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Alaska Center for Energy and Power

Fostering development of innovative solutions to Alaska's energy challenges.

Research Briefing

Economic Analysis of Propane Distribution to Rural Communities in Interior Alaska

A full report, *Economic Analysis of Propane Distribution to Rural Communities in Interior Alaska*, can be found online at www.uaf.edu/acep.

Project Overview

The high price of home heating oil has put tremendous economic pressure on residents in rural Alaska. As a result, much attention has been paid to finding alternatives to heating oil. One proposed alternative involves the distribution of propane to rural communities from developed Alaska North Slope gas supplies. From preliminary findings in this report, it appears that without significant government support substantial savings are not available due largely to the costs of the existing diesel fuel system, high cost of converting to propane technology, lack of infrastructure to support shipping large quantities, relatively heavier shipping containers of propane and added labor needs of handling propane.

There does appear to be some potential for the household use of propane when oil prices are high. Most savings that do exist come from comparing a nonprofit, subsidized propane delivery system against a for-profit diesel fuel operation.

This report presents two mechanisms that may result in cost savings. First is an efficiency gain from combined heat and power units and second is a conversion from electrical to propane appliances. These savings assume public investment and may disappear, however, in an unregulated, noncompetitive, for-profit market.

Project Background

This report looks at three rural communities in Interior Alaska to determine whether supplying propane can reduce the financial burden of heat and electricity on residents. The use of diesel fuel for heat and electrical generation is prevalent throughout rural Alaska due to the lack of access to the electricity grid and the absence of significant alterna-

Propane tanks in Ugashik. Propane has been used in rural Alaska since before statehood. The typical rural user purchases propane in small containers holding 20 or 100 pounds (5 or 24 gallons).Photo from the Alaska Division of Community and Regional Affairs, http://www.commerce.state.ak.us/dca/photos

If propane were to be used in larger scale for electrical generation or home heating, large tanks would be needed and additional infrastructure would be required to manage the movement of the tanks or the gas.

tive energy sources. A central power generation unit exists in each community. The cost of diesel fuel used to generate power and the infrastructure maintenance costs are relatively high, while the number of consumers being serviced is small. Between the high marginal input costs and high average fixed costs, the people living in these communities face some of the highest electricity rates in the United States.

Propane has been used in rural Alaska since before statehood. The typical rural user purchases propane in small containers holding 20 or 100 pounds (5 or 24 gallons). Historically this propane use has been small and mainly for cooking, heating water or drying clothes. In addition to these uses, propane has long been discussed as a potential energy alternative to diesel fuel for home heating and electrical generation. The recent rise in the cost of diesel fuel in rural communities has prompted many studies on the feasibility of using propane in increased quantities for these uses. These studies have had mixed results in terms of the potential savings and market forces have not presented propane as an option on its own.

The communities evaluated in this report are Tanana, Galena and Holy Cross — all Yukon River villages in the Doyon region. Waterway delivery systems have proven to be the least costly for off-road systems over the history of Alaska. Therefore, communities without reliable river/barge access (e.g., Nikolai, Birch Creek) have higher costs than those studied in this report. If savings are not possible in river communities, it can be inferred that the same is true for off-river communities. Communities on the road system already have access to larger quantities of propane and lower costs of heating oil. Therefore, fuel switching is already available if deemed economic. Finally, Kuskokwim River communities such as McGrath are served by a propane distribution system in Bethel that receives its propane from ocean barges. North Slope gas that must traverse the length of the state before reaching the ocean will not compete with the price available. Therefore, the most likely market for North Slope gas would be Fairbanks, road-accessible communities and possibly Yukon River communities. The latter is the focus of this investigation.

This report evaluates the relative costs of providing diesel fuel and propane to the rural community to see if potential savings exist at the margin. Where those results are positive the report evaluates the potential and volume required in order to overcome the conversion costs. Finally, the relative prices at which conversion is economic can be determined.

Considering the costs associated with the current delivery of 100-pound bottles, it is believed that economies of scale can reduce cost if larger shipping and storage containers are used. In order to account for these savings, this report will express results at three volume levels: (1) the current supply system of 100-pound bottles (24 gallons), (2) a 1,000-gallon container, which is believed to be the largest container that can be delivered with the current docking system available, and (3) a 20-foot international shipping container (ISO 20), which holds approximately 5,000 gallons of propane when filled to specified fill limits and pressure. The latter would require docking upgrades that are not accounted for in this report since those upgrade costs would be spread beyond the use for propane delivery or would be subsidized and not added to the cost of propane. However, this shipping method is not available without such upgrade.

Propane vs. Home Heating Fuel

In a comparison between home heating fuel and propane, the respective costs can be evaluated at each stage of the supply chain to assess where savings may exist. This report evaluates the added cost associated with each link in the supply chain, first at the margin and then in full. The supply chain for either fuel is as follows: (a) commodity price, (b) processing cost, (c) transportation cost and (d) delivery and storage costs.

To compare propane and heating fuel energy content, not volume, must be used since a gallon (or any such unit) of one is not equal to a gallon of the other. To get a true comparison, they must be converted to a common measure in terms of energy content. The conversion from gallons to MMBtu allows an easy comparison of relative prices in order to realize a savings. The ratio 7.22/10.91 = 0.66178 implies that in order for savings to exist, the ratio of prices must also follow this ratio at the point of purchase. Therefore, the gallon price of propane must be 66 percent of the gallon price of diesel for the products to be equal in true price. To avoid this confusion, all prices are converted to dollars per MMBtu for comparison. For simplification, the relative efficiency for utilizing each fuel is assumed to be equal so that the same number of MMBtus is required for either fuel.

Propane characteristics

Propane is considered a natural gas liquid (NGL), which is a group of lightweight hydrocarbons of fewer than six carbon atoms per molecule. Propane is the combination of three carbon and eight hydrogen atoms (C3H8); it holds the energy potential of about 92,000 Btus per gallon of volume under compression and weighs about 4.11 pounds. When propane is produced, it must be separated from the rest of the hydrocarbon mix found underground through a process of first separating carbon dioxide, water and other unwanted components from the gas, then separating the NGLs from the methane, and finally cooling the gas package past the liquefaction point of each hydrocarbon in turn to separate the gas components. It is then held under pressure in special containers for storage, transportation and delivery.

The shipping process to rural communities is more labor-intensive for propane than diesel fuel as the gas must be transferred into pressurized containers that must be loaded onto a barge and off-loaded at the village. These tanks also tend to be heavier in order to maintain integrity under the additional pressure. Once at the delivery point, infrastructure must be in place to off-load the tanks, which may act as the storage facility, or the propane may then be transferred from the containers to a storage tank. It is typical for individual residents to purchase 100-pound tanks of propane (about 24 gallons) for individual household use. If propane were to be used in larger scale for electrical generation or home heating, large tanks would be needed and additional infrastructure would be required to manage the movement of the tanks or the gas.

	Heating Oil	Propane
Pounds per gallon	7.15	4.23
Btus per gallon	138,500	91,690
Gallons per MMBtu	7.22	10.91
Pounds per MMBtu	51.62	46.13

Table 1: Comparison of fuel characteristics

Findings

Barge companies charge shipping costs based on the weight and dimensions of the freight being moved. For this reason, the relative weight of propane versus diesel fuel is important in the comparison of price. As noted in Table 1, propane has a lower weight and a lower Btu count per gallon. The two fuels can be compared on a common basis by converting each to weight per MMBtu. Doing so demonstrates that propane is indeed lighter weight, but by less than first appears. While a gallon of propane is 57 percent the weight of a gallon of diesel, the MMBtu comparison is 89 percent. Although savings on the raw commodity weight still exist, the heavier container consumes those savings very quickly.

Table 2 estimates round-trip cost of moving each of the three empty propane containers to three Yukon River communities:

	100-pound bottle (24 gallons)	1,000-gallon container	5,000-gallon container
Tanana	$13.48	$346.68	$1,348.20
Galena	$15.90	$408.78	$1,589.70
Holy Cross	$26.83	$689.85	$2,682.75

Table 2: Estimated transportation costs of empty shipping containers

Table 3 shows the added one-way cost of shipping the propane and expressing the prices in MMBtu.

	100-pound bottle (24 gallons)	1,000-gallon container	5,000-gallon container
Tanana	$11.89	$9.54	$8.70
Galena	$14.02	$11.25	$10.26
Holy Cross	$23.65	$18.98	$17.31

Table 3: Added cost of transportation via barge per MMBtu

Tables 2 and 3 show the cost of transportation from Nenana, a barge station 55 road miles south of Fairbanks, to each of the communities, which must be added to the cost of the fuel purchased at Nenana. Table 4 shows the added cost of transportation for home heating fuel.

Tanana	$6.65
Galena	$7.84
Holy Cross	$13.23

Table 4: Added cost of diesel between Nenana and destination per MMBtu

This amount can be used as a mean estimate of cost above price at Nenana, but the actual additional cost will vary from this amount due to many factors. For example, this does not include the capital or shipping cost of the shipping container because the shipper typically owns that capital. The shipper may also receive wholesale prices for bulk purchases, which clouds the actual amount of added costs, and no additional markup has been accounted for by a retailer. Finally, the market price paid depends on when the purchase was made as well as the amount of relief provided by tribal, city or state subsidies.

These added shipping costs illustrate the intuitive fact that the cost of energy will always be higher in the delivered area than the area it is delivered from. In the case of rural communities where that delivery is difficult, dangerous, and intensive, that price difference will be high. Therefore, the goal of "cheap energy" is not possible if the energy source is delivered, but the goal of "cheaper energy" is more realistic.

By assuming that the transportation costs are as developed above, it is possible to revise the relative prices to reflect the required price difference at Nenana to obtain the 66 percent ratio at the point of use established earlier. The following establishes the minimum cost that propane could be delivered to Nenana, assuming that all capital costs are paid by outside agents and the price of propane simply reflects the operating costs on the system. Those capital costs will then be added back in to show the true cost.

The wellhead price of propane has been estimated by Alaska Department of Natural Resources at $0.045 per MMBtu for every dollar per barrel of crude oil. At $100 per barrel, approximately $4.50 is added per MMBtu. This raw gas must then be processed. Based on studies from the Institute of Social and Economic Research, the cost of operating a propane processing plant on the North Slope or at a gas pipeline takeoff point is estimated at $16,220,000 per year to produce 30,660,000 gallons per year (2,810,266 MMBtu). This adds a cost of $5.77 per MMBtu for operations and maintenance of the plant.

In addition, a delivery system to Nenana must be operated. In the case of North Slope production, that system is a fleet of 10 tanker trucks each carrying 8,400 gallons (770 MMBtu) per day, or 3,066,000 gallons (281,027 MMBtu) per year. The operation of this fleet includes includes the cost of diesel fuel, which adds approximately $0.0116 for every dollar of a barrel of crude oil to each MMBtu. Additional costs include maintenance, insurance, drivers' salaries and handling costs of transferring the propane from the truck to smaller containers for barge shipment. These costs are estimated at about $180,000 per truck per year ($0.64 per MMBtu). Combined, these costs add $6.41 + $0.0566x to the cost of propane, where x is the barrel price of crude oil.

According to the estimates of plant construction costs, a processing plant that could generate 2.8 million MMBtus per year would cost $74,090,000. At a 6 percent interest rate and a 25-year payback period, the annual cost of the construction would be $5.8 million. The tanker trucks required to move the propane cost about $500,000 each (Amerigas, 2011). Therefore, the size of government subsidy required to limit the cost to the scenario above would be approximately $80,000,000 to build a processing plant and to purchase the trucks required. This also leaves an additional funding requirement for new trucks as the original equipment reaches the end of its useful life, which is not being paid for by the system as presented. If instead, the project had to find its own funding at an assumed 6 percent interest rate, it would add approximately $2.48 per MMBtu and be self-sustaining, with no profit.

The final and underappreciated cost in the equation is the cost of the storage tank. For example, the $140 spent on a 100-pound tank for propane is not likely considered in the cost of propane because it is spent upfront and then ignored. In reality, that cost should be spread over the quantity of propane that it stores and, because it can only be filled once or maybe twice per year, that quantity is fairly small. If the tank lasts 10 years and is filled once per year, it adds a true cost of $6.36 per MMBtu without discounting. Larger tanks provide marginal savings but add the additional complication of moving the tanks or the gas between them.

Conclusions

In total, the marginal costs associated with shipping propane to these communities amount to the following, without any profits for the processing plant or the delivery to Nenana. This can be viewed as the absolute minimum cost of propane in the community, if all capital is subsidized, before the cost of the raw gas itself.

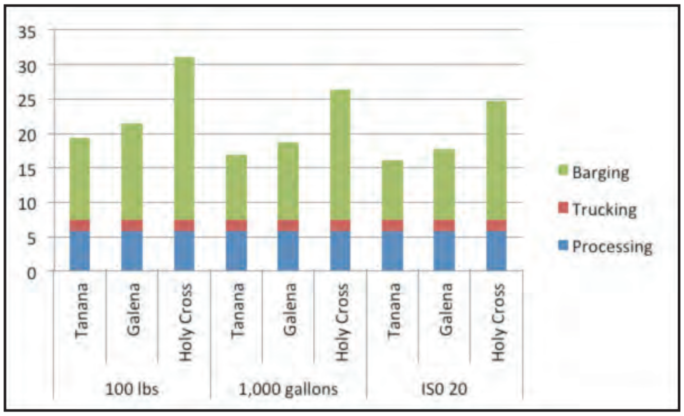

Figure 1: Lowest possible price per MMBtu

Using the established absolute low price of propane above and adding the commodity price of the gas at various crude oil prices, it appears that savings potential begin to emerge at the following trigger prices of crude oil.

	100-pound bottle (24 gallons)	1,000-gallon container	5,000-gallon container
Tanana	$58.25	$46.51	$42.31
Galena	$62.94	$49.11	$44.15
Holy Cross	$84.18	$60.83	$52.47

Table 5: Barrel price of crude oil where potential savings begin

The following graphs depict how the prices of heating oil and propane compare at various prices of crude oil. The intersection points are the numbers listed in table 5.

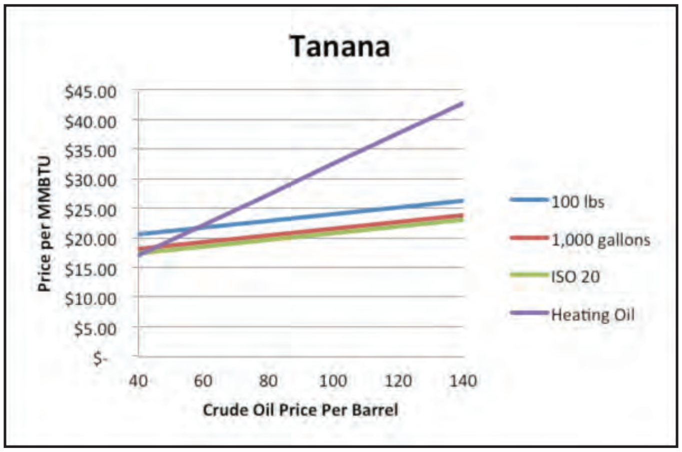

Figure 2: Relative prices of each fuel in Tanana at various crude oil prices

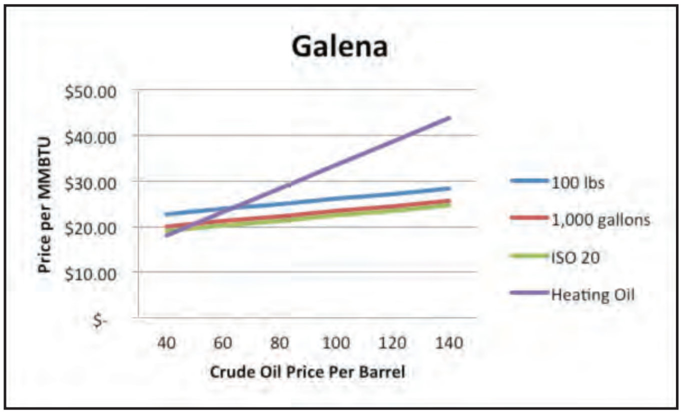

Figure 3: Relative prices of each fuel in Galena at various crude oil prices

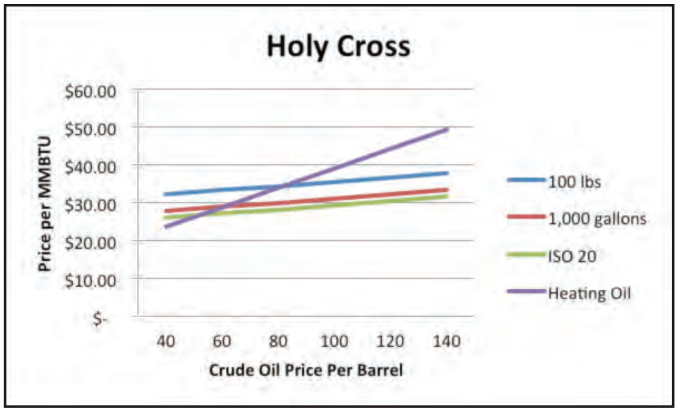

Figure 4: Relative prices of each fuel in Holy Cross at various crude oil prices

Potential savings emerge at the above prices because up-front capital costs are not being paid for by the unit sales, but rather by government subsidies. No profit is being garnered off of the processing or delivery of the propane, and the trucks are assumed to be owned and operated by a nonprofit agency with no capital cost being recovered. In effect, the delivered price is being bought down with up-front capital investment. By relaxing those assumptions, the trigger price rises considerably. If those additional capital costs were paid on a per unit basis, the real trigger point for propane providing possible saving increases significantly.

	100-pound bottle (24 gallons)	1,000-gallon container	5,000-gallon container
Tanana	$102.45	$95.97	$84.36
Galena	$107.14	$98.56	$86.20
Holy Cross	$128.38	$110.29	$94.52

Table 6: Trigger price of crude oil when all costs are paid

Under these assumptions, propane provides no savings at crude prices less than $102.45 per barrel using current delivery methods. The price of energy at these levels is still quite high and the actual savings to the consumer is dependent on the assumption that a nonprofit agency is operating the delivery system. If that assumption were also impressed upon the heating fuel system, these savings would not exist. The one advantage that propane does have over heating oil is a reduced variability in price.

Implications

The potential for true savings from propane depends on the use of the gas and the costs of conversion, assuming that the efficiency of each fuel is equal. In reality, diesel fuel is typically more efficient in its ability to convert feedstock into electrical generation than propane at the levels of electricity being generated in rural communities. If that assumption holds true, more Btus of energy would be needed when converting to propane, which drives the trigger price much higher. Additionally, the conversion cost itself must be covered. Therefore, fuel switching is most attractive whenever the existing capital is in need of replacement. Given the state of current investment, the conversion costs and the efficiency uncertainty, it is not believed that savings exist by using propane to generate electricity in rural communities.

Another potential use for propane is to replace the use of home heating fuel for space heating. Propane has the potential for slightly higher efficiency ratings than heating oil due to lower levels of impurities that must be expelled as exhaust. However, a distribution system to deliver the quantity of gas required for a winter's worth of fuel is lacking. If propane is to be used in such a large quantity, tank farms, distribution systems and docking facilities are needed. These costs add a financial burden in changing from the established system, which implies that a higher level of savings is required to make the change viable. The actual costs of conversion were beyond the scope of this report.

The final use for propane is to operate household appliances. In this case, propane use would displace electricity, which is converted from diesel fuel, but does not displace diesel fuel directly. Given the extremely high cost of electrical generation, propane appears to provide savings at all crude prices, given the delivered cost assumptions. This explains the current demand for propane in rural villages and indicates that household use might hold the best potential under any delivery system. This demand also explains why the price of propane currently delivered is much higher than this report shows, as suppliers capture some of those potential savings.

Summary

Market forces and physical realities limit the potential of propane to reduce energy costs in rural Alaska. While this report demonstrates that potential savings may be available in the absolute best-case scenarios, those saving are only available if public incentives are available. A cost-benefit analysis is likely to show that true savings do not exist because the capital costs associated with diesel fuel are already paid while conversion costs would be high. In order for savings to truly exist, extremely high and sustained costs of heating oil relative to propane would be required and nonmarket forces would likely have to intervene. Even at current prices, an extremely high up-front cost is required to achieve fairly minor and uncertain savings.

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This report was prepared as part of a rural energy partnership between ACEP and Tanana Chiefs Conference, a nonprofit consortium of forty-two Alaska Native tribes in the Interior region of the state.

Since 1971, TCC has provided a unified voice to advance tribal governments, economic and social development, promote education and physical and mental wellness, and protect language and traditional and cultural values. The partnership with ACEP, in place since 2009, matches the service mission of TCC with the technical expertise of ACEP to educate and assist tribal members in energy planning and develop sustainable energy systems that lower cost and meet community goals.

The three communities in this study — Tanana, Galena and Holy Cross — were selected from the TCC region as being representative of the size and geographical distribution of communities in the Interior. Other hub communities, such as Fort Yukon, McGrath and Tok (on the road system), would experience different economic scenarios as those in this study. Rural communities in other parts of the state, especially coastal villages with year-round barge access, would similarly be subject to different economic and environmental factors regarding the use and delivery of propane. This study was undertaken as a first look at the economic conditions of propane delivery in the Interior only.

For more information about TCC, please go to: www.tananachiefs.org

For more information about ACEP, please go to: www.uaf.edu/acep

The Tanana Chiefs. The photo was taken during the land meetings with Territorial Judge James Wickersham in 1916. Photo courtesy of the University of Alaska Fairbanks, Charles Bunnell Collection

For further information on this report, please visit www.uaf.edu/acep, or contact:

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