COLD CLIMATE HOUSING RESEARCH CENTER

CCHRC

Preliminary Economic Analyses of Several Options for Delivering Natural Gas from a Local CNG Hub to Households in the Fairbanks North Star Borough

IR 2009-01: Final Report for FNSB Contract 902997 On Compressed Natural Gas

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Abstract

The cost of energy in Fairbanks is a critical issue for many residents and businesses and for the economy of Interior Alaska as a whole. There have been many proposals advanced to provide lower cost fuel to Fairbanks including natural gas, biofuels, hydropower, and coal. Each of these proposals has drawbacks such as cost of construction, expected price, environmental impacts, and estimated delivery date. This report examines capital and operational costs and expected retail prices for several different options for delivering natural gas to Fairbanks homes from a local compressed natural gas (CNG) distribution hub. The evaluation of these options is done at a fairly preliminary level and is suitable for selecting options for further study. From this preliminary evaluation, several of these delivery options appear advantageous both from the perspective of the consumer and the distributor and are worthy of further examination.

Executive Summary

The Cold Climate Housing Research Center (CCHRC) was contracted by the Fairbanks North Star Borough (FNSB) to perform a preliminary economic evaluation of three options for delivering natural gas to Fairbanks homes from a local compressed natural gas (CNG) hub. For this evaluation, it is assumed that CNG is available at the local hub at a price per BTU that is significantly below the current equivalent price for fuel oil. The main deliverables are estimated profitability for the distributor and price to the consumer for each option evaluated. Additionally, as the work progressed CCHRC was tasked with evaluation each of the options under a nonprofit model and also to compare the result to the price of propane; in this case the deliverables are just the price to the homeowner for each option. Again, while these evaluations are based on our best efforts to determine the basic costs for each option, they are very preliminary in nature and are solely intended to see if some of the options are promising enough to warrant further consideration.

This report evaluates several options for distributing natural gas to homes across the Fairbanks North Star Borough in terms of the wholesale price of the CNG at the main hub, capital costs of required infrastructure, and operational costs of the delivery system. Three basic scenarios are considered: (1) truck delivery of CNG direct from the main hub to homes, (2) truck delivery of CNG to a neighborhood hub and distribution pipeline delivery from that hub to individual homes, and (3) direct pipeline distribution of natural gas from the main hub to homes.

<u>Scenario 1: Residential Home Delivery</u> - Under this scenario, it is assumed that each household will acquire a CNG storage tank through the necessary permitting process and convert their heating system to natural gas. The total capital cost to the household would be approximately $37,200. CNG would then be delivered to the homes via GTM (gas transport module) transport trucks.

<u>Scenario 2a: Neighborhood Hub (all major capital expenses by distributor)</u> - Under this scenario, it is assumed that each household will convert their heating system to

natural gas. This is a total capital cost to the household of approximately $1,750. Natural gas would be delivered to the homes via an installed system of natural gas lines connected to a neighborhood hub. CNG would be trucked to the neighborhood hub from the main hub. In the methodology section below, we also considered a variant of this scenario, 2b, in which the capital expenses of the hub and local distribution lines are borne by a neighborhood association.

Scenario 3: Main Line to Neighborhoods - Under this scenario, it is assumed that each household will convert their heating system to natural gas. This is a total capital cost to the household of approximately $1,750. Natural gas would be delivered directly to the homes via natural gas lines from the main hub.

In the methodology sections below, we also considered a combination of Scenarios 2a and 3, (Scenario 4) in which the local hub is only operated until a direct line can be laid from the main hub to the neighborhood hub.

Further, each of these scenarios has been evaluated under two different economic models. The first model assumes a for-profit entity operating the distribution system and the second assumes a not-for-profit entity. In the first case (for-profit), the scenarios are evaluated from the perspective of both the consumer and the distributor; in the second case the evaluation metric is just the price to the consumer assuming that no profit is needed and a certain wholesale price is obtainable.

The principal results for the two models under each of the three main scenarios are shown in Table 1 below:

Table 1. Main Results for Models One and Two

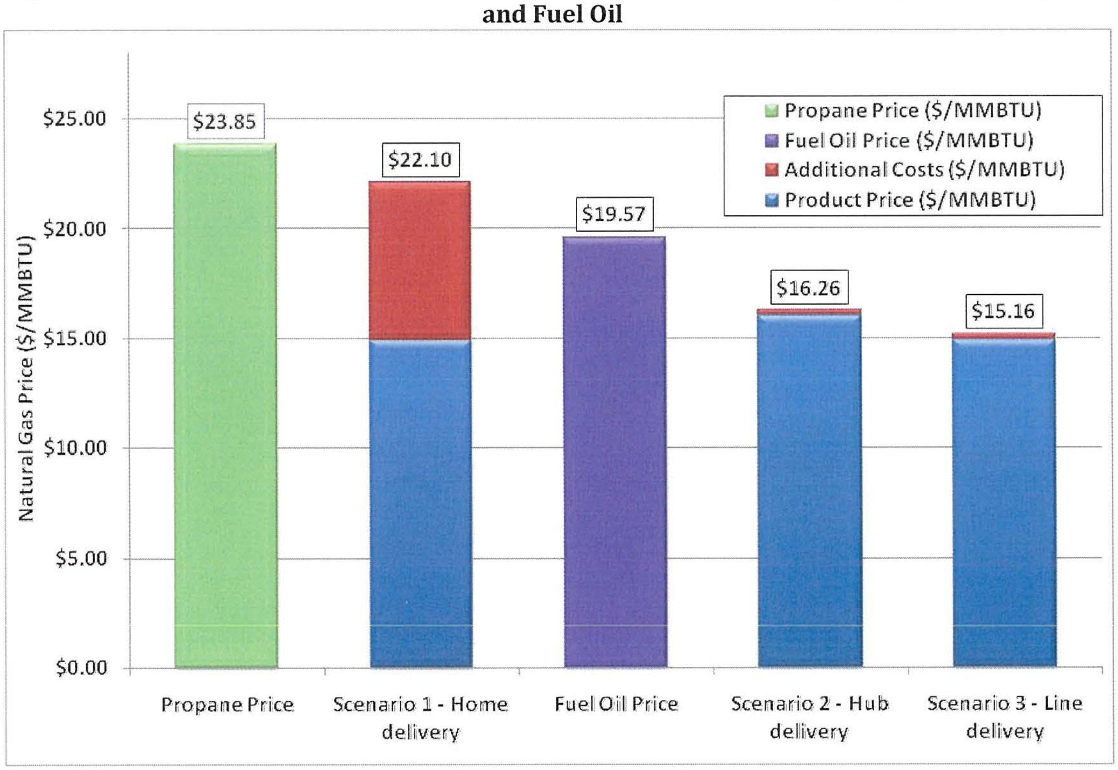
Model One (for profit)	**Scenario 1** (home delivery)		**Scenario 2a** (hub delivery)		**Scenario 3** (line delivery)	
	Household	**Distributor**	**Household**	**Distributor**	**Household**	**Distributor**
Fuel cost savings per MMBTU (% Reduction)	**Payback (in years)**	**IRR**	**Payback (in years)**	**IRR**	**Payback (in years)**	**IRR**
@ No Reduction	--	196%	--	31%	--	44%
@ 5% Reduction	--	169%	6.46	26%	6.46	39%
@ 10% Reduction	403.96	142%	3.23	20%	3.23	33%
@ 15% Reduction	102.44	115%	2.15	15%	2.15	28%
@ 20% Reduction	58.66	88%	1.61	9%	1.61	22%
@ 25% Reduction	41.09	60%	1.29	2%	1.29	17%
@ 30% Reduction	31.63	33%	1.08	< 0%	1.08	11%

Model Two (non-profit)	Scenario 1 (home delivery)	Scenario 2 (hub delivery)	Scenario 3 (line delivery)
	Dollars/MMBTU	**Dollars/MMBTU**	**Dollars/MMBTU**
	$22.10	$16.26	$15.16

For Model One, Scenarios 2 and 3 have solutions that work for both the consumer and the distributor. For example, consider the 15% price reduction case - for the consumer there is a pay-back period of just over two years in each scenario and an internal rate of return for the distributor of 15% and 28%, respectively. These are attractive enough economics from both perspectives that further consideration of either Scenario 2 or 3 is warranted.

For Model Two, again both Scenario 2 and 3 have retail prices that work for the consumer and pencil out for a not-for-profit. A price in the range of $15.16 to $16.26 per million BTUs is about a 20 percent reduction compared to the current fuel-oil-equivalent price of $19.57/MMBTU. These prices are compared in Figure One.

Figure One. Retail Prices for each Scenario under Model Two (not-for-profit) versus Propane and Fuel Oil



In no case, for either model, does Scenario 1 (CNG home delivery) have a solution that works for both the consumer and distributor.

Methodology and Results

Three basic scenarios (and some sub-scenarios) are considered: (1) truck delivery direct from the main hub to homes, (2) truck delivery to a neighborhood hub and distribution pipeline delivery from that hub to individual homes, and (3) direct pipeline distribution from the main hub to homes. Further, each of these main scenarios has been evaluated under two different economic models. The first model assumes a for-profit entity operating the distribution system and the second assumes a not-for-profit entity. In the first case (for-profit), the scenarios are evaluated from the perspective of both the consumer and the distributor; in the second case the evaluation metric is just the retail price to the consumer assuming that no profit is needed and a certain wholesale price is obtainable.

Throughout the methodology section there are a number of formulas. These formulas are not direct copies of those used in the spreadsheet model, but present the pieces of information used in various calculations in a generalized format.

Model One

Each scenario was evaluated from two perspectives, the consumer (or household), and the distributor. Costs were divided up into household or distributor costs, and also into annual operations and maintenance (O&M) or capital costs. From the household perspective, total capital costs are divided by net savings per year to determine a simple payback period. From the distributor perspective, costs are used with revenues to calculate an internal rate of return (IRR).

Household Perspective - Savings from a reduced price ($/MMBTU) for natural gas vs. fuel oil, capital and operating costs for the household are used to calculate simple payback.

Formula 1. Simple payback = (Total capital costs)/(Annual savings + Annual operating costs)

Where,

Total capital costs vary by scenario.

Annual operating costs vary by scenario.

Annual savings are derived from the "Price" in $/MMBTU.

Distributor Perspective - From the distributor's perspective, an internal rate of return calculation is done. For all scenarios, we used a period of 30 years.

Formula 2. IRR is determined by $\sum_{n=0}^{N} [C_n / (1+r)^n] = 0$ solved for r.

Where,

C_0 = Capital costs (vary by scenario).

C_1 to C_n = Operating costs (vary by scenario) + Annual revenues.

N = 30 years.

Annual revenues are derived from the "Price" in $/MMBTU.

The calculation in Formula 2 is simplified with Excel® and the use of its function, "IRR".

The results of these calculations are compared at several different prices for fuel. The base-line price uses the assumption that the price for natural gas is the same per million BTUs (MMBTU) as fuel oil. The price used in the model is $19.57. This price is derived from a price for fuel oil of $2.71/gallon (http://www.commerce.state.ak.us/dca/pub/Fuel_Report_July_2009_web.pdf, accessed 9/21/09), and assuming 138,500 BTU/gal for #2 fuel oil. To establish the effect of change in price on a scenario, the price for natural gas is reduced by 5% increments to a maximum reduction of 30%. Each reduction has an effect on household savings and distributor revenue that is calculated and used in either the simple payback for the household perspective (Formula 1 above), or the internal rate of return for the distributor's perspective (Formula 2 above).

Basic Assumptions for Model One:

The following are basic assumptions and inputs used in one or more of the scenarios in Model One. There are some assumptions and inputs that are specific to a single scenario. These are directly addressed in the discussion of that scenario.

1. Fuel oil is assumed to have 138,500 BTUs per gallon.
2. One CCF is 100 standard cubic feet (SCF) of natural gas.
3. One MCF is 1,000 SCF of natural gas.
4. One MMBTU is 1,000,000 BTUs.
5. Natural gas is assumed to have 101,500 BTUs per CCF.
6. "Home energy use" is assumed to be 2,000 gallons of fuel oil.
7. "Rural area household (HH) density" is assumed to be 300 HH/mi^2. This is an approximation of RE2.
8. "Delivery area" is assumed to be in square mile blocks.
9. "Residential NG need" is the number of SCF of NG that is equal to the (Home energy use) x (Rural area household density) x (Delivery area).
10. "Price" is in $/MMBTU. The price used in the model is $19.57, which is the $/MMBTU of fuel oil at $2.71/gallon (http://www.commerce.state.ak.us/dca/pub/Fuel_Report_July_2009_web.pdf, accessed 9/21/09)). Fairbanks Natural Gas' (FNG) rate is currently $2.335/CCF or $23.00/MMBTU. (http://www.fngas.com/calculate.html, accessed 9/21/09).
11. The "Mark-up factor" is assumed to be 100%. The retail price is the wholesale price multiplied by one plus the mark-up factor.
12. The cost of natural gas for the distributor is assumed to be the "Price" / (1 + "Mark-up factor").
13. The "Home heating system conversion cost" is assumed to be $1,500. This price was quoted to John Davies to convert his boiler to natural gas in personal communication.
14. "Compressor capital cost" is an estimate from GTM Manufacturing, LLC (Wednesday, 9/23/09). It agrees with and estimate derived from a smaller

unit (50.4 SCFM, $39,500) and that was assumed to scale linearly. (http://www.usedcompressors.ca/used_equipment.php?eID=100, accessed 9/18/09).

15. "Compressor annual maintenance" is assumed to be 2.5% of the compressor's capital cost ($/unit).
16. "Transport cost, distributor ($/day)" represents the cost of employing drivers to distribute natural gas, either to neighborhood hubs, or through residential delivery. This is currently at 2 FTE per square mile block of service area.
17. "Transport cost, household (Residential delivery)" is the surcharge added to a HH's bill for home delivery of fuel. This is assumed to be $50.
18. "Transport (deliveries/year)" is the number of deliveries necessary in one year. This is derived from the size of the home tank and the modeled number of BTUs for "Home Energy Use".
19. "GTM (trailer and one; 50,000#), cost" represents a single gas transport module (GTM) mounted on a trailer and fully charged. Weight is not used in the calculation. This cost is a quote from phone communication with Brian Kelley at the selling company, GTM Manufacturing, LLC on Thursday, 9/17/09.
20. "GTM (trailer and one; 50,000#), number" indicates the number of GTMs needed to meet the residential NG need for the serviced area. This cost is a quote from phone communication with Brian Kelley at the selling company, GTM Manufacturing, LLC on Thursday, 9/17/09.
21. "Neighborhood lines installation costs" are the cost ($/trench-foot) to install the natural gas lines. Costs are rough estimates from FNG through personal communication on Wednesday, 9/16/09.
22. "Line annual maintenance" is assumed to be 10% of the lines' installations costs.
23. "Neighborhood lines lengths" are rough generic estimates of the number of trench-feet of each type of pipe needed. They assume one mile of main line (4") per square mile, eight miles of distribution line (3") per square mile, and one 100-ft service line per household per square mile.
24. "Residential meter, regulator, valve, and riser". A set of these components is needed per household. The cost estimate was obtained from FNG through personal communication on Wednesday, 9/16/09.

<u>Scenario 1: Residential Home Delivery</u> - Under this scenario, it is assumed that each household will acquire a CNG storage tank through the necessary permitting process and convert their heating system to natural gas. The total capital cost to the household would be approximately $37,200. CNG would then be delivered to the homes via GTM (gas transport module) transport trucks.

The following are used in the simple payback for the household perspective (formula 1 above):

Formula 3. Capital costs = Residential tank + Residential permitting + Residential meter & regulator + Home heating system conversion cost.

Formula 4. Operating costs = Annual transportation surcharge.

Formula 5. Annual savings = Price reduction percent * "Price" in $/MMBTU * Amount of natural gas needed in MMBTU.

For Scenario 1, Table 2 indicates the simple payback period (years) assuming various natural gas prices as a percentage below the fuel oil equivalent price of $19.57/MMBTU.

Table 2. Simple payback period – Scenario 1

Household Perspective	Savings	Operating Costs	Capital Costs	Payback (in years)
@ No Reduction	--	$450	$37,200	--
@ 5% Reduction	$271	$450	$37,200	--
@ 10% Reduction	$542	$450	$37,200	**403.96**
@ 15% Reduction	$813	$450	$37,200	**102.44**
@ 20% Reduction	$1,084	$450	$37,200	**58.66**
@ 25% Reduction	$1,355	$450	$37,200	**41.09**
@ 30% Reduction	$1,626	$450	$37,200	**31.63**

The following are used in the internal rate of return (IRR) formula for the distributor's perspective (Formula 2 above):

Formula 6. Capital costs = Compressor cost + GTM Trailers cost

Formula 7. Annual operating costs = Cost of bringing natural gas to Fairbanks + Compressor annual maintenance + Use, maintenance & salary for GTM deliveries to residences.

Formula 8. Annual revenue = ("Price" in $/MMBTU) * (MMBTU of natural gas needed)

For Scenario 1, Table 3 indicates the internal rate of return assuming various natural gas prices as a percentage below the fuel oil equivalent price ($/MMBTU) of $19.57.

Table 3. IRR Scenario 1

Distributor Perspective	Total Revenue	Operating Costs	Capital Costs	IRR
@ No Reduction	$4,806,700	$3,070,100	$885,000	**196%**
@ 5% Reduction	$4,566,365	$3,070,100	$885,000	**169%**
@ 10% Reduction	$4,326,030	$3,070,100	$885,000	**142%**
@ 15% Reduction	$4,085,695	$3,070,100	$885,000	**115%**
@ 20% Reduction	$3,845,360	$3,070,100	$885,000	**88%**
@ 25% Reduction	$3,605,025	$3,070,100	$885,000	**60%**
@ 30% Reduction	$3,364,690	$3,070,100	$885,000	**33%**

Scenario 1 Notes:

1. "Residential tank (& fittings)" is the cost for a 30,000 SCF capacity tank cascade. The tank size is used in determining the number of needed deliveries/year. This cost is from http://www.phoenixenergycorp.net/refurb.html, accessed 9/18/09.
2. "Residential permitting, etc., costs (if any)" is a placeholder. The regulations regarding home installation of pressure vessels, compressed gas cylinders, or compressed natural gas involve the NFPA and the EPA. References also make use of ASTM standards. If home installation is possible, the tanks would require certification and testing, but no hard number or range for the cost of this was determined in the time available.
3. "Residential meter and regulator" is the cost for the installation of a meter and regulator system at the residence. This was obtained from FNG through personal communication on Wednesday, 9/16/09.

Scenario 2a: Neighborhood Hub (all major capital expenses by distributor) - Under this scenario, it is assumed that each household will convert their heating system to natural gas. This is a total capital cost to the household of approximately $1,750. Natural gas would be delivered to the homes via an installed system of natural gas lines connected to a neighborhood hub. CNG would be trucked to the neighborhood hub from the main hub.

The following are used in the simple payback for the household perspective (Formula 1 above):

Formula 9. Capital costs = Residential meter, regulator, valve, riser cost + Home heating system conversion cost

Formula 10. Operating Costs = 0.

Formula 11. Annual Savings = Price reduction percent * "Price" in $/MMBTU* Amount of natural gas needed in MMBTU.

The following are used in the internal rate of return formula for the distributor's perspective (Formula 2 above):

Formula 12. Capital costs = Compressor costs + GTM trailers costs + Neighborhood hub costs + Neighborhood lines costs

Formula 13. Annual operating costs = Cost of bringing natural gas to Fairbanks + Compressor annual maintenance + Use, maintenance & salary for GTM deliveries to hub + Neighborhood hub annual maintenance + Neighborhood lines annual maintenance

Formula 14. Annual revenue = "Price" in $/MMBTU * Amount of natural gas needed in MMBTU

Scenario 2b: Neighborhood Hub (neighborhood pays capital expenses for hub and lines, but not vehicles or compressors) - Under this scenario, it is assumed that each household will convert their heating system to natural gas. The household is responsible for the installation of the meter, regulator, valve, and riser at their home, and for their heating system conversion. Under this scenario, they are also responsible, collectively, for the capital costs of the installation of the neighborhood natural gas lines and the neighborhood hub. This additional cost, when divided among the base 900 households used in this model, is approximately $3,960, for a total capital cost to the consumer of approximately $5,710. Natural gas would then be delivered to the homes via an installed system of natural gas lines connected to the neighborhood hub.

The following are used in the simple payback for the household perspective (Formula 1 above):

Formula 15. Capital costs = Portion of neighborhood hub costs + Portion of neighborhood lines costs + Residential meter, regulator, valve, riser costs + Home heating system conversion costs.

Formula 16. Operating costs = 0.

Formula 17. Annual savings = Price reduction percent * "Price" in $/MMBTU* Amount of natural gas needed in MMBTU.

The following are used in the internal rate of return formula for the distributor's perspective (Formula 2 above);

Formula 18. Capital Costs = Compressor Costs + GTM Trailers Costs.

Formula 19. Annual operating costs = Cost of bringing natural gas to Fairbanks + Compressor annual maintenance + Use, maintenance, & salary for GTM deliveries to hub + Neighborhood hub annual maintenance + Neighborhood lines annual maintenance.

Formula 20. Annual revenue = "Price" in $/MMBTU * Amount of natural gas needed in MMBTU.

Table 4 compares the household's simple payback to the distributor's IRR for Scenario 2b. Table 4 compares the household's simple payback to the distributor's IRR for scenario 4. The table shows simple paybacks and IRRs assuming various natural gas prices as a percentage below the fuel oil equivalent price of $19.57/MMBTU. The 20% and 25% reduction cases indicate a circumstance that might benefit both the household and the distributor and may warrant further investigation.

Table 4. Comparison: Household vs. Distributor - Scenario 2b

Fuel cost savings per MMBTU (% Reduction)	Household Payback (in years)	Distributor IRR
@ No Reduction	--	157%
@ 5% Reduction	21.07	130%
@ 10% Reduction	10.53	103%
@ 15% Reduction	7.02	76%
@ 20% Reduction	5.27	49%
@ 25% Reduction	4.21	22%
@ 30% Reduction	3.51	< 0%

Scenario 2 (a & b) Notes:

1. "Neighborhood hub annual maintenance" is assumed to be 2.5% of the hub's capital cost ($/unit).
2. "Neighborhood hub, capital (w/ daily refill)" is an estimate from GTM Manufacturing, LLC (Wednesday, 9/23/09).

Scenario 3: Main Line to Neighborhoods - Under this scenario, it is assumed that each household will convert their heating system to natural gas. This is a total capital cost to the household of approximately $1,750. Natural gas would be delivered directly to the homes via natural gas lines from the main hub.

The following are used in the simple payback for the household perspective (Formula 1 above):

Formula 21. Capital costs = Residential meter, regulator, valve, riser costs + Home heating system conversion costs.

Formula 22. Operating costs = 0.

Formula 23. Annual savings = Price reduction percent * "Price" in $/MMBTU* Amount of natural gas needed in MMBTU.

The following are used in the internal rate of return formula for the distributor's perspective (Formula 2 above):

Formula 24. Capital costs = Connection line costs + Neighborhood lines costs.

Formula 25. Annual operating costs = Cost of bringing natural gas to Fairbanks + Connection line maintenance + Neighborhood lines annual maintenance

Formula 26. Annual revenue = "Price" in $/MMBTU)* Amount of natural gas needed in MMBTU.

<u>Scenario 3 Notes:</u>

1. "Connection line annual maintenance ($/mile)" is assumed to be 10% of the capital cost of installation. The connection line connects the neighborhood main line to the rest of the FNG grid.
2. "Connection line installation ($/mile)" is the cost ($/trench-foot) to install a main line neighborhood line multiplied by 5,280 ft. Costs are rough estimates from FNG through personal communication on Wednesday, 9/16/09.

<u>Scenario 4: Hub for 10 years, direct line for next 20 years</u>. Under this scenario, it is assumed that each household will convert their heating system to natural gas. Natural gas would then be delivered to the homes via an installed system of natural gas lines connected to a temporary neighborhood hub that would be replaced with a direct distribution line from the main hub in 10 years. The household is responsible for the installation of the meter, regulator, valve, and riser at their home, and for their heating system conversion. Under this scenario, they are not responsible for any of the capital or operating costs from the installation of the natural gas lines and the neighborhood hub. This would be a total capital cost to the household of approximately $1,750.

The following are used in the simple payback for the household perspective (Formula 1 above):

Formula 27. Capital costs = Residential meter, regulator, valve, riser costs + Home heating system conversion costs.

Formula 28. Operating costs = 0.

Formula 29. Annual savings = Price reduction percent * “Price” in $/MMBTU* Amount of natural gas needed in MMBTU.

The following are used in the internal rate of return formula for the distributor’s perspective (Formula 2 above):

Formula 30. Capital costs = Compressor costs + GTM trailers costs + Neighborhood hub costs + Connection line costs + Neighborhood lines costs. Also included in this calculation is a salvage value for the neighborhood hub systems. This is assumed to be 50% after 10 years.

Formula 31. Annual operating costs = Cost of bringing natural gas to Fairbanks + Compressor annual maintenance + Use, maintenance & salary for GTM deliveries to hub + Neighborhood hub annual maintenance + Connection line maintenance + Neighborhood lines annual maintenance.

Formula 32. Annual revenue = “Price” in $/MMBTU * Amount of natural gas needed in MMBTU.

Table 5 compares the household’s simple payback to the distributor’s IRR for scenario 4. The table shows simple paybacks and IRRs assuming various natural gas prices as a percentage below the fuel oil equivalent price of $19.57/MMBTU. The 15% reduction case indicates a circumstance that might benefit both the household and the distributor and may warrant further investigation.

Table 5. Comparison: Household vs. Distributor - Scenario 4

Fuel Cost savings per MMBTU (% Reduction)	Household Payback (in years)	Distributor IRR
@ No Reduction	--	33%
@ 5% Reduction	6.46	28%
@ 10% Reduction	3.23	23%
@ 15% Reduction	2.15	18%
@ 20% Reduction	1.61	14%
@ 25% Reduction	1.29	9%
@ 30% Reduction	1.08	5%

<u>Scenario 4 Notes:</u>

The notes from Scenarios 2 and 3 both apply to Scenario 4. Scenario 4 does not have any notes unique to it. As such, please see the notes for those scenarios.

Model One Results

The three main scenarios for Model One appear below in Table 6. Both Scenarios 2 and 3 have solutions that work for both the consumer and the distributor under a for-profit situation. Consider the 15% price reduction case - for the consumer there is a pay-back period of just over two years in each scenario and an internal rate of return for the distributor of 15% and 28%, respectively. This shows that in Scenarios 2 and 3 the consumer price of natural gas can be reduced as compared to present day fuel oil price while still affording the distributor a positive IRR.

Table 6. Main Results for Models One

Model One (for profit)	**Scenario 1** (home delivery)		**Scenario 2a** (hub delivery)		**Scenario 3** (line delivery)	
	Household	**Distributor**	**Household**	**Distributor**	**Household**	**Distributor**
Fuel cost savings / MMBTU (% Reduction)	**Payback (in years)**	**IRR**	**Payback (in years)**	**IRR**	**Payback (in years)**	**IRR**
@ No Reduction	--	196%	--	31%	--	44%
@ 5% Reduction	--	169%	6.46	26%	6.46	39%
@ 10% Reduction	403.96	142%	3.23	20%	3.23	33%
@ 15% Reduction	102.44	115%	2.15	15%	2.15	28%
@ 20% Reduction	58.66	88%	1.61	9%	1.61	22%
@ 25% Reduction	41.09	60%	1.29	2%	1.29	17%
@ 30% Reduction	31.63	33%	1.08	< 0%	1.08	11%

Model Two. Examining Savings and Costs on a Price per MMBTU basis

Model Two evaluates the following three scenarios:
Scenario 1: Home delivery by CNG truck.
Scenario 2: Hub delivery for neighborhood line distribution.
Scenario 3: Direct delivery by line from main hub.

For each of these scenarios, a local distribution cost was calculated and added to base costs for: Commodity, Liquefaction, Transportation (to Fairbanks), and Incurred debt. Each of these costs were stated in units of $/MMBTU. This created a "Product Price" as follows:

Formula 33. Product price ($/MMBTU) = Commodity cost + Liquefaction cost + Transportation (to Fairbanks) cost + Incurred debt cost + Distribution cost

The distribution cost will vary depending on the scenario. The distribution cost for each scenario is calculated by conducting a net present value (NPV) calculation on the capital and operating cost stream for each major component set involved in the distribution process from the main hub to the consumer. These systems were assumed to have a useful life of 30 years, except where noted otherwise. The resultant NPV was then divided by the amount of natural gas (in BTUs) that is expected to pass through the piece of equipment. This provided a $/MMBTU value for each piece of equipment.

A variable, "Additional costs", was then added to the product price to arrive at a "Final price to consumers". "Additional costs" is calculated from the capital and operating costs of any equipment the household is required to purchase, and which comes after the delivery mechanism to the house. Like the distribution cost, this will vary depending on the scenario. It is also calculated using the method described for distribution cost.

<u>Basic Assumptions for Model Two:</u>
The following are basic assumptions and inputs used in one or more of the scenarios in Model Two. There are some assumptions and inputs that are specific to a single scenario. These are directly addressed in the discussion of that scenario.

1. Fuel oil is assumed to have 138,500 BTUs per gallon.
2. One CCF is 100 standard cubic feet (SCF) of natural gas.
3. One MCF is 1,000 SCF of natural gas.
4. One MMBTU is 1,000,000 BTUs.
5. Natural gas is assumed to have 101,500 BTUs per CCF.
6. "Home energy use" is assumed to be 2,000 gallons of fuel oil.
7. "Rural area household (HH) density" is assumed to be 300 HH/mi^2. This is an approximation of RE2.
8. "Delivery area" is assumed to be in square mile blocks.
9. "Residential NG need" is the number of SCF of NG that is equal to the (Home energy use) x (Rural area household density) x (Delivery area).
10. "Price" is in $/MMBTU. The price used in the model is $19.57, which is the $/MMBTU of fuel oil at $2.71/gallon. (http://www.commerce.state.ak.us/dca/pub/Fuel_Report_July_2009_web.pdf, accessed 9/21/09). Fairbanks Natural Gas' (FNG) rate is currently $2.335/CCF or $23.00/MMBTU. (http://www.fngas.com/calculate.html, accessed 9/21/09).
11. The "Home heating system conversion cost" is assumed to be $1,500. This price was quoted to John Davies to convert his boiler to natural gas in personal communication.
12. "Compressor capital cost" is an estimate from GTM Manufacturing, LLC (Wednesday, 9/23/09). It agrees with and estimate derived from a smaller unit (50.4 SCFM, $39,500) and that was assumed to scale linearly. (http://www.usedcompressors.ca/used_equipment.php?eID=100, accessed 9/18/09).
13. "Compressor annual maintenance" is assumed to be 2.5% of the compressors capital cost ($/unit).
14. "Transport cost, distributor ($/day)" represents the cost of employing drivers to distribute natural gas, either to neighborhood hubs, or through

residential delivery. This is currently at 2 FTE per square mile block of service area.

15. "GTM (trailer and one; 50,000#), cost" represents a single gas transport module (GTM) mounted on a trailer and fully charged. Weight is not used in the calculation. This cost is a quote from phone communication with Brian Kelley at the selling company, GTM Manufacturing, LLC on Thursday, 9/17/09.
16. "GTM (trailer and one; 50,000#), number" indicates the number of GTMs needed to meet the residential NG need for the serviced area. This cost is a quote from phone communication with Brian Kelley at the selling company, GTM Manufacturing, LLC on Thursday, 9/17/09.
17. "Neighborhood lines installation costs" are the cost ($/trench-foot) to install the natural gas lines. Costs are rough estimates from FNG through personal communication on Wednesday, 9/16/09.
18. "Line annual maintenance" is assumed to be 10% of the lines' installations costs.
19. "Neighborhood lines lengths" are rough generic estimates of the number of trench-feet of each type of pipe needed. They assume one mile of main line (4") per square mile, eight miles of distribution line (3") per square mile, and one 100-ft service line per household per square mile.
20. "Residential meter, regulator, valve, riser". A set of these components is needed per household. The cost estimate was obtained from FNG through personal communication on Wednesday, 9/16/09.
21. The following starting point estimates are based on conversations with Borough staff (10/06/09):
    - Commodity cost = $2.00/MMBTU
    - Liquefaction cost = $5.00/MMBTU
    - Transportation (to Fairbanks) cost = $3.50/MMBTU
    - Incurred debt cost =$3.00/MMBTU

<u>Scenario 1: Home delivery by fuel truck</u>. Under this scenario, it is assumed that each household will acquire a residential natural gas tank through the necessary permitting process and convert their heating system to natural gas. Natural gas would then be delivered to the homes via GTM transport trucks. This is a total capital cost to the household of approximately $37,200.

Formula 34. Distribution cost ($/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1)$

Where,

r = Interest rate. This is assumed to be 5% for this model.

C_0 = Capital cost of the compressor(s).

O_0 = Operating cost of the compressor(s).

C_1 = Capital cost of the transport vehicles.

O_1 = Operating cost of the transport vehicles (including wages).

Formula 35. Additional costs ($/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1) + NPV_2(r, C_2, O_2) + NPV_3(r, C_3, O_3)$

Where,

r = Interest rate. This is assumed to be 5% for this model.
C_0 = Capital cost of the residential storage tank.
O_0 = Operating cost of the residential storage tank.
C_1 = Capital cost of the permitting of the residential storage tank.
O_1 = Operating cost of the permitting of the residential storage tank.
C_2 = Capital cost of the meter and regulator assembly.
O_2 = Operating cost of the meter and regulator assembly.
C_3 = Capital cost of the home heating system conversion.
O_3 = Operating cost of the home heating system conversion.

Formula 36. Final price to consumers (\$/MMBTU) = Product price (\$/MMBTU) + Additional costs (\$/MMBTU)

The calculations in formulas 34 and 35 are simplified with Excel® and the use of its "NPV" function.

Scenario 1 Notes:

1. "Residential tank (& fittings)" is the cost for a 30,000 SCF capacity tank cascade. The tank size is used in determining the number of needed deliveries/year. (http://www.phoenixenergycorp.net/refurb.html, accessed 9/18/09).
2. "Residential permitting, etc., costs (if any)" is a placeholder. The regulations regarding home installation of pressure vessels, compressed gas cylinders, or compressed natural gas involve the NFPA and the EPA. References also make use of ASTM standards. If home installation is possible, the tanks would require certification and testing, but no hard number or range for the cost of this was determined in the time available.
3. "Residential meter and regulator" is the cost for the installation of a meter and regulator system at the residence. This was obtained from FNG through personal communication on Wednesday, 9/16/09.

Scenario 2: Hub delivery. Under this scenario, it is assumed that each household will convert their heating system to natural gas. Natural gas would then be delivered to the homes via a system of natural gas lines connected to the neighborhood hub. The household is responsible for the installation of the meter, regulator, valve, and riser at their home, and for their heating system conversion. Under this scenario, they are not responsible for any of the capital or operating costs from the installation of the natural gas lines and the neighborhood hub. This would be a total capital cost to the household of approximately \$1,750.

Formula 37. Distribution cost (\$/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1) + NPV_2(r, C_2, O_2) + NPV_3(r, C_3, O_3)$

Where,

r = Interest rate. This is assumed to be 5% for this model.

C_0 = Capital cost of the compressor(s).
O_0 = Operating cost of the compressor(s).
C_1 = Capital cost of the transport vehicles.
O_1 = Operating cost of the transport vehicles (including wages).
C_2 = Capital cost of the neighborhood hub.
O_2 = Operating cost of the neighborhood hub.
C_3 = Capital costs of the gas line assembly.
O_3 = Operating costs of the gas line assembly.

Formula 38. Additional costs (\$/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1)$
Where,
r = Interest rate. This is assumed to be 5% for this model.
C_0 = Capital cost of the meter, regulator, valve, riser assembly.
O_0 = Operating cost of the meter, regulator, valve, riser assembly.
C_1 = Capital cost of the home heating system conversion.
O_1 = Operating cost of the home heating system conversion.

Formula 39. Final price to consumers (\$/MMBTU) = Product price (\$/MMBTU) + Additional costs (\$/MMBTU)

The calculations in formulas 37 and 38 are simplified with Excel® and the use of its "NPV" function.

Scenario 2 Notes:

1. "Neighborhood Hub Annual Maintenance" is assumed to be 2.5% of the hub's capital cost (\$/unit).
2. "Neighborhood Hub, Capital (w/ Daily Refill)" is an estimate from GTM Manufacturing, LLC (Wednesday, 9/23/09).

Scenario 3: Line delivery. Under this scenario, it is assumed that each household will convert their heating system to natural gas. Natural gas would then be delivered to the homes via a system of natural gas lines connected by direct distribution line from the main hub. The household is responsible for the installation of the meter, regulator, valve, and riser at their home, and for their heating system conversion. Under this scenario, they are not responsible for any of the capital or operating costs from the installation of the natural gas lines. This would be a total capital cost to the household of approximately \$1,750.

Formula 40. Distribution cost (\$/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1) + NPV_2(r, C_2, O_2) + NPV_3(r, C_3, O_3)$
Where,
r = Interest rate. This is assumed to be 5% for this model.
C_0 = Capital costs of the gas line assembly.
O_0 = Operating costs of the gas line assembly.

Formula 41. Additional costs ($/MMBTU) = $NPV_0(r, C_0, O_0) + NPV_1(r, C_1, O_1)$

Where,

r = Interest rate. This is assumed to be 5% for this model.

C_0 = Capital cost of the meter, regulator, valve, riser assembly.

O_0 = Operating cost of the meter, regulator, valve, riser assembly.

C_1 = Capital cost of the home heating system conversion.

O_1 = Operating cost of the home heating system conversion.

Formula 42. Final price to consumers ($/MMBTU) = Product price ($/MMBTU) + Additional costs ($/MMBTU)

The calculations in formulas 40 and 41 are simplified with Excel® and the use of its "NPV" function.

Scenario 3 Notes:

1. "Connection line annual maintenance ($/mile)" is assumed to be 10% of the capital cost of installation. The connection line connects the neighborhood main line to the rest of the FNG grid.
2. "Connection line installation ($/mile)" is the cost ($/trench-foot) to install a main line neighborhood line multiplied by 5,280 ft. Costs are rough estimates from FNG through personal communication on Wednesday, 9/16/09.

Model Two Results

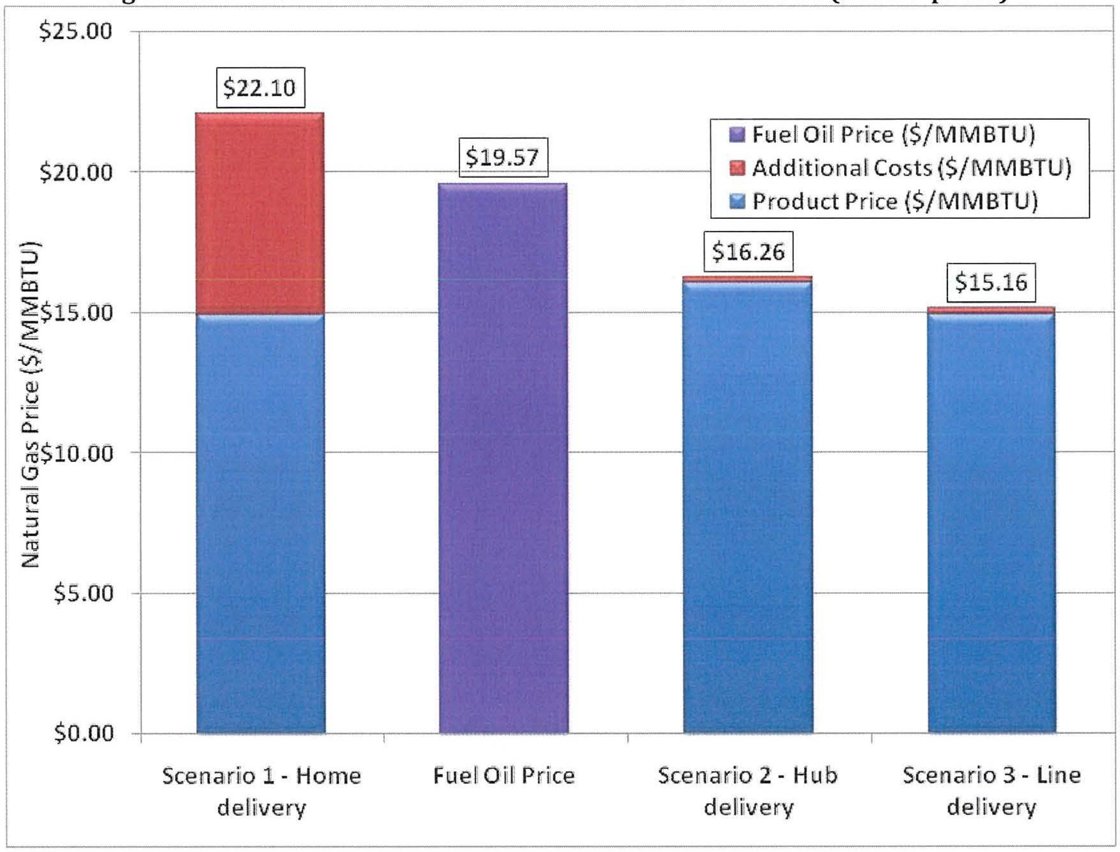
Both Scenario 2 and 3 have retail prices that work for the consumer and pencil out for a not-for-profit. A price in the range of $15.16 to $16.26 per million BTUs is about a 20 percent reduction compared to the current fuel-oil-equivalent price of $19.57/MMBTU. The final results from Model Two are given in Table 7 below.

Table 7. Retail Price ($/MMBTU) for CNG to Natural Gas in Fairbanks Homes

Model Two (non-profit)	**Scenario 1** (home delivery)	**Scenario 2** (hub delivery)	**Scenario 3** (line delivery)
	Dollars/MMBTU	**Dollars/MMBTU**	**Dollars/MMBTU**
	$22.10	$16.26	$15.16

These prices are also compared to the fuel oil price in Figure Two below.

Figure Two. Retail Prices for each Scenario under Model Two (not-for-profit)



Conclusions

From a relatively high-level, this report examines the feasibility of transporting CNG to a main hub in Fairbanks and then distributing it from there to homes in the FNSB. The report considers three scenarios under two economic models. Three basic scenarios are considered: (1) truck delivery direct from the main hub to homes, (2) truck delivery to a neighborhood hub and distribution pipeline delivery from that hub to individual homes, and (3) direct pipeline distribution from the main hub to homes. Each of these options has been evaluated under two different economic models. The first model assumes a for-profit entity operating the distribution system and the second assumes a not-for-profit entity. In the first case (for-profit), the scenarios are evaluated from the perspective of both the consumer and the distributor; in the second case the evaluation metric is just the price to the consumer assuming that no profit is needed and a certain wholesale price is obtainable. The main result from this analysis is given in Table 1.

For Model One, Scenarios 2 and 3 have solutions that work for both the consumer and the distributor. Consider the 15% price reduction case - for the consumer there is a pay-back period of just over two years in each scenario and an internal rate of return for the distributor of 15% and 28%, respectively.

For Model Two, again both Scenario 2 and 3 have retail prices that work for the consumer and pencil out for a not-for-profit. A price in the range of $15.16 to $16.26 per million BTUs is about a 20 percent reduction compared to the current fuel-oil-equivalent price of $19.57/MMBTU. This comparison can be seen in Figures One and Two (above).

In no case, for either model, does Scenario 1 (CNG home delivery) have a solution that works for both the consumer and distributor.

In the 25% reduction case for Scenario 2b of Model One (the neighborhood installs the hub and local distribution lines) there is a simple pay-back period of a little over 5 years for the neighborhood residents and an IRR of 49% for the distributor.

The 15% reduction case for Scenario 4 (a combination of Scenarios 2a and 3) of Model One in which the hub is run for 10 years and then replaced by the direct line system for an additional 20 years, shows a simple payback period of just over 2 years for the household and an IRR for the distributor of 18%.

Taken together these results show that there are likely several different scenarios that would be judged feasible under a more rigorous analysis. It is also quite likely that options could be chosen based on an ability to get gas to the most households within a given period of time depending upon considerations such as right-of-way permitting and workforce availability.