heating oil price is roughly $2.61 per gallon.

4.3 Delivered/ Prices

The delivered price of diesel fuel and heating oil to Alaska consumers includes the crude oil cost, the refining cost, and the cost of transportation, storage and distribution to Alaskan households. Heating oil is exempt from state and federal taxes. Alaska has no state sales tax and neither Fairbanks nor Anchorage administers a local sales tax.[3] Delivery costs are lower in Fairbanks and Big Lake than in rural Alaska because these cities are in close proximity to Alaskan refineries. Anchorage (near Big Lake) is connected by pipeline and road to refineries on the Kenai Peninsula and Fairbanks is a short truck trip from the North Pole refineries.[4] From the Anchorage Fuel terminal, heating oil can be delivered to area homes by truck. From the North Pole refinery, heating oil is trucked directly to Fairbanks and neighboring communities. Figure 4.3 below shows the sale price of No. 2 distillate to residential customers against the wholesale No. 2 distillate and ANS crude prices. The difference between the residential distillate fuel price and the wholesale price is the cost of transporting, storing, and handling the fuel from the wholesale point/refinery to the end consumer.

Figure 4.3. Residential Sale vs. Wholesale No. 2 Distillate Prices 2000-2010



Source: Energy Information Administration

Figure 4.3 shows that the delivery markup between the wholesale price and the residential end-user heating oil price varied significantly from month to month. Overall, the residential heating oil markup averaged 31 cents per gallon between 2000 and 2010 with a range of ten to 56 cents per gallon. Markups versus the wholesale price tended to be the lowest when prices were rapidly increasing and highest when prices were rapidly decreasing, possibly representing the fact that fuel distributors often store wholesale fuel over several months before reselling it. Alaskan fuel distributors interviewed for this report estimate that distribution costs typically range from 25-30 cents per gallon above the wholesale price. For the purpose of this report, a 25-cent per gallon distribution cost will be assumed. Given the average delivery cost of 25 cents per gallon, the average burner tip price of diesel is $2.86 per gallon when WTI oil is at $82.40 per barrel.

4.4 Price Build Up

Based on the assumptions and formulas developed in the previous sections it is possible to provide a No. 2 distillate fuel price build up. Figure 4.4 below shows the built-up cost of heating oil to residential Alaska consumers by cost component when WTI is at $82.40 per barrel.

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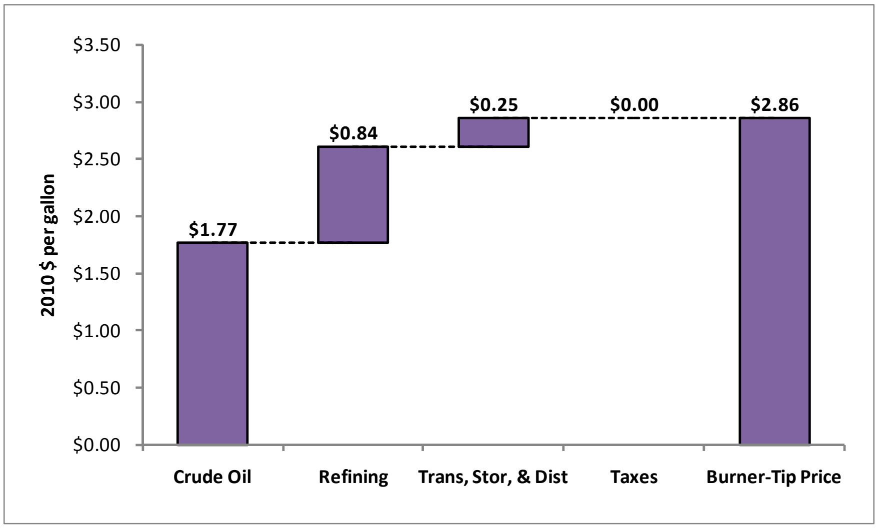
[3] http://www.tax-rates.org/Alaska/sales-tax/

[4] http://www.iser.uaa.alaska.edu/publications/Finalfuelpricedelivered.pdf p. 22

Figure 4.4. Estimated Build Up of the Heating Oil Price to Residential Alaska Consumers by Cost Component*



* WTI is assumed to be $82.40 per barrel

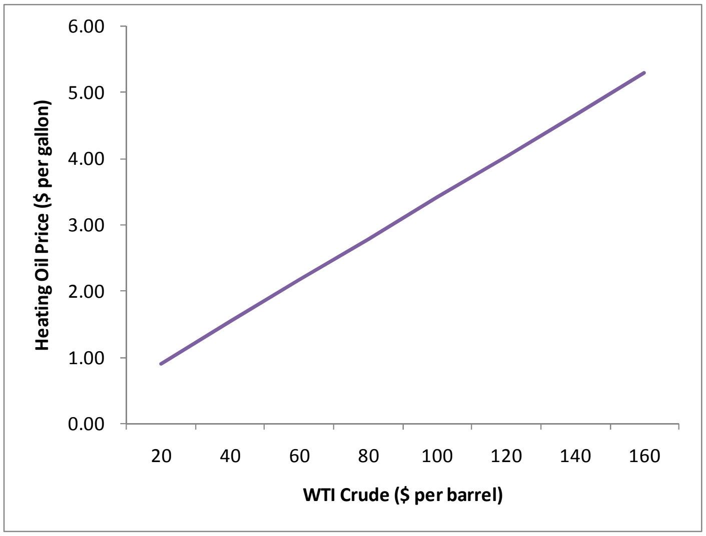
Figure 4.4 shows that at $82.40 per barrel, the ANS crude cost would be $1.77 per gallon, refining costs would be 84 cents per gallon, and transportation, storage, and distribution costs would be an estimated 25 cents per gallon. Taxes would be zero because federal and state diesel taxes only apply to diesel fuel sold as on-highway diesel and because neither Anchorage nor Fairbanks has a sales tax. Overall, these cost components sum to a burner tip price of $2.86 per gallon. This is the estimated cost of heating oil to residential customers in Alaska.

The "burner tip" prices reported in this section are the same as the delivered price to the consumer. When the fuel is burned, however, only a percentage of the energy content is actually utilized by homes and businesses for heating. The remaining percentage escapes up the chimney and elsewhere. Older heating systems have efficiencies in the range of 68-72%, while newer furnaces and boilers have ratings of 80-83% for mid-efficiency systems and 90-97% for high efficiency systems.[5] No data was available on Alaska heating system efficiency for the production of this report. As a result, burner tip prices are presented on a gross energy, or higher heating value (HHV), basis.

This cost build-up in Figure 4.4 is highly sensitive to the price of crude oil, which accounts for roughly 60 percent of the heating oil price when oil is at $82.40 per barrel. Figure 4.5 below shows the impact of changes in the WTI crude oil price on the final price of No. 2 distillate at the burner tip.

[5] http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12530

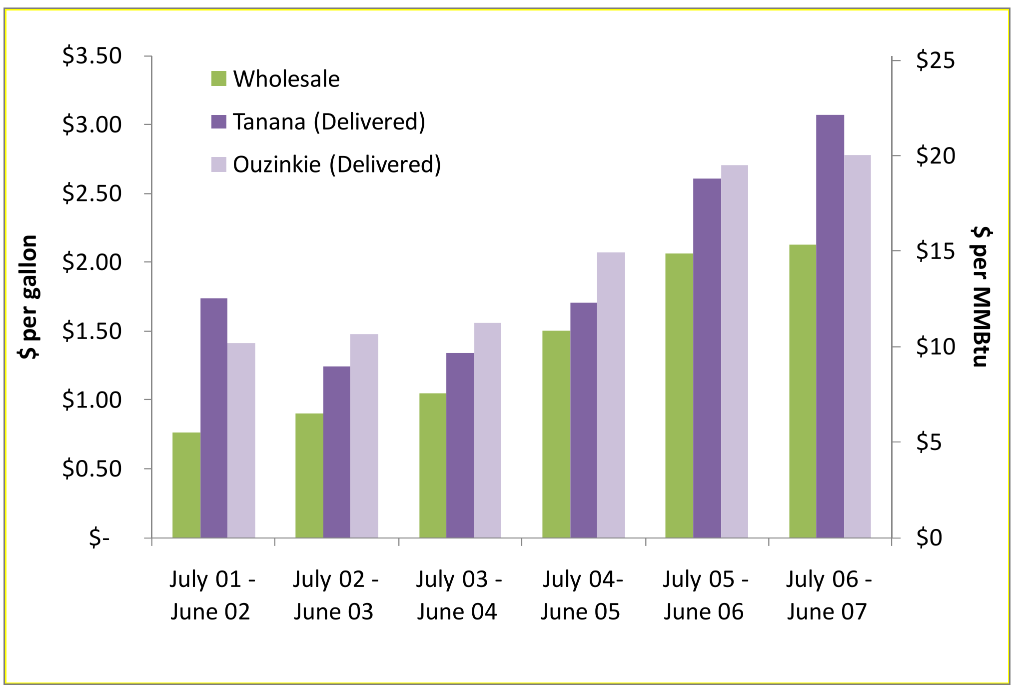
Figure 4.5. Sensitivity of No. 2 Distillate Burner Tip Price to WTI Crude Price



4.5 Rural Alaska Distillate Price Build Up

Rural Alaskan communities pay significantly more for heating oil because of their distance from Alaska refineries. This increases transportation, storage, and distribution costs. Alaska's Power Cost Equalization (PCE) program tracks the price of distillate fuel purchased by electric power utilities in rural Alaska. Figure 4.6 below presents the delivered price of bulk distillate fuel to electric power utilities in Tanana (a potential rural market in the Fairbanks scenario) and Ouzinkie (a potential rural market in the Big Lake scenario).

Figure 4.6. Wholesale Distillate No. 2 vs. Delivered Rural Alaskan Distillate Prices

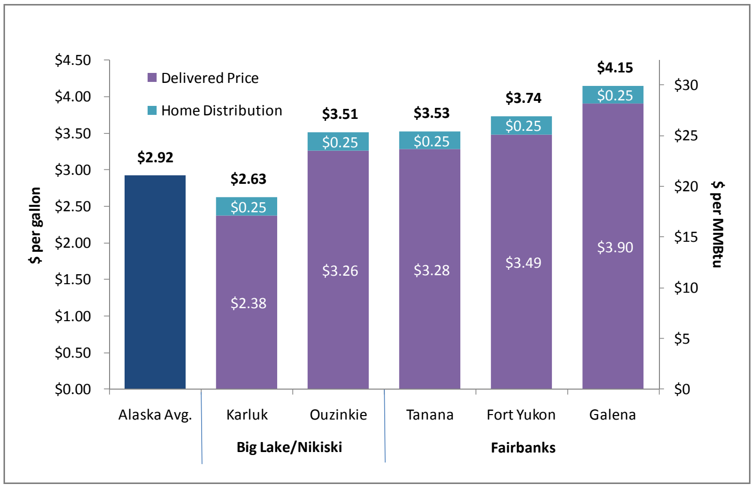


Source: PCE, ISER, EIA

The delivered price of fuel in Ouzinkie, a small community on Kodiak Island south of Nikiski, was more expensive than the price of fuel in Tanana, a river community roughly 40 miles west of Fairbanks, for every year that the PCE data covered except 01-02 and 06-07. The estimated delivery cost (delivered price less wholesale price) was relatively stable in Ouzinkie, ranging from 51 to 65 cents per gallon. In three years, the estimated delivery cost was exactly 65 cents per gallon. In Tanana, estimated delivery costs varied significantly from as low as 21 cents to as high as 98 cents per gallon. It is not clear why delivery costs fluctuated so significantly in Tanana.

Given this data, it is possible to use a regression analysis to estimate the price of fuel based on a wholesale delivery price for Tanana and Ouzinkie, as well as a number of other potential markets that could be accessed by NGL/LPG plants in Dunbar/Fairbanks and Big Lake/Nikiski. Figure 4.7 below presents the delivered cost of distillate in the community when the WTI crude oil price is $82.40 per barrel, as well as an estimate of the cost to distributing the fuel from the receipt point to households in the community (~25 cents). This premium is added to delivered fuel costs in Figure 4.7 in order to produce a "burner tip" price of fuel for household consumers.

Figure 4.7. Estimated Burner Tip Diesel Prices by Village*



*When WTI is $82.40 per barrel. Using ULSD in rural communities would add ~5 cents per gallon to the burner tip price.
Source: Appendix: Price Data and Regression Analysis

Figure 4.7 above shows that all rural Alaska customers, with the exception of consumers in Karluk, would pay significantly more for distillate than the average Alaska customer at the burner tip when the oil price is $82.40 per barrel. It is not clear why Karluk consumers pay less.

In 2010, Alaska was scheduled to complete an EPA-mandated transition to ultra low sulfur diesel (ULSD) in all areas, both urban and rural.[6] Although high sulfur diesel is still permitted for home heating uses, the EPA mandate requires ULSD use in highway vehicles and stationary equipment, such as power generators.[7] This presented a unique situation for rural Alaska. Prior to the transition, each rural community was typically equipped with a single storage tank, thus allowing only a single grade of distillate fuel to be stored and distributed. The fuel typically used in these communities was Jet A due to its suitability for use in arctic conditions.[8] The EPA-mandated transition to ULSD for highway and generator use thus required rural communities to either construct separate storage tanks so that multiple grades of arctic-suitable fuel could be stored and distributed, or to switch to a single grade of fuel meeting the ULSD standard. The status of this transition is currently unclear. Determining which communities have built or are building separate storage facilities and which communities have switched or are switching entirely to ULSD is beyond the scope of this study. ULSD is typically more expensive than other distillate fuels due to additional refining costs. The Institute of Social and Economic Research (ISER) at the University of Alaska uses a fixed 5-cent premium for ULSD in rural communities in its Alaska fuel price projections to 2030.[9]

[6] http://www.dec.state.ak.us/air/anpms/ulsd/ulsdhome.htm
[7] http://www.dec.state.ak.us/air/anpms/ulsd/ulsd-bg.htm
[8] http://www.epa.gov/compliance/resources/policies/civil/caa/mobile/alaskadiesel053106.pdf
[9] http://www.iser.uaa.alaska.edu/Publications/Fuel_price_projection_2011-2030_final_01252011.pdf p. 2

5.0 - PROPANE PRICE BUILD-UP

This section will provide a price build-up for propane produced on the North Slope and extracted from the natural gas stream in Fairbanks and Big Lake/Nikiski. This chapter will leverage outputs from the previously delivered "Economic Feasibility Study of The Transportation and Sale of Natural Gas Liquids/LP Gas for the Alaska Gasline Development Corporation" (hereafter referred to as the "NGL/LPG export study") to estimate wholesale propane prices in Fairbanks and Big Lake/Nikiski. New analysis of transportation, storage, and distribution costs will be used to estimate the delivered price of propane.

Throughout this chapter, prices will be presented in $ per million British Thermal Units (MMBtu) or $ per gallon. A gallon of propane contains 91,033 Btu, or about one-third less gross energy content than distillate heating oil.[10] Conversely, 1 MMBtu contains 1,000,000/91,033 = 10.99 gallons of propane. Thus, a propane price of $3.00 per gallon is equal to a price of roughly $32.96 per MMBtu. These conversions refer to the gross energy content of propane but not the net energy output. Net energy output – the energy content actually utilized – will vary by household and business depending on fuel utilization efficiency of the consumer's furnaces or boilers. Throughout this chapter, per-unit propane prices will be reported on a gross energy, or higher heating value (HHV), basis. It should be noted, however, that propane's combustion characteristics are an estimated 10% less efficient than diesel.[11] This 10% efficiency adjustment will be addressed in Chapter 6 when propane and heating oil prices are compared at the "burner tip".

5.1 NGL/LPG Scenarios

In the NGL/LPG export study, North Slope pipeline entry netbacks were calculated for three locations and three capacity options of the natural gas processing and NGL extraction facilities. Of these, two scenarios were deemed technically viable:

1. **Big Lake/Nikiski (Case NGL 3.1.2):** Propane entrained in natural gas is produced on the North Slope and transported via a wet gas pipeline from Prudhoe to Fairbanks and onto Big Lake. At Fairbanks, a spur with 60 MMSCFD of capacity feeds a straddle plant for meeting local dry gas requirements. NGLs extracted at the Straddle Plant are re-injected into the wet gas pipeline for transport to Big Lake. An export-scale NGL extraction facility is located in the greater Big Lake area sufficiently close to the existing Beluga Pipeline so that the dry residual gas pipeline distance and interconnection cost is minimized. NGLs extracted at Big Lake are then transported via a 12-inch, 180-mile liquids pipeline from Big Lake to Nikiski, where a fractionation facility separates propane from the NGL stream. From Nikiski, LP Gas is exported from Nikiski to East Asian customers.

    - **Local-Scale Fairbanks Fractionation.** For this propane study, an alternate scenario will occasionally be referenced that involves the installation of a local-scale fractionation facility at the 60 MMSCFD straddle plant. Under this scenario, propane is produced in Fairbanks at a level sufficient to meet local demand (38 million gallons per year), while excess NGLs are re-injected into the wet gas pipeline to Big Lake.

2. **Fairbanks/Dunbar (Case NGL 2.1):** Propane entrained in natural gas is produced on the North Slope and transported via a wet gas pipeline from Prudhoe to Fairbanks, where export-scale NGL extraction and LP Gas fractionation facilities are located. From the NGL extraction facility, dry gas is supplied directly to Fairbanks-area consumers, and a dry residual gas pipeline is run south to the Beluga pipeline interconnection to serve consumers in South Central Alaska. Propane produced in Fairbanks is transported by rail to either Port MacKenzie or Seward. The Port MacKenzie option requires a rail spur to be constructed from the Big Lake area to the port area. From Port MacKenzie or Seward, propane is exported from to East Asian customers.

One of the primary conclusions of the NGL/LPG export study was that larger gas pipelines and processing plants result in higher producer netbacks due economies of scale. For the purpose of this price

[10] http://www.eia.gov/energyexplained/index.cfm?page=about_energy_units
[11] PND Incorporated "Feasibility Study of Propane Distribution throughout Coastal Alaska" p. 25

comparison, it will be assumed that the processing facility in Big Lake or Fairbanks/Dunbar will be built to a capacity of 500 million standard cubic feet per day (MMSCFD) in order to take advantage of economies of scale.

<u>5.2 Wholesale Prices</u>

Wholesale propane prices in Alaska can be estimated using outputs from the NGL/LPG export study. Table 5.1 shows the "built-up" price of North Slope propane sold to Alaska consumers assuming a fixed netback on the North Slope of $2.00 per MMBtu and using levelized service costs in constant 2011 dollars from the NGL/LPG study. The pipeline tariffs were supplied by AGDC for the scenarios of Big Lake extraction ($7.75/MMBtu levelized nominal) and Fairbanks extraction ($6.25/MMBtu levelized nominal) at the 500 MMSCFD gas flow rate, and adjusted to 2011 $ values using the same methodology as for the levelized NGL project fees. Line-item costs associated with domestic propane production, transportation, and fractionation were taken from the NGL/LPG export study and adjusted, where appropriate, to remove costs associated with export facilities. Project profits (cash flow to investors) and taxes are apportioned to domestic sales at the same rate as for exports.

Table 5.1
Levelized North Slope Propane Prices at Wholesale Alaska Distribution Points by Scenario and Cost Component (2011 $/MMBtu)

Unit Cost Items	Big Lake (NGL 3.1.2)	Fairbanks/Dunbar (NGL 2.1)*
Pipeline Entry Netback Value**	2.00	2.00
North Slope Deethanizer	1.21	1.21
Model Pipeline Tariff Calculated in 2011$	4.63	3.73
NGL Fractionation	0.38	0.43
Liquids pipeline***	0.85	N/A
System Fuel, G&A, Working Capital****	0.44	0.32
Product Subtotal	**9.51**	**7.69**
Taxes (Fed 35%, State 9.4%)	0.50	0.53
Cash flow to investors @12% return	0.44	0.47
Wholesale Price ($/MMBtu)	**10.45**	**8.69**
Wholesale Price ($/gallon)	**0.95**	**0.79**

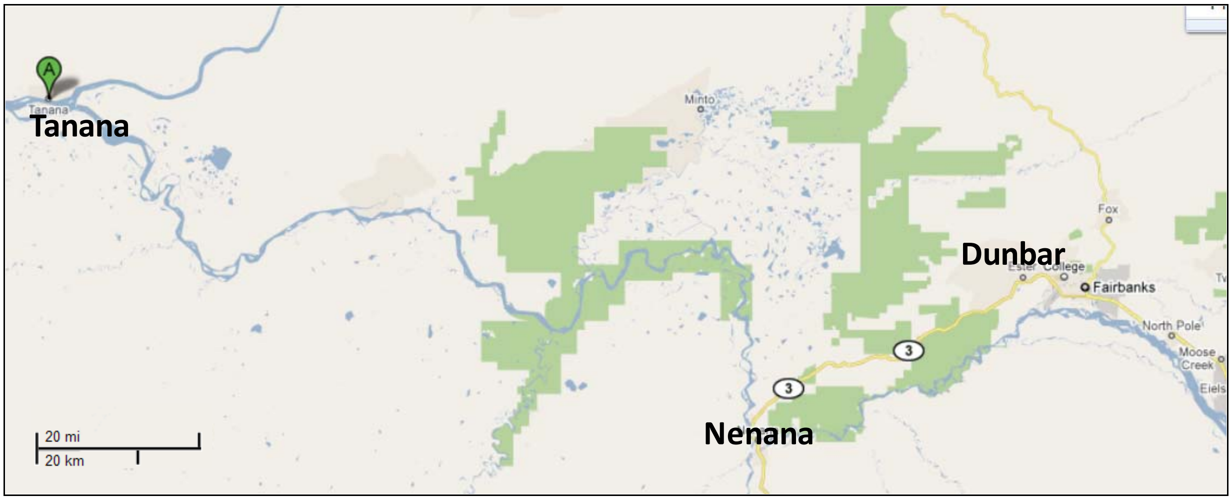
*Propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
**Assumed
***Does not include storage, ship loading facilities, or harbor improvements
****Alaska costs for this line item were estimated by taking 75% of the cost export project line item. Other fuel streams many not be accounted for.

The wholesale price at the fractionation facility would be $10.45 per MMBtu under the Big Lake/Nikiski scenario and $8.69 per MMBtu under the Fairbanks/Dunbar scenario. The primary reason for this pricing difference is the facility configuration at Dunbar that does not require a straddle plant or NGL products pipeline.

5.3 Delivered Prices

In the previous section we developed wholesale propane pricing for supply at Fairbanks (Dunbar) and Big Lake/Nikiski. Based on these wholesale prices, this section will estimate the delivered price of propane to select marine-only rural communities that could be reached from Fairbanks or Big Lake.

5.3.1 Fairbanks/Dunbar



Under the Fairbanks/Dunbar scenario, propane would be fractionated and stored at Dunbar where it would be available for year round conventional truck distribution to the greater Fairbanks area. Transporting propane to river communities along the Nenana and Yukon rivers, such as Tanana, requires much more complicated and expensive transportation infrastructure. Delivering propane to these communities would involve loading and trucking 6,400-gallon ISO containers and 100-pound bottles from Dunbar 25 miles southeast to the riverside village of Nenana, then barging the containers from Nenana on the inland water system to communities along the Nenana, Tanana, and Yukon rivers. In order to receive the bulky ISO containers, each river village would need to be equipped with facilities to receive barges, offload the containers, and reload empty containers for the return trip to Nenana. Once the ISO containers have been received and stored in the riverside communities, the propane can be filled in smaller, 100-pound bottles for distribution to household distribution.

Currently barge deliveries of any product to these communities only occurs starting in the early summer, when ice melt and heavy runoff make river transport possible, and continue only until the late fall when the rivers ice over again. As a result, river communities that wish to consume propane year round would need to receive one or more ISO containers before the rivers ice over. The number of ISO containers required would depend on each community's expected demand and the length of time that the barge traffic is expected to be suspended due to icing.

Considering the cost components discussed for delivering propane to rural riverside communities from Dunbar, and cost estimates gathered during local site visits, it is possible to provide a cost build-up to estimate the burner tip price of propane. Table 5.2 below provides a cost build-up for propane delivery from Dunbar to the village of Tanana.

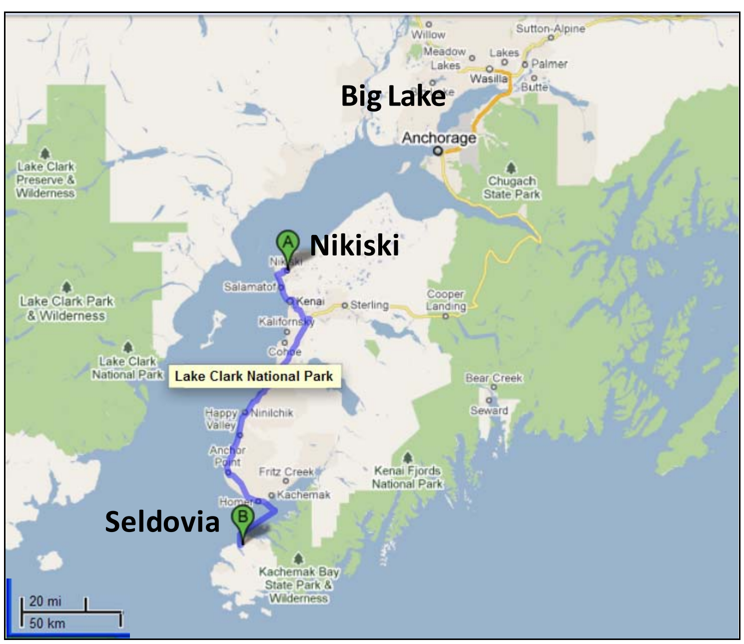
Table 5.2
Estimated Delivered Cost Build-Up for Propane Delivered to Tanana River Community from Dunbar (2011 $)

Unit Cost Items	100-pound Bottles		6,400-gallon ISO Containers	
	$/gallon	$/MMBtu	$/gallon	$/MMBtu
Wholesale Price*	0.79	8.69	0.79	8.69
Truck Loading	0.25	2.74	0.25	2.74
Truck Transportation**	0.25	2.74	0.25	2.74
Barge Transportation***	1.87	20.48	1.98	21.68
Barge Unloading w/ Crane****	N/A	N/A	0	0.00
Local Distribution	0.25	2.74	0.25	2.74
Delivered Price	**3.41**	**37.38**	**3.52**	**38.58**

*Wholesale propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
**from Dunbar to Nenana
***from Nenana to village, including barge loading and the return cost for empty containers
****a crane would be required to unload ISO containers in villages for year-rounds use. This expense is assumed to be financed by the state and thus free to consumers.

Table 5.2 shows that transporting propane via 100-pound bottles (holding roughly 24 gallons each) is roughly 11 cents less expensive on a per-gallon basis than transporting propane via 6,500-gallon ISO containers (that hold roughly 6,400 gallons each). The cost reported in Table 5.2 are preliminary and based on inputs supplied by companies that currently transport propane in small quantities to Tanana. Loading and offloading of 6,400-gallon ISO containers for intermodal transport would require the use of large cranes that would add to the overall cost of transportation. The per-unit cost of offloading the ISO containers in each village is as yet unknown. It has been assumed that infrastructure needed for ISO container unloading would be financed by the State, and would thus not add to the delivered cost of fuel in river communities.

5.3.2 Big Lake/Nikiski



Under the Big Lake/Nikiski scenario, propane would be available year round for conventional truck delivery to towns with highway access around Anchorage and south on the Kenai Peninsula. For villages and towns with only marine access, propane trucks would be loaded at Nikiski then driven to Homer where the trucks would be driven on to landing craft barges and shipped to their delivery points. The propane trucks could be equipped with a single, large, pressurized containers (like a bobtail trucks), which would fill local storage tanks at their delivery points. Alternatively, the trucks could be equipped with ISO containers or multiple 100-pound propane cylinders, which could be delivered to a central point for distribution and exchange with empty cylinders. Unlike under the Fairbanks scenario, the marine-only communities that can be readily accessed from Big Lake/Nikiski can be supplied year round, so winter and spring storage is not necessary.

Considering the cost components discussed for delivering propane to rural marine communities from Nikiski, and cost estimates gathered during local site visits, it is possible provide a cost build up to estimate the burner tip price of propane. Table 5.3 below provides a cost build up for propane delivery by truck and barge to the village of Seldovia.

Table 5.3
Estimated Delivered Cost Build-Up for Propane Delivery to Seldovia from Nikiski
(2011 $)

Unit Cost Items	$/gallon	$/MMBtu
Wholesale Price	0.95	10.45
Truck Loading	0.25	2.74
Truck Transportation*	0.25	2.74
Barge Transportation**	2.62	28.69
Local Distribution	0.25	2.74
Delivered Price	**4.32**	**47.35**

*from Nikiski to Homer
**from Homer to village

6.0 - PROPANE VERSUS HEATING OIL COST COMPARISON

In Chapter 3, residential and commercial heating were identified as the primary market segments where propane could potentially displace heating oil/diesel/distillate fuel. The feasibility of converting these segments will depend heavily on the significance of the propane price advantage versus heating oil. In order for propane conversion to be an economically feasible option, the propane price advantage must be sufficiently large so that it justifies investment in propane-fired furnaces and boilers on the part of residential and commercial consumers.

In order to provide an "apples to apples" comparison between propane and heating oil, prices will be presented on a gross energy content basis; in $ per million British Thermal Units (MMBtu). A gallon of propane contains 91,033 Btu and a gallon of heating oil contains 138,690 Btu.[12] Conversely, 1 MMBtu is equal 10.99 gallons of propane or 7.21 gallons of heating oil. These conversions refer to the gross energy content of propane and heating oil but not the net energy output. Net energy output – the energy content actually utilized – will vary by household and business depending on the fuel utilization efficiency of the consumer's furnaces and boilers. Throughout this chapter, per-unit propane prices will be reported on a gross energy, or higher heating value (HHV), basis. It should be noted, however, that propane's combustion characteristics are an estimated 10% less efficient than heating oil.[13] This 10% efficiency penalty will be applied later in this chapter when propane and heating oil prices are compared at the "burner tip."

Because readers of this report may be more familiar with per-gallon heating oil prices, fuel comparisons will also be presented on a "diesel gallon equivalent" (DGE) basis. DGE is the amount of alternative fuel it takes to equal the energy content of one liquid gallon of diesel. For heating oil, the DGE is one, as heating oil and diesel have the same energy content. In the case of propane, it would take 138,690 Btu /91,033 Btu, or roughly 1.52 gallons of propane to equal the same energy content as a gallon of diesel. Thus, a propane price of $3.00 per gallon is equal to $4.50 per DGE.

6.1 Wholesale Price Comparison

Based on analysis provided in Chapter 4, Alaska wholesale distillate No. 2 prices at the refinery gate (before transportation, storage, and distribution) were estimated to be $2.61 per gallon or roughly $18.84 per MMBtu when oil is at $82.40 per barrel. In Chapter 5, the wholesale price of propane (before transportation, storage, and distribution) was $0.95 per gallon ($10.45 per MMBtu) in Big Lake/Nikiski and $0.79 per gallon ($8.69 per MMBtu) in Fairbanks/Dunbar. Table 6.1 below compares the wholesale prices of propane and distillate No. 2 per MMBtu and per DGE.

Table 6.1
Estimated Wholesale* Propane and Distillate No. 2 Prices (2011 $)

Fuel	Big Lake/Nikiski (NGL 3.1.2)		Fairbanks (NGL 2.1)**	
	$/MMBtu	$/DGE	$/MMBtu	$/DGE
Distillate No. 2* **	18.84	2.61	18.84	2.61
Propane	10.45	1.45	8.69	1.21
Potential Savings	**8.39**	**1.16**	**10.15**	**1.41**

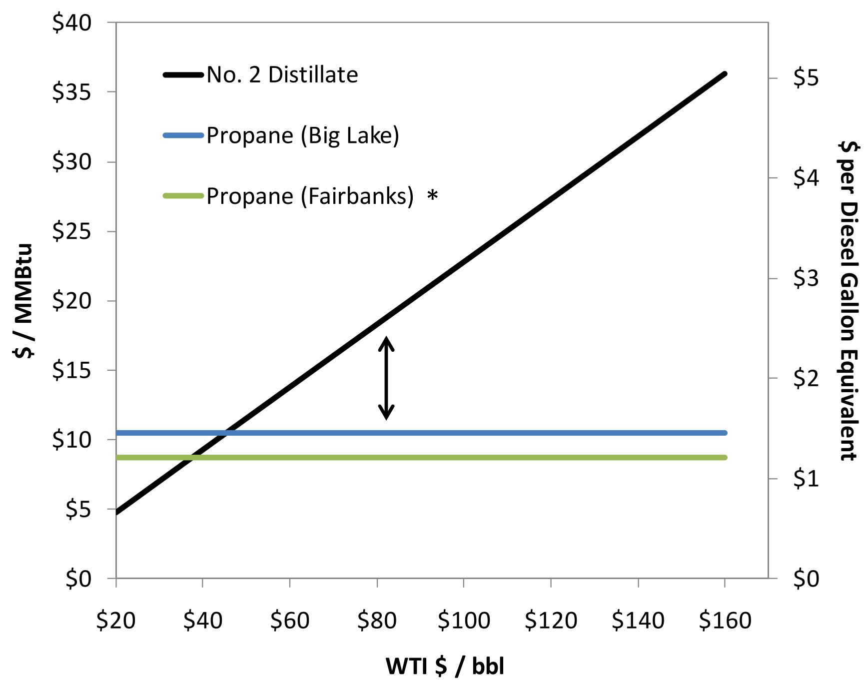
*Wholesale prices are at the fractionation or refinery outlet and do not include transportation, storage, and distribution.
**Propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE).
***WTI price is assumed to be $82.40/bbl.

[12] http://www.eia.gov/energyexplained/index.cfm?page=about_energy_units
[13] PND Incorporated "Feasibility Study of Propane Distribution throughout Coastal Alaska" p. 25

Table 6.1 shows that propane offers significant savings versus distillate No. 2 on an energy equivalent basis. The propane prices presented in Table 6.1 are wholesale prices at the fractionation facility outlet and do not include the cost of a storage facility and rack terminal for local propane distribution (by ISO container, bobtail trucks, barges, etc.). A true price comparison would include the cost of transportation, storage, and distribution for both fuels and would compare the delivered cost of each. Transportation, storage, and distribution costs are likely to be more expensive than the equivalent cost items for diesel because propane must be transported and stored in pressurized vessels and because larger volume tanks are required in order to ship the same amount of energy due propane's lower per-gallon energy content. A full "burner tip" comparison of propane and distillate will be provided in the next section.

It should also be noted that the propane price advantage is sensitive to the oil price. At high oil prices, propane is likely to be considerably less expensive than No. 2 distillate. At lower oil prices, however, this advantage erodes, thus worsening the economics of propane conversion. Figure 6.1 below shows how the spread between wholesale propane and No. 2 distillate prices increases with the oil price. At an oil price of roughly $45 per barrel, which corresponds with a wholesale diesel price of $1.45 per gallon, the wholesale price of diesel and propane is roughly equivalent per unit of energy in the Big Lake/Nikiski market. The propane price in Fairbanks reaches diesel price parity on an energy equivalent basis when oil is at $37 per barrel.

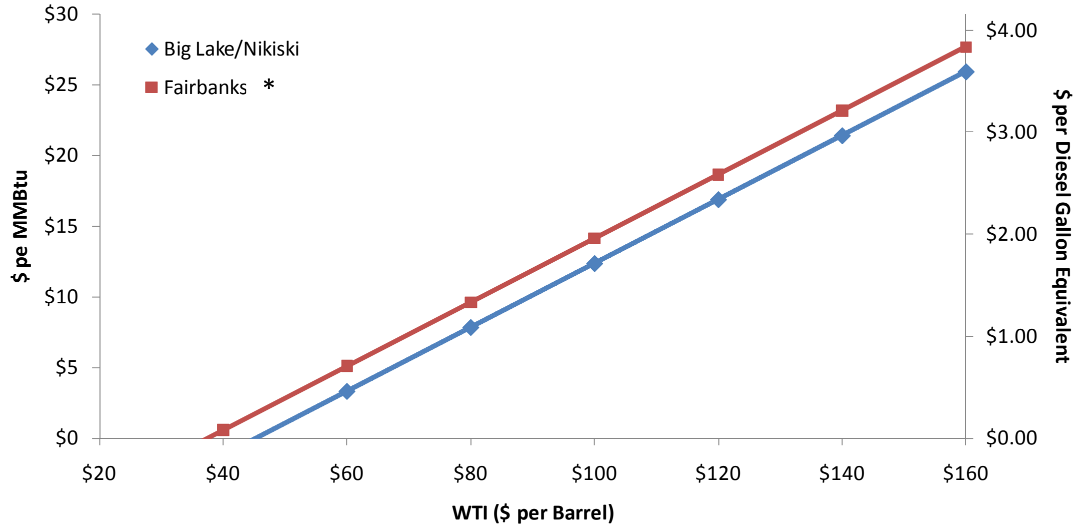
Figure 6.1. Sensitivity of Wholesale Propane and No. 2 Distillate Prices to WTI Oil Price



*Propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE) at every WTI price level.

Figure 6.2 below graphs the estimated spread between No. 2 distillate and propane wholesale prices given different WTI oil assumptions. Transportation, storage, and distribution costs are likely to be more expensive for propane than for distillate. If the spread between these distribution costs is less than the spread between the distillate and propane wholesale prices, then propane will experience a price advantage over distillate. If this price advantage is significant enough to justify the cost of converting to propane heating systems, consumers will switch fuels. Higher oil prices improve the economics of propane conversion by increasing the distillate spread.

Figure 6.2. Estimated No. 2 Distillate Spread Over Propane ($/MMBtu)



*Propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE) at every WTI price level.

6.2 Urban Burner Tip Price Comparison

A burner tip price comparison is required to fully evaluate the economics of propane conversion. For highway-accessible consumers, this calculation is relatively simple. Interviews with Alaskan fuel distributors indicate that typical fuel delivery costs from the refinery rack or storage facility to the household is 25-30 cents per gallon or roughly ($1.80-2.16 per MMBtu). Twenty-five cents was chosen as a standard per-gallon shipping assumption for this study. From Chapter 5, propane truck loading and truck transportation were estimated to cost $0.50 per gallon, or roughly $5.47 per MMBtu. Table 6.2 below compares the burner tip price of each fuel in each market based on the wholesale price and transportation, storage and distribution cost estimates. In addition, we add 10% to the propane price to account for the loss of efficiency caused by propane's combustion characteristics. This provides an equivalent "burner tip" price comparison.

Table 6.2
No. 2 Distillate vs. Propane Prices by Urban Market and Cost Item (2011 $/MMBtu)

	Big Lake/Nikiski NGL 3.1.2		Fairbanks/Dunbar NGL 2.1*	
Unit Cost Items	**No. 2 Distillate**	**Propane**	**No. 2 Distillate**	**Propane**
Wholesale Price**	18.84	10.45	18.84	8.69
Transportation, Storage, and Distribution	1.80	5.47	1.80	5.47
Efficiency Adjustment (+10%)	N/A	1.59	N/A	1.42
Burner Tip Price	**20.64**	**17.52**	**20.64**	**15.58**
Potential Savings ($/MMBtu)	**3.12**		**5.06**	
Potential Savings ($/DGE)	**0.43**		**0.70**	

*Propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE) before the 10% burner-tip efficiency adjustment.
**When WTI is at $82.40 per barrel.

Table 6.2 shows that significant savings can be received from propane conversion in both the urban Big Lake/Nikiski and Fairbanks/Dunbar markets.

6.3 Rural Burner Tip Price Comparison

A burner tip price comparison is required to fully evaluate the economics of propane conversion. Burner tip prices will vary from community to community due to differences in transportation, storage, and distribution costs. Based on a preliminary analysis of propane and distillate delivery costs in Chapters 4 and 5, comparative burner tip prices for each fuel delivered to the village of Tanana are presented in Table 6.3 below.

Table 6.3
Burner Tip Cost Comparison of Heating Oil vs. Propane Delivered to Tanana (2011 $/MMBtu)

Unit Cost Items	Heating Oil*	Propane (Bottles)	Propane (ISO Containers)
Wholesale Price**	18.84	8.69	8.69
Transportation, Storage, and Distribution	6.60	28.69	29.89
Efficiency Adjustment (+10%)	N/A	3.74	3.86
Burner Tip Price	**25.44**	**41.11**	**42.44**
Potential Savings ($/MMBtu)		**(15.68)**	**(17.00)**
Potential Savings ($/DGE)		**(2.17)**	**(2.36)**

* When WTI is at $82.40 per barrel. Using ULSD in Tanana would add ~5 cents per gallon to the burner tip price.
**Wholesale propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.25/DGE) before the 10% burner-tip efficiency adjustment.

Table 6.3 shows that despite a significant wholesale price advantage, propane extracted in Fairbanks (Dunbar) and delivered to the river community of Tanana would be significantly more expensive when the cost of transportation, storage, and distribution, and the efficiency penalty, are considered. This conclusion is true for when oil is at $82.40 per barrel, which corresponds with a burner tip diesel price of $3.53 per gallon in Tanana. The choice of transportation container (100-pound bottles or 6,400-gallon ISO containers) does not make a significant difference in this conclusion.

Table 6.4 below compares the estimated burner tip propane price in Seldovia versus the estimated burner tip price when crude oil is at $82.40 per barrel. The fuel oil price in Ouzinkie (located on Kodiak Island) was used as a proxy for the price in Seldovia, which was not available through PCE data.

Table 6.4
Burner Tip Cost Comparison of Heating Oil vs. Propane Delivered to Seldovia (2011 $/MMBtu)

Unit Cost Items	No. 2 Distillate (Oil at $82.40)*	Propane
Wholesale Price	18.84	10.45
Transportation, Storage, and Distribution	6.48	36.90
Efficiency Adjustment (+10%)	N/A	4.73
Burner Tip Price	**25.32**	**52.08**
Potential Savings ($/MMBtu)	**(26.76)**	
Potential Savings ($/DGE)	**(3.71)**	

*When WTI is at $82.40 per barrel. Distillate prices to Ouzinkie used as a proxy for Seldovia. Using ULSD in Seldovia would add ~5 cents per gallon to the burner tip price.

The conclusion from Table 6.4 is that propane would be significantly more expensive in Seldovia than distillate fuel due to very high delivery costs and to the significant efficiency penalty. The cost comparisons for Tanana and Seldovia presented above are based on preliminary cost estimates for transportation, storage, and distribution provided by companies currently involved in these activities.

6.4 Potential for Fuel Switching

Ultimately consumers will not choose to switch from diesel to propane unless the cost savings from propane are significant enough to justify the cost of converting their current heating facilities to use propane. PND Incorporated's 2005 "Feasibility Study of Propane Distribution throughout Coastal Alaska" provides estimated propane conversion costs for households at roughly $1,800 for home (space) heating and $1,500 for water heating. These capital cost estimates were based on PND Incorporated's conversations with local suppliers. SAIC adjusted these costs for inflation and lists them in 2011 dollars in the Table 6.5 below.

Table 6.5
Cost of Converting Heating Facilities from Diesel to Propane and Required Annual Savings for 10-Year Payback (2011 $)

Facility	Cost	Required Annual Savings for 10-year Payback
High Efficiency Direct Vent Diesel Home Heating	2,150	215
High Efficiency On-Demand Diesel Water Heating	1,800	180

Source: PND Incorporated "Feasibility Study of Propane Distribution throughout Coastal Alaska." Adjusted to 2011 dollars.

In order for fuel switching to make economic sense, the annual savings from propane usage must offset the cost of conversion over a reasonable timeframe. For the purpose of this study, it will be assumed that household consumers desire a full payback on conversion investment within ten years of conversion. Thus, annual savings for space heating must be at least $215 per year for consumers to convert space heating facilities and the annual savings for water heating must be at least $180 for consumers for converting water heaters. The annual savings in each market will depend primarily on two factors: 1) the magnitude of savings per unit of energy consumed, and 2) the quantity of energy required per household for space and water heating. Table 6.6 below lists the estimated quantity of fuel used per year by heating type and market. Total annual heating oil usage was estimated by taking the average annual consumption of No. 2 distillate (off-highway) and kerosene consumed by residential users in Alaska over the past 10 years and dividing by the total number of households that use heating oil as their primary heating source. This average consumption rate (879 gallons) was then adjusted upward or downward based on the average heating degree days for each market (See Appendix C). The breakdown in fuel usage between space and water heating was estimated using assumptions from the PND study. The PND study assumed that 17.2% of each household's heating oil consumption was for water heating and 82.8% was for space heating.

Table 6.6
Estimated Household Heating Oil Usage by Market and Heating Type (gallons per year)

	Space	Water	Total
Fairbanks	879	183	1061
Big Lake	678	141	818
Tanana	935	194	1130
Seldovia	636	132	768

Based on the heating oil consumption estimates in the Table 6.6 and the cost of propane conversions in Table 6.5, it is possible to estimate the minimum savings per unit of energy required for consumers to receive a full payback on propane conversion investment within 10 years. For instance, in order to save $215 on space heating annually, a residential consumer in Fairbanks would need to save $215 / 879 gallons, or roughly 24 cents per gallon ($1.76 per MMBtu) by switching to propane. Given a burner tip price (including 10% efficiency penalty) for propane in Fairbanks of $15.58 per MMBtu, this means that the burner tip price of heating oil must be at least $17.34 per MMBtu ($2.40 per gallon) for propane conversion to be economically viable. Based on the modeling efforts from Chapter 4, a heating oil price of $2.40 would be associated with a WTI crude oil price of roughly $68 per barrel. Table 6.7 below shows the minimum burner tip savings required for propane conversion in each market for both space and water heating system conversions. The Table also shows the associated WTI crude oil price at which the required savings materialize.

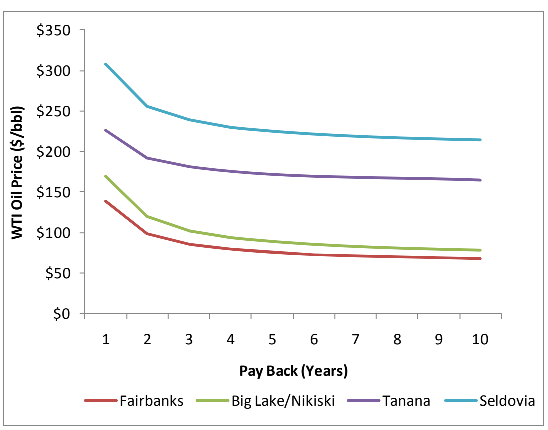
Table 6.7
Minimum Propane Savings Required for 10-Year Pack Back on Propane Conversion and WTI price at which Minimum Savings is Achieved (2011 $)

	Space Heating		Water Heating	
	Savings* ($/MMBtu)	WTI** ($/bbl)	Savings* ($/MMBtu)	WTI** ($/bbl)
Fairbanks (NGL 2.1)* **	1.76	68	7.11	92
Fairbanks (NGL 3.1.2)****	1.76	76	7.11	100
Big Lake (NGL 3.1.2)	2.29	79	9.22	109
Tanana (NGL 2.1)	1.66	165	6.68	186
Seldovia (NGL 3.1.2)	2.44	215	9.83	246

*Burner tip savings of propane vs. heating oil (including 10% efficiency penalty)
**This is the minimum crude oil price at which conversion becomes economical.
***Under this scenario, Fairbanks propane markets are served by an export-scale fractionation plant (see scenario NGL 2.1).
****Under this scenario, Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario).

The savings reported in Table 6.7 are based on a 10-year payback period. However, it is not clear how quickly households would desire a full payback on conversion investments. Some users may only be willing to invest in conversion if the payback occurs over a shorter time period. This payback period is likely to be different for different users. Figure 6.3 below shows how the length of the required payback period impacts the WTI price required to generate adequate savings to encourage propane conversion for space heating.

Figure 6.3. WTI Oil Price (2011 $/bbl) Required for Propane Conversion in Space Heating by Expected Payback Years



Note: Under the Fairbanks scenario propane markets are served by an export-scale fractionation plant (NGL 2.1).

7.0 - NORTH SLOPE PROPANE PRICING COMPARISON

SAIC has completed a study that analyzes propane production from Fairbanks (Dunbar) and Big Lake/Nikiski. For distribution of propane, SAIC has estimated propane commodity costs based on fractionation plants being located at Dunbar and Nikiski. Table 7.1 summarizes the wholesale propane costs at these distribution points and the estimated cost of transportation, storage, and distribution from these points to Tanana and Seldovia.

Table 7.1
North Slope Propane Prices by Delivery Scenario and Cost Item (2011 $/gallon)

Cost Item	Fairbanks (Dunbar) to Tanana*	Big Lake/Nikiski to Seldovia
Wholesale Price	0.79	0.95
Transportation, Storage, and Distribution	2.73	3.37
Delivered Price	**3.52**	**4.32**

*Using ISO containers. Wholesale propane costs in this scenario assume an export-scale fractionation plant in Fairbanks (see NGL 2.1 scenario). If Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario), the cost would be higher by $1.81/MMBtu ($0.16/propane gallon)

The wholesale price is based on wellhead net back pricing from the previously performed AGDC NGL Feasibility Study, including wellhead net back, natural gas pipeline tariff, NGL fractionation costs, and propane storage costs. A detailed cost buildup for wholesale prices and transportation, storage, and distribution costs are included in Chapter 5: Propane Price Build Up.

The propane loading terminal infrastructure costs are associated with developing infrastructure that transfers propane from the product storage tanks into bobtail delivery trucks for regional delivery. In the case of the Dunbar facility this would also involve the capability to fill ISO containers for delivery to the Port of Nenana. For the Nikiski facility it is assumed that bobtail trucks would be loaded at the terminal site and driven on landing craft barges for transport to the respective marine village.

For Dunbar, transportation costs include highway transportation costs from Dunbar to Nenana for the ISO containers. The ISO containers are then transported to the Port of Nenana for loading onto barges for delivery to river communities such as Tanana. The distribution costs would include loading the ISO containers onto the barge, barge transportation of full ISO containers, pick-up of empty ISO containers, and transport of the empty containers back to Dunbar. For the marine communities such as Seldovia, it is assumed that transportation costs would include barge transportation from loading terminal to the marine village. In addition distribution costs would include local delivery charges for the bobtail trucks from the landing craft barge.

For supply of propane to river communities, the annual inventory must be delivered typically once per year during the river access period of May through September. This requires that storage must be accounted for during the approximately eight months when supplemental delivery is not possible. Assumptions associated with storage costs include tank utilization up the nearest whole ISO container. For purposes of this study, propane use in Tanana is assumed to be 8,000 gallons per year or two 6,400 gallon ISO containers.

The prices in Table 7.1 are relatively favorable compared to recently obtained price quotes for propane in these communities. Table 7.2 below compares current propane prices with estimated prices of propane supplied to these communities from the North Slope. Propane used in Alaska is currently produced at oil refineries and propane pricing is sensitive to the price of oil. The "Current Propane" price quotes shown in Table 7.2 were obtained in April and May 2011 when WTI crude oil was trading at around $100 per barrel. Diesel comparisons conducted in other parts of this report were conducted assuming a lower oil price of $82.40 per barrel. There is insufficient historical data available to perform a regression analysis to normalize the "Current Propane" price to $82.40 per barrel. "North Slope Propane" prices were based on a price build-up with a constant $2.00 per MMBtu producer netback and are not sensitive to the price of oil.

Table 7.2
Current vs. Estimated North Slope Propane Prices by Rural Community
(2011 $/gallon)

Price	Tanana (NGL 2.1)*	Tanana (NGL 3.1.2)**	Seldovia (NGL 3.1.2)
Current Propane* **	5.32	5.32	5.22
North Slope Propane******	3.27	3.43	4.32
Potential Savings	**2.05**	**1.89**	**0.90**

*Under this scenario, Fairbanks propane markets are served by an export-scale fractionation plant (see scenario NGL 2.1).
**Under this scenario, Fairbanks propane markets are served by a local-scale fractionation plant (see the "Local-Scale Fairbanks Fractionation" alternative to the NGL 3.1.2 scenario).
***For Tanana, May 31 price quote. For Seldovia, April 26 price quote
****For Tanana, the home delivery surcharge has been subtracted to provide a cost an "off the barge" cost that is equivalent to the price quote.

8.0 - END USER COST BREAKDOWN

8.1 Nenana

8.1.1 Site Visit

SAIC visited the Port of Nenana on 23 May 2011 to see the existing infrastructure for propane shipping to customers living on the Tanana and Yukon Rivers. Crowley currently has infrastructure to load and ship freight, propane, and diesel fuel. Propane is primarily delivered from the Bethel area upriver or propane can be loaded into conventional propane trucks from supplies located in Fairbanks to fill small 1000 gallon tanks by truck. The Crowley equipment includes a Manitowoc 4100 track mounted 200 ton capacity crane for assisting with loading and unloading materials for barges. During a meeting with Crowley staff in Anchorage on 24 May 2011, SAIC was informed that the majority of river community propane is supplied by 100-pound bottles traveling on the deck of fuel barges containing diesel fuel. SAIC also contacted the City Manager of Nenana (Jason Mayrand) to discuss local concerns associated with propane delivery in the area and City Manager of Tanana (Bear Ketzler) to discuss seasonal propane and diesel utilization. Also contacted was the Chief Executive Officer of the Toghottele Corporation (Jim Sackett) for information on possible native village corporation roles in providing infrastructure for propane tank barge unloading equipment. Of particular importance was the discussion with Crowley regarding propane bottle delivery. Currently 100-pound propane bottles are primarily delivered as “above deck” cargo on diesel fuel barges. Delivery of diesel fuel from “double hulled fuel barges” is substantially cheaper than propane because freight charges are based on weight including the tank or bottle that the propane is contained. In the case of diesel fuel barges, the barges acts as the “container”, so no shipping costs area incurred for shipping the “container”. Conversely for propane, dedicated propane barges are not typically designed to also haul freight. Construction of propane barges and loading/unloading cranes will have to be added into the infrastructure development costs if propane utilization is to be significantly expanded. The City of Tanana utilizes power supplied by Tanana Power Company. Tanana Power Company uses four diesel engines (2 X Detroit and 2 X Caterpillar) operating in different configurations depending on the season. None of the diesel engines is currently configured to operate on propane. Conversion to propane for power generation in future would depend on specific incentives available. There is currently 112,000 gallons of diesel fuel storage at Tanana.

The Tanana value chain starts at the fractionation plant assumed to be located in Dunbar. A truck loading facility is required at an estimated capital cost of US$16 million. Based on a 15 percent return, this equates to approximately $0.24 per gallon processing charge. Transportation costs will be incurred for moving propane via a 6400 gallon ISO containers plus 100-pound bottles from Dunbara to Nenana. Based on discussions with local propane vendors, local truck delivery costs average $0.25 per gallon. After arrival in Nenana, the ISO container and 100-pound bottles must be transferred to a barge for transportation down the Tanana River to the City of Tanana. Based on review of different barge shipping companies tariffs, an average cost of $1.40 per gallon was calculated based on freight rates plus fuel charges to transport the propane to Tanana where it off loaded for local use. In addition, empty containers are hauled off for freight charges of $0.58 and $0.55 per gallon based on the weight of the respective container.

8.2 Seldovia

8.2.1 Site Visit

SAIC visited the marine community of Seldovia on 20 May 2011 to observe the local utilization of propane and diesel fuel by local residents. The site visit included a walk down of the Homer Electric Association (“HEA”) Gerry Willard Power Station and harbor diesel fuel tank farm. Discussions were also held the local propane vendor Seldovia Fuel and Hardware Store covering delivery schedules and constraints. A meeting also took place with City Manager (Tim Dillon) to provide insights into local areas of concern plus local residents were questioned regarding local consumption preferences. The walk down of the Gerry Willard Power Station included discussions with Ron Day of HEA. The power station includes 10,000 gallons of onsite fuel storage. The two 1200kW diesel generators are operated as a remote start capable back-up supply power plant in case power lines along Kachemak Bay are damaged. The diesel generators are started monthly as part of a predictive preventative maintenance program. Operating hours are approximately 75 to 100 per annum. Advantages to propane conversion for this facility are reduced environmental risks associated with diesel fuel spills and lower engine maintenance costs attributed to propane utilization. However, these units are not capable of operation on propane. Any consideration for conversion would have to occur during the next capital replacement cycle. Local fuel storage capabilities consist of five - 45,000 gallon diesel fuel tanks that are filled periodically by fuel barges and 4000 gallons of propane storage. Portable propane bottles are filled by Seldovia Fuel and Hardware Store for local use. Typical residences use diesel fuel for home heating and propane for cooking and clothes dryers. Distribution of propane and diesel fuel to fixed tanks located at private homes is provided by bobtail tanker trucks that arrive via landing craft barge periodically during the year. Delivery of propane and diesel fuel to residents and businesses in Seldovia is not typically seasonally constrained.

The Seldovia value chain starts at the fractionation plant assumed to be located in Nikiski. A truck loading facility is required at an estimated capital cost of US$16 million. Based on a 15 percent return, this equates to approximately $0.24 per gallon processing charge. Transportation costs will be incurred for moving propane via a 2500 gallon bobtail delivery truck from Nikiski to Homer. Based on discussions with local propane vendors, local truck delivery costs average $0.25 per gallon. After arrival in Homer, the fuel must be transported across Kachemak Bay to Seldovia. Based on discussions with different barge shipping companies, an average cost of $2.62 per gallon was calculated based on barge rental, crew services, and fuel charges to transport the 2500 gallons of propane to Seldovia where it is delivered to private homes and the local propane supply store bulk tank.

9.0 - SUGGESTIONS FOR PROPANE MARKET GROWTH

This chapter will provide suggestions for the encouragement of propane market growth in rural Alaska by utilizing and referring to the PND Incorporated's "Feasibility Study of Propane Distribution throughout Coastal Alaska" plus findings based on this study. Generally, the PND Incorporated study concurs with SAIC's analysis that propane's price advantage versus diesel will be the largest factor driving demand growth in rural areas. In addition, the report suggests several strategies for further encouraging the use of propane. A few of these suggestions are summarized below:

- Currently Alaska has limited facilities to service and recertify 100-pound propane bottles. Regulations require that propane bottles be recertified twelve years from the date of manufacture and every five years after that.[14] Many bottles are sent to the Seattle area for recertification and are filled with propane in Seattle to take advantage of lower propane prices in the Northwest portion of the United States. State officials should consider developing a bottle recertification facility in the Fairbanks or Anchorage area to create jobs and reduce servicing costs.

- Delivery of propane to communities should "start small" using currently available shipping means and methods such as ISO containers shipped along with other bulk freight.[15] Trucks and other vehicles fitted with propane tanks can be used to distribute to residences. This scenario minimizes startup costs for transport and fully utilizes the current system of existing infrastructure and transportation industry.

Figure 9.1. ISO Container for Propane Transportation

Source:
http://www.angda.state.ak.us/Propane%20Distribution/ANGDA%20NWPGA%20Consortium%20Mtg%20Sept%2009%20Osgood.pdf

- Purchasing ISO containers and the large cranes needed to handle them is expensive for individual communities. This is a possible program where Native Corporations or grant money could be used purchase these types of items.

[14] "Propane Cylinders." Propane 101. http://www.propane101.com/propanecylinders.htm (May 31, 2011).
[15] "Feasibility Study of Propane Distribution throughout Coastal Alaska." PND Incorporated for ANGDA. August 2005. Page 4.

- A standardized lifting crane and infrastructure design needs to be developed to create economies of scale for remote marine and river communities to use in order to utilize ISO containers. Many marine and river based communities are forced to use 100-pound bottles for their cooking and other household uses because they do not have any way of managing larger propane bottles that could be used.

- Having a local ISO container of propane available in a village would enable consumers to fill their own bottles remotely. However, propane vendors have complained that 100-pound bottles were often exchanged in a condition that rendered them unsuitable for further service. Local government should provide incentives to local citizens to manage 100-pound bottles in good condition in order to take advantage of “in-village” propane service.

- As demand increases, storage, transfer facilities and shipping methods will adjust to efficiently meet the increased demand. Supply of large quantities of propane, as would be needed for electric power generation, requires the construction of special ocean-going multi-product or single product barges and/or pipelines. The development of strategic distribution hubs would allow more efficient transport to smaller rural communities.

Figure 9.2. Typical Propane Barge

Source:
http://www.angda.state.ak.us/Propane%20Distribution/ANGDA%20NWPGA%20Consortium%20Mtg%20Sept%2009%20Osgood.pdf

Figure 9.3. Propane Bulk Storage Facility

Source:
http://www.angda.state.ak.us/Propane%20Distribution/ANGDA%20NWPGA%20Consortium%20Mtg%20Sept%2009%20Osgood.pdf

- Propane storage facility construction costs could be funded separately by grants or other means, as is common for the diesel fuel tanks and equipment in many communities. The PND study suggests making 20- or 30-year, zero interest loans available to Alaska communities to build propane-based-tank farms.[16]

[16] "Feasibility Study of Propane Distribution throughout Coastal Alaska." PND Incorporated for ANGDA. August 2005. Page 11.

10.0 - CONCLUSIONS

Economics at the "burner tip" will be the primary force that drives propane conversion for residential and commercial consumers in Fairbanks, Big Lake/Nikiski, and rural Alaskan communities. Consumers that currently use diesel, fuel oil, or kerosene for heating in the highway-accessible areas around Fairbanks and Big Lake/Nikiski could realize significant savings by switching to propane. Rural consumers that lack highway access are less likely to switch fuels because distillate will remain less expensive than propane at the burner tip due to high intermodal transportation, storage, and distribution costs for propane.

The majority of Alaskan consumers should be able to take advantage of reduced wholesale propane pricing. However, each remote village needs to have the ability to receive and store propane in quantities larger than 100-pound bottles. Because freight costs are based on a weight-based formula, per-unit shipping costs for 100-pound (25-gallon) and 6,400-gallon containers are comparable and there is no cost advantage to bulk deliveries. However, the primary benefit to local consumers of receiving bulk 6,400-gallon containers is the ability to strategically purchase propane in greater quantities at seasonally lower prices. By having a large propane inventory available year round, local consumers also avoid having to fly in full 100-pound bottles in emergency situations. Unfortunately, equipping villages to receive ISO containers will involve significant infrastructure improvements. The Port of Nenana has a crane capable of loading ISO containers onto barges. However, at the village level there are typically minimal facilities for barge unloading; therefore a crane will have to be constructed and local storage facilities constructed. Based on seasonal delivery constraints for Alaskan river communities, all propane has to be delivered during the summer season when the Tanana and Yukon rivers are open for shipping. Multiple ISO containers will be required based on local annual use requirements. Purchase of filled ISO containers will need to be scheduled in advance with the supplier and shipper.

Based on discussions with different propane and diesel fuel consumers, the bulk of their annual fuel requirements are purchased at one time. This does not allow market timing to be used to reduce fuel pricing costs. Regardless of whether propane or diesel fuel is purchased, the remote villages should form a fuel purchase coop in order to maximize bulk purchase discounts and to be able to hedge against seasonal price spikes.

Only those communities that can access propane deliveries directly from inventory located close to the fractionation facility should see savings by replacing diesel fuel with propane. Where propane delivery is accomplished by barge or requires multiple handlings, propane will be more expensive than fuel barge delivered diesel fuel due to the substantially lower transportation costs per gallon.

For Alaskan power utilities, purchase or upgrade of power plant equipment capable of utilizing both propane and fuel oil may be to their advantage, especially if reducing carbon emissions becomes a higher priority in future years.

GLOSSARY OF TERMS FOR THE NATURAL GAS INDUSTRY

Diesel Fuel – a refined, low volatile content, liquid hydrocarbon product primarily used as a transportation fuel. The heat content of diesel fuel is approximately 138,690 Btu/gallon and a density of 6.94 pounds per gallon.

Ethane - Ethane is an organic compound with the chemical formula of C_2H_6. At room temperature it is a colorless and odorless gas. Ethane is a common feedstock for petrochemical facilities.

FOB - Free on Board, delivered on board ship or other carrier without charge to the buyer to that point. Product prices "FOB Alaska Tidewater" are the prices at that export point.

Fuel Oil – a grouping of refined, low volatile content, liquid hydrocarbon products with variable viscosities and heat content ranging from 133,000 156,000 Btu per gallon depending on the specific grade.

ISO Container (propane) – standardized container sizing to fit specific shipping profiles nominally 20 feet in length, 8.5 feet height, and 8 feet width. The tare weight is approximately 20,000 pounds and typical tank capacity is 6,400 gallons.

LNG - Liquefied natural gas refers to a refrigerated and/or compressed form of methane with the chemical formula of CH_4. The methane is liquefied for ease of transportation to end users. The liquefaction process results in a volumetric reduction of approximately 650 times.

LPG - Liquefied Petroleum Gas, a mixture of gases, primarily propane, that are derived from petroleum refining.

LP Gas - Liquid Propane Gas, a mixture of propane and butane marketed globally for transportation, home heating, cooking, agriculture, and manufacturing. LP Gas is produced from two sources: Liquefied Petroleum Gases (LPGs) from oil refineries, and Natural Gas Liquids (NGLs) from natural gas processing.

NGL - Natural gas liquids refer to the entrained liquids in natural gas such as ethane, propane, normal butane, iso-butane, and pentane. Typically NGL refers to mix of liquids.

Propane - Propane is an organic compound with the chemical formula of C_3H_8. At room temperature it is a colorless and odorless gas. Propane is a common product used for transportation fuel, cutting torches, plus heating and cooking in homes. Nominal density of propane is 4.1 pounds per gallon and heat content is 91,033 Btu per gallon.

Straddle Plant - Straddle plant refers to a processing plant that removes NGLs from a natural gas pipeline producing a "dry gas" product.

APPENDIX A. PHOTOS OF PORT OF NENANA INFRASTRUCTURE

100-Pound Bottles at Port of Nenana

AmeriGas Nenana Facility

Crane at Port of Nenana

Forklift at Port of Nenana

Fuel shipping Container at Port of Nenana

Port of Nenana

PHOTOS OF SELDOVIA FUEL HANDLING INFRASTRUCTURE

Dual Fuel Seldovia Home


Seldovia City Dock

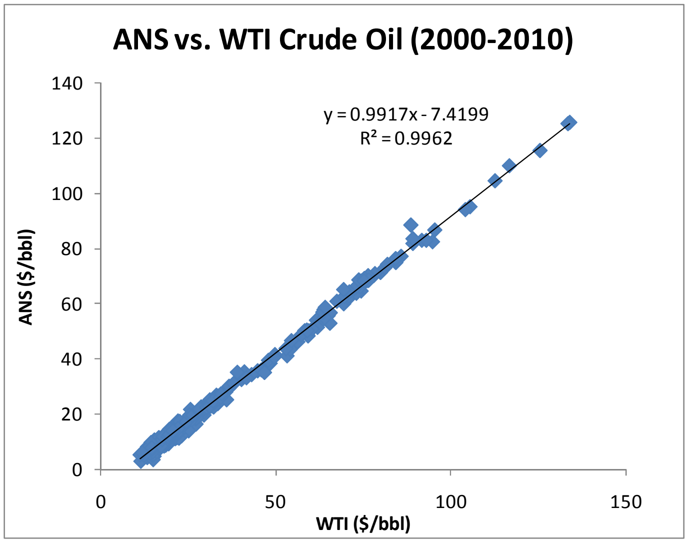
Seldovia Diesel Fuel Storage Facilities

Seldovia Diesel Tanks

Seldovia Power Plant

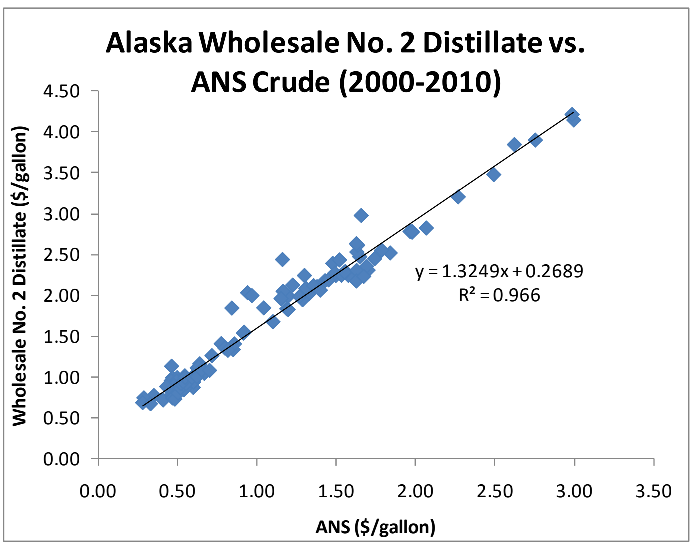
Seldovia Propane Storage Facilities

APPENDIX B. PRICE DATA AND REGRESSION ANALYSIS



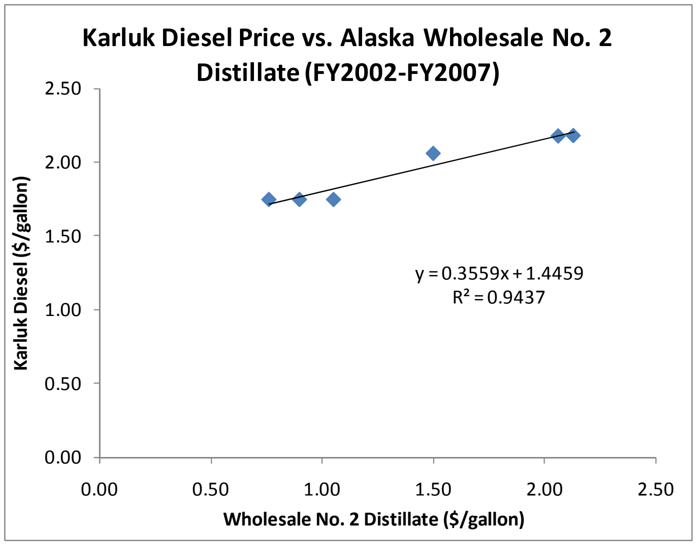
When WTI is $82.40/bbl, ANS is $74.30/bbl.

Sources: EIA: Monthly Alaska North Slope First Purchase Price:
http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=F005071__3&f=M,
EIA: Monthly Cushing, OK WTI Spot Price FOB:
http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M

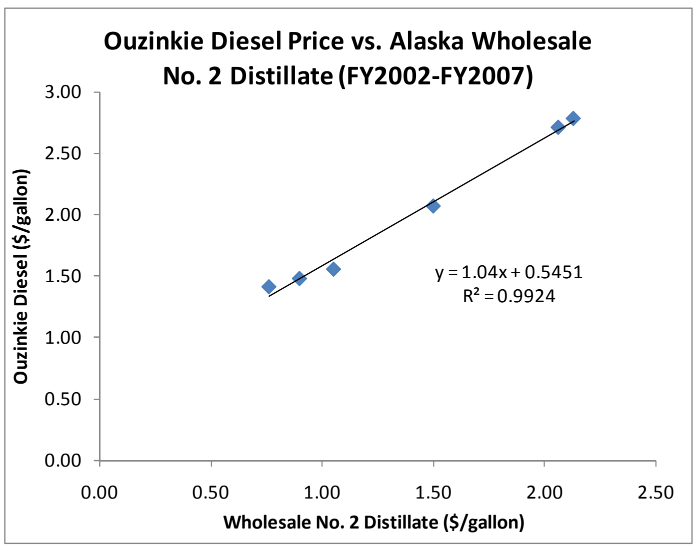


When ANS is $74.30/bbl ($1.77/gallon), Alaska wholesale No. 2 distillate is$2.61/gallon.

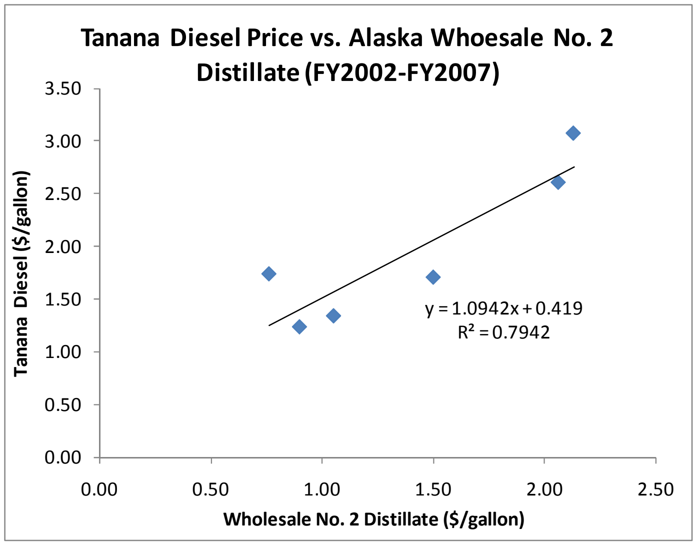
Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
EIA: Monthly Alaska North Slope First Purchase Price:
http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=F005071__3&f=M,



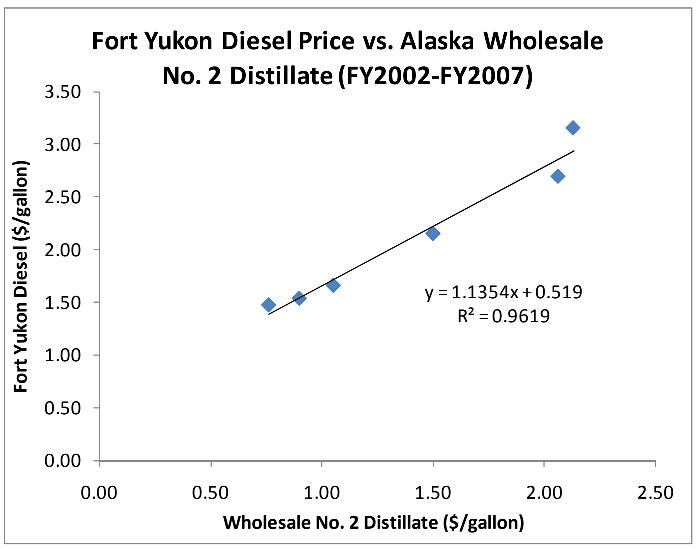
When Alaska wholesale No. 2 distillate is$2.61/gallon, Karluk diesel is $2.38/gallon.
Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
ISER: Alaska Fuel Price Projections 2011-2030, Accompanying Workbook:
http://www.iser.uaa.alaska.edu/Publications/oil_price_projection_aea01_2011_v1.xlsx



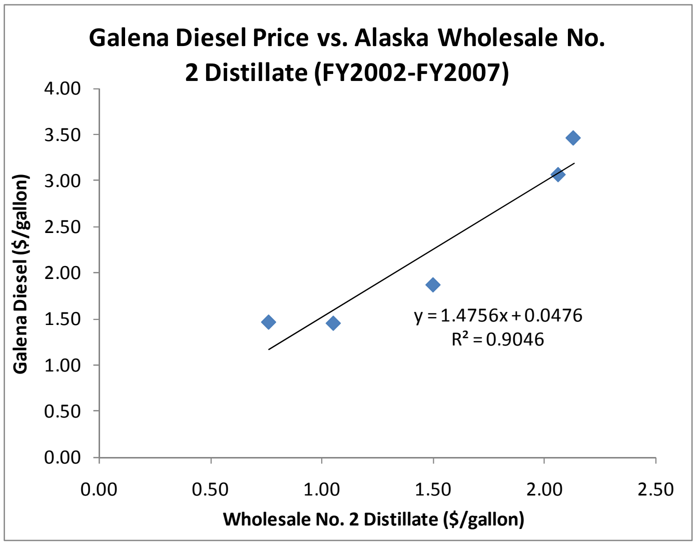
When Alaska wholesale No. 2 distillate is$2.61/gallon, Ouzinkie diesel is $3.26/gallon.
Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
ISER: Alaska Fuel Price Projections 2011-2030, Accompanying Workbook:
http://www.iser.uaa.alaska.edu/Publications/oil_price_projection_aea01_2011_v1.xlsx



When Alaska wholesale No. 2 distillate is$2.61/gallon, Tanana diesel is $3.28/gallon.
Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
ISER: Alaska Fuel Price Projections 2011-2030, Accompanying Workbook:
http://www.iser.uaa.alaska.edu/Publications/oil_price_projection_aea01_2011_v1.xlsx



When Alaska wholesale No. 2 distillate is$2.61/gallon, Fort Yukon diesel is $3.49/gallon.
Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
ISER: Alaska Fuel Price Projections 2011-2030, Accompanying Workbook:
http://www.iser.uaa.alaska.edu/Publications/oil_price_projection_aea01_2011_v1.xlsx



When Alaska wholesale No. 2 distillate is$2.61/gallon, Ouzinkie diesel is $3.90/gallon.

Sources: EIA: Monthly Alaska No. 2 Distillate Wholesale/Resale Price by Refiners:
http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PWG_SAK_DPG&f=M
ISER: Alaska Fuel Price Projections 2011-2030, Accompanying Workbook:
http://www.iser.uaa.alaska.edu/Publications/oil_price_projection_aea01_2011_v1.xlsx

APPENDIX C. HOUSING UNITS USING HEATING OIL, AVERAGE HEATING DEGREE DAYS (HDDs), AND HEATING OIL CONSUMPTION ADJUSTMENT FACTORS BY BOROUGH

Borough	Housing Units Using Heating Oil*	Average Heating Degree Days**	Heating Oil Consumption Adjustment Factor***
Aleutians East	483	9,733	0.85
Aleutians West	972	9,733	0.85
Anchorage	939	10,570	0.92
Bethel	3,700	13,098	1.14
Bristol Bay	463	11,456	1.00
Denali	563	12,773	1.11
Dillingham	1,422	12,277	1.07
Fairbanks North Star	22,851	13,940	1.21
Haines	706	9,191	0.80
Juneau	8,131	8,897	0.77
Kenai Peninsula	6,525	10,054	0.87
Ketchikan Gateway	4,145	6,987	0.61
Kodiak Island	3,819	8,817	0.77
Lake and Peninsula	527	11,456	1.00
Matanuska-Susitna	4,971	11,606	1.01
Nome	2,481	14,129	1.23
North Slope	749	20,226	1.76
Northwest Arctic	1,583	15,812	1.37
Prince of Wales-Outer Ketchikan	1,420	7,942	0.69
Sitka City	2,392	7,942	0.69
Skagway-Hoonah-Angoon	1,050	9,191	0.80
Southeast Fairbanks	1,386	13,535	1.18
Valdez-Cordova	3,004	9,953	0.86
Wade Hampton	1,453	13,795	1.20
Wrangell-Petersburg	2,152	7,942	0.69
Yakutat	242	9,485	0.82
Yukon-Koyukuk	1,300	14,790	1.28
Total Alaska Housing Units Using Heating Oil	**79,429**		
Alaska Avg. HDDs (Arithmetic)		**11,309**	
Alaska Avg. HDDs Weighted by Housing Units Using Heating Oil		**11,511**	

*Fuel oil, kerosene, etc.
**Measured at 65 degrees F
***This factor is used to estimate each borough's heating oil consumption per housing unit relative to the Alaska average. This measure is calculated by taking the average heating degree days for each borough and dividing it by the Alaska average HDDs weighted by housing units using heating oil (11,511).

Sources:
U.S. Census Bureau, 2000: http://censtats.census.gov/cgi-bin/pct/pctProfile.pl
Climate Zone: http://www.climate-zone.com/climate/united-states/alaska/
Western Regional Climate Center: http://www.wrcc.dri.edu/summary/Climsmak.html