

Fairbanks North Star Borough **Gas Distribution System Analysis**



June 29, 2012

Prepared by



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Abbreviations

AAC	Alaska Administrative Code
AFUE	Annual Fuel Utilization Efficiency
AIDEA	Alaska Industrial Development and Export Authority
ANS	Alaska North Slope
BCA	Benefit-cost analysis
Bcf	Billion cubic feet
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
Btu	British thermal units
CNG	Compressed Natural Gas
CO	Carbon monoxide
COS	Cost-of-Service
DEC	Alaska Department of Environmental Conservation
DOT	U.S. Department of Transportation
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FMA	Free Main Allowance
FNG	Fairbanks Natural Gas, LLC
FNSB	Fairbanks North Star Borough
FY	Fiscal Years
GIS	Geographic information system
GVEA	Golden Valley Electric Association
ISER	Institute of Social and Economic Research, University of Alaska
kWh	Kilowatt-Hour
LID	Local Improvement District
LNG	Liquefied Natural Gas
Mcf	Thousand cubic feet
MMBtu	Million British thermal units
MMcfd	Million cubic feet per day
MW	Megawatt
NEPA	National Environmental Protection Act
NO _x	Oxides of nitrogen

PA	Propane-air
PESR	Preliminary Executive Summary Report
PM	Particulate matter (2.5 and 10.0 microns or micrometers)
PSI	Pounds per square inch
RCA	Regulatory Commission of Alaska
RFP	Request for Proposal
RMA	Risk Management Association
ROW	Right-of-way
SIP	State Implementation Plan
SO ₂	Sulfur dioxide
Tpy	tons per year
SWOT	Strengths, Weaknesses, Opportunities, Threats
TIC	Total Installed Cost
TPY	Tons of pollutant emitted per year (also tpy)
VOC	Volatile organic compounds

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Fuel Cost Comparison Aid, June 2012

Several readers and reviewers of initial drafts of this report noted difficulty in converting costs between the three main fuels used in Fairbanks: fuel oil, propane and natural gas. In an effort to address this issue, the project team developed the following conversion aid, based on June 2012 prices in Fairbanks.

The table below shows fuel oil costs from \$1.00 to \$7.00 per gallon, along with corresponding propane costs (on a per gallon basis) and natural gas costs on a per MCF (1,000 cubic feet) basis. For reference, Anchorage's current cost of residential natural gas (rounded to \$11.00 per MCF) is highlighted in blue and Fairbanks' current cost of fuel oil (rounded to \$4.00 a gallon) is highlighted in red.

Simplified Fuel Cost Comparison: Fuel Oil, Propane, Natural Gas

Location, Tariff, System	Fuel Oil, \$/gallon	Propane, \$/gallon	Natural Gas, \$/MCF
	1.00	1.12	7.96
Anchorage June 2012	1.38	1.54	11.00
	2.00	2.24	15.92
	3.00	3.35	23.88
Fairbanks, June 2012	4.00	4.47	31.84
	5.00	5.59	39.80
	6.00	6.71	47.76
	7.00	7.83	55.72

Source: Northern Economics.

More specifics are contained in Table 15 of the report, along with a June 2012 ranking of fuels based on cost.

Executive Summary

Current high energy prices in the Fairbanks North Star Borough (FNSB) are adversely affecting families and businesses in the borough. The doubling in the price of crude oil over the past five years, and the subsequent increase in the price of refined petroleum products has more than doubled the cost of space heating, electric generation, and transportation in Interior Alaska.

High energy prices coupled with increased scrutiny regarding air quality, specifically PM_{2.5} (particulate matter that is 2.5 microns and smaller) have the potential to stifle economic development in the borough.

In response to these issues, the FNSB issued a Request for Proposals (RFP) for development of an optimized plan for a rapid build-out of the borough's proposed energy distribution system. The analysis was also directed to assess the potential for improved air quality by switching from primarily fuel oil and wood to natural gas or propane.

Project Goals

As stated by the FNSB, there are two overarching goals for the study:

1. To define a supply-neutral optimized plan for the rapid build-out of the FNSB's energy distribution infrastructure, one that delivers propane or natural gas as affordably as possible, to the largest number of borough residents, business and residential properties; and
2. To assess the impact of the proposed infrastructure build-out on air quality in the Fairbanks North Star Borough nonattainment area.

Major Findings

Construction and operation of a piped natural gas distribution system in the high-density and medium-density areas of the FNSB (See Figure ES-1), and a propane distribution system in the low-density areas of the borough, has the potential to reduce fuel costs for space heating of residential and commercial structures from approximately \$524 million in 2021, the first full year of operations, to about \$210 million, a savings of roughly \$315 million annually (See Table ES-5.), a savings of 60 percent compared to the status quo using fuel oil and wood. These estimates will change with different assumptions or if capital costs or commodity costs change, but the magnitude of the savings is so large that it is evident that substantial savings will accrue under almost any future scenario that employs natural gas and propane.

Similarly, converting to natural gas for space heating will reduce the overall emissions of PM_{2.5} in the Fairbanks area by a significant amount (See Figure ES-3). The conversion to natural gas will also reduce NO_x and SO₂ emissions, which are precursors to the formation of secondary PM_{2.5} in the atmosphere. Combined, these emission reductions will help bring the Fairbanks area into attainment with the ambient PM_{2.5} air quality standard. PM_{2.5} emissions are estimated to decrease from approximately 2,200 tons per year to less than 200 tons per year.

Background

Northern Economics, based in Anchorage, created a project team with economists, business analysts, pipeline distribution system engineers and air quality specialists to suggest an organization and structure for development of the conceptual system.

The project began on December 29, 2011 and the team prepared a Preliminary Executive Summary Report in late January 2012. That preliminary report became the basis for this final report, which contains updates, greater detail, and results of more intensive analysis.

Project analysis and results for the executive summary are organized into the following sections:

- Market Demand
- Conceptual Design
- Business Models
- SWOT Analysis
- Cost of Service, Financial Analysis
- Consumer Savings
- Benefit-Cost Analysis
- Air Quality
- Decision Points

The key points for each section are summarized in the remainder of this Executive Summary.

Market Demand

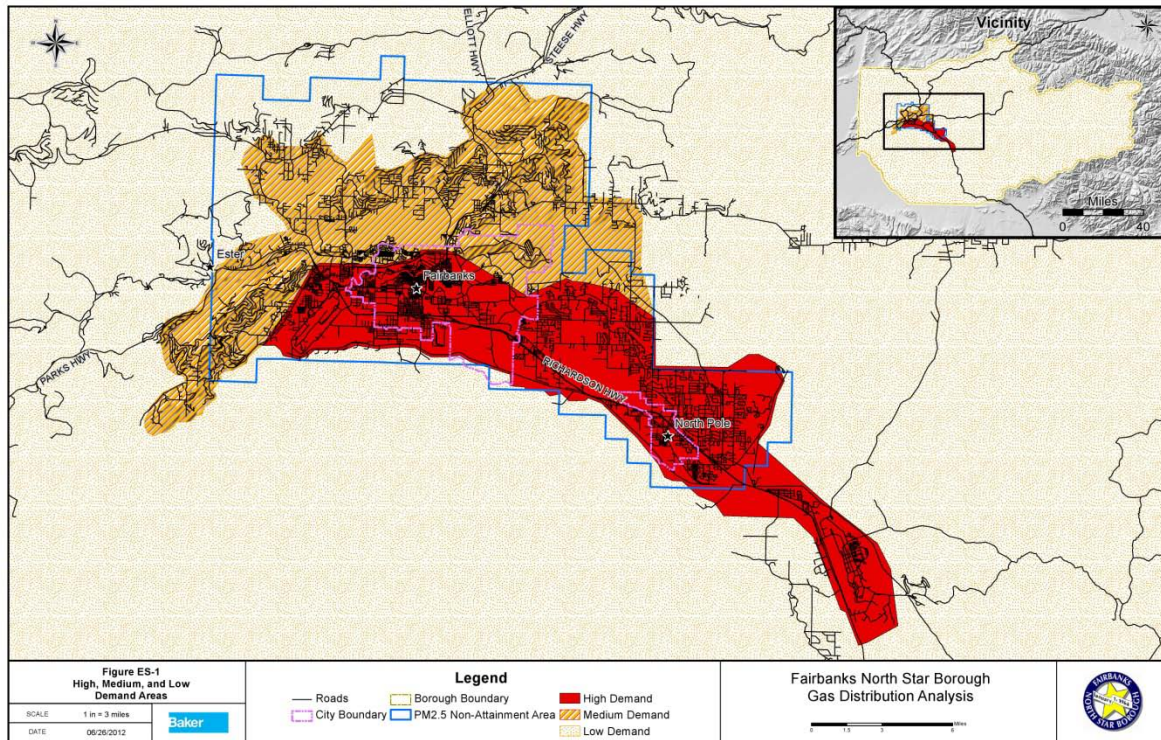
Total estimated market potential for natural gas or propane in the Fairbanks North Star Borough is equivalent to 20.5 billion cubic feet (Bcf) per year or an average of 56 million cubic feet per day. This estimate assumes that all existing residential and commercial structures plus specific industrial sector facilities will convert to natural gas or propane for heating, power generation, and processing requirements. However, not all of the households and businesses in the borough will be served by the natural gas distribution system or switch to natural gas or propane due to the fact that some structures are presently served by other utility systems, some businesses have plans to source their energy needs internally, and some structures in the low-demand area do not have significant heating loads because they are only used seasonally. As a result of these adjustments, the estimated market demand is equivalent to 11.5 Bcf per year rather than 20.5.

The estimated potential natural gas demand for the industrial sector assumes that an existing 60 megawatt combustion unit owned by Golden Valley Electric Association that currently burns naphtha would convert to natural gas and that the Flint Hills and Petro Star refineries in the North Pole would also convert to natural gas for their refining operations.

Market penetration for natural gas in the region has been limited due to supply constraints. In 2011, Fairbanks Natural Gas (FNG) sold 841,288 thousand cubic feet of gas to all its customers. This volume represents only four percent of the total estimated market potential for natural gas in the region. Access to natural gas and expansion of the existing distribution infrastructure are necessary in order for the market for natural gas to grow.

The RFP specified three zones for analysis: a high-density zone, a medium-density zone, and a low-density zone, all radiating from the heart of downtown Fairbanks. An analysis using geographic information system (GIS) software was undertaken to identify these zones. See Figure ES-1.

Figure ES-1. Fairbanks North Star Borough PM_{2.5} Zone of Non-attainment and Three Demand Zones.



Source: Baker Engineers, FNSB, DEC, EPA.

Note: A larger format map is available in Appendix A of this report.

Table ES-1 summarizes the total market potential for natural gas or propane for the residential, commercial, and industrial sectors within each of the demand areas.

Table ES-1. Potential Natural Gas or Propane Requirements in the High, Medium, and Low-Demand Areas by Category

Category	High Demand	Medium Demand	Low Demand	Total
	Bcf/Year			
Residential	3.27	2.28	0.84	6.38
Commercial	5.58	0.43	0.16	6.18
Taxable Structures	5.06	0.34	0.16	5.56
Non-Private Structures	0.52	0.09	0.01	0.61
Industrial	7.90	0.00	0.00	7.90
Power Generation	3.1	0	0	3.1
Refinery Processing	4.8	0	0	4.8
Total	16.75	2.71	1.00	20.46

Source: Michael Baker Jr. and Northern Economics estimates.

Notes: The “Non-private structures” category generally refers to schools, government buildings, and other structures owned by non-private entities. Natural gas requirements for residential and commercial structures were estimated using square footage data available from the FNSB Assessor and secondary sources as well as information on average base and heating loads provided by ENSTAR for particular size and types of structures, adjusted for Fairbanks heating degree days. Natural gas requirements for the industrial sector were estimated using information provided by Golden Valley Electric Association, Flint Hills Refinery, and secondary sources. Totals and subtotals may not add due to rounding.

The natural gas distribution system will not deliver gas to all households and businesses in the FNSB because some are already served by FNG or by Aurora Energy, which delivers steam and hot water within its service area, and the low-demand area does not have housing densities sufficient to economically justify a piped distribution system. In addition, Golden Valley Electric Association (GVEA) and the Flint Hills North Pole refinery have proposed a liquefaction plant on the North Slope and trucking liquefied natural gas to their plants so this industrial demand would not be served by the piped distribution system. Furthermore, there are a number of residential structures in the low demand area that were vacant at the time of the 2010 census due to being recreational or seasonally occupied cabins that are not heated in the winter and have a minimal heating load in other times of the year. Taking these factors into account results in an adjusted market demand of 11.5 Bcf per year (Table ES-2). The potential market that will be served by the piped distribution system is also shown in Table ES-2. The remaining volumes of the adjusted market demand not served by the piped distribution system are anticipated to be served by propane or propane-air systems. Note that prices of natural gas and propane compared to competing fuels will affect the amount of gas or propane that is ultimately sold. See Section 2.6 for a discussion of natural gas and propane sales.

Table ES-2. Potential and Adjusted Market Demand

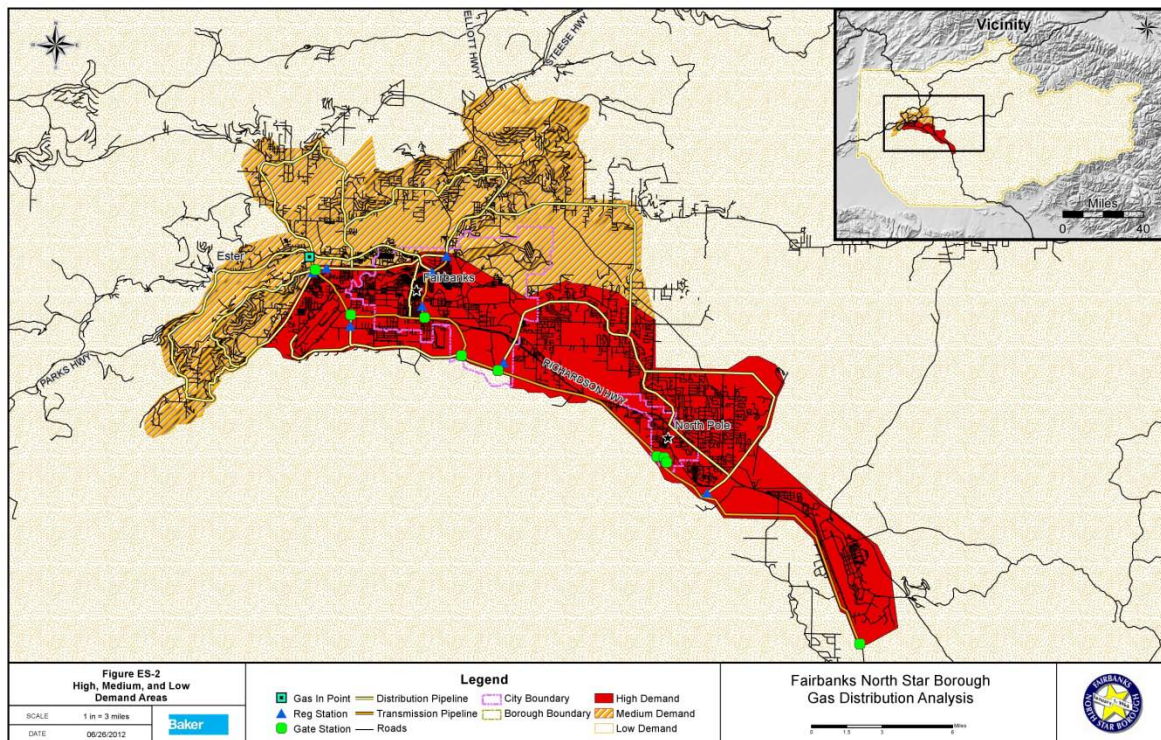
Category	Total Estimated Market Potential	Adjusted Market Demand	Potential Market Served by Piped Distribution System
	Bcf/Year		
Residential Sector	6.4	6.1	5.6
Commercial Sector	6.2	5.1	4.9
Industrial Sector	7.9	0.3	0.3
Total	20.5	11.5	10.8

Source: Michael Baker Jr. and Northern Economics estimates.

Conceptual Design

Project engineers designed a conceptual piped distribution system layout, as shown in Figure ES-2, for the high and medium density zones. The high-density area system would be completed in 2015 with conversions to natural gas occurring over a five-year period ending in 2019. The medium-density zone pipeline system would be completed in 2016, with the conversions occurring through 2020. The low-density zone would be served with propane using piped propane-air system or a similar distribution system as exists today with trucks delivering propane to individual residences and businesses, with conversions occurring over the 2015 to 2019 period. The conceptual design meets the objectives of providing lower-cost energy to as many residents and businesses in the FNSB as possible with an optimized schedule.

Figure ES-2. Conceptual Distribution System Layout



Source: Michael Baker, Jr. Inc.

Note: A larger format of this map is available in Appendix A of this report.

Design engineers developed a detailed cost estimate, contained in Appendix B of this report, based on 7.4 million lineal feet of piping (transmission, distribution, service), approximately 1,400 miles. A cost estimate, based on Level 4 classification by the Association for the Advancement of Cost Engineering ranged from \$282.8 million (-30 percent) to \$606.0 million (+50 percent), with a base estimate of \$404.0 million. As project planning and design continues, the cost estimate will be refined with the range becoming narrower.

Business Models

Choosing a specific type of organization to implement the gas distribution system raises different issues regarding management, governance and ratepayer control, the efficiency of raising capital, and regulatory requirements, and a number of other topics. Regardless of the organizational preference, to be considered effective, any business structure needs to minimize the cost of providing service while incentivizing residences and businesses to convert to natural gas in a timely manner.

For the purposes of this report, the likely business structures which could be implemented for the FNSB Natural Gas Distribution System include:

1. Private Company;
2. Non-Profit or Public Entity such as Cooperative or Municipal Utility or Local Improvement District; or
3. Public/State Partnership.

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis (below) provides specific abilities of each business structure to achieve the goal of expanding and maintaining a gas distribution system, but the results of a quantitative analysis discovered the differences in cost of capital, taxes, and profits accounts for about nine percent of the overall cost to consumers.

On a cost basis alone, the difference between business models is not likely to be the determining factor driving customers to switch over to natural gas.

SWOT Analysis

The SWOT analysis is based on the ability of the organization to meet the primary goals of achieving the lowest cost energy to the most residences and businesses in the Fairbanks area as soon as possible. The specific aspects considered in the SWOT analysis are based on preliminary system design and costs estimates.

A full list of each organizational structure's Strengths, Weaknesses, Opportunities, and Threats is included in Table 11 through Table 14 later in the report. A summary of that analysis is presented in Table ES-3.

Table ES-3 Summary of SWOT Analysis

Organizational Structure	Strengths	Weaknesses	Opportunities	Threats
Private Company	Ability to raise capital for initial distribution system	Highest cost of service option	Potential sales tax income	Stability of future corporation
Non-Profit	Potential for lowest cost of service	May not have bonding capacity to construct the system	May qualify for funding partnership with the State	Potentially least flexible of the business structures
Local Improvement District	Access to borough's special assessment bonding capability	Borough assumes the risk of repayment for construction	Borough can benefit from taxes on gas utility	A decline in property values may create difficulty in repaying bonds
State Partnership	Lowest cost of service	Complicated ownership structure	Can leverage state investment and technical support	Uncertain regulatory requirements

Source: Alaska Energy Board

The SWOT and cost of service analysis indicate that a state partnership organization, especially with the support of grants or loan guarantee arrangements, could substantially improve project returns and end-user affordability. This business organization is the most likely to result in end-user costs near the \$15 MMBtu target to promote solid fuel switching. With the monetary backing and financial support of the state, the state partnership is also most likely to achieve the trifold community goals of the lowest costs, for the broadest service area, within five years or less.

Cost of Service, Financial Analysis

The cost of service (COS) is the cost of the natural gas delivered to the end consumer. It includes the cost of the purchased gas, transportation to the city gate at Fairbanks, operations and maintenance costs, general and administration costs, depreciation, debt service, and other factors. Guidelines from the Federal Energy Regulatory Commission were used to calculate the COS reported here. However, within Alaska, the Regulatory Commission of Alaska (RCA) issues certificates and requirements for public utilities; including two natural gas utilities. The RCA does not issue guidelines for calculating the COS for natural gas utilities (3AAC52.010), though it does publish regulations for electric power COS calculations (3AAC48.500).

Table ES-4 summarizes the estimated cost of service for the piped distribution area, consisting of the high and medium-density areas, using proposed operations as a private company and a public organization. Note that the costs shown in the table are based on a specific set of assumptions described in the body of the report. For example, conversion costs from fuel oil to natural gas are not included in COS calculations.

Changes in assumptions, capital costs, or commodity costs will change these results. However, in general it is anticipated that a private organization will have a higher cost of service due to a private company having a higher cost of capital, higher taxes, and other factors.

Table ES-4. Estimated Cost of Service, Natural Gas, by Organization, Piped Distribution Area, 2015 to 2020, in \$/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Private Company						
Total cost per MMBtu	\$20.56	\$18.41	\$17.77	\$17.77	\$17.97	\$18.26
Total selling value with 20% margin over cost	24.67	22.09	21.32	21.32	21.56	21.91
Public Organization or Cooperative						
Total cost per MMBtu	\$20.12	\$16.67	\$16.06	\$16.07	\$16.29	\$16.59
Total selling value with 10% margin over cost	22.13	18.34	17.67	17.68	17.92	18.25
Difference in Total Cost of Service	2.54	3.76	3.66	3.65	3.65	3.66

Source: Northern Economics, Inc.

Consumer Savings

The natural gas and propane alternative results in substantial savings for residents and businesses in the borough compared to the status quo. Table ES-5 shows the estimated annual fuel costs for the status quo and the natural gas and propane alternatives for the 2015 through 2022 time period, and the resultant cost savings.

Table ES-5. Fuel Costs and Savings

Alternative/ Sector	2015	2016	2017	2018	2019	2020	2021	2022	Total 2015- 2021	Total 2015- 2022
(Millions of Nominal \$)										
Status Quo										
Residential	219.9	223.3	234.9	245.2	255.6	266.3	277.5	289.7	1,722.7	2,012.4
Commercial	187.3	189.8	200.0	209.0	218.0	227.3	237.1	247.7	1,468.5	1,716.2
Industrial	8.0	8.0	8.3	8.6	8.9	9.2	9.5	9.8	60.6	70.4
Total	415.1	421.2	443.2	462.8	482.6	502.9	524.1	547.3	3,251.8	3,799.1
Natural Gas/Propane										
Residential	213.5	193.5	168.4	139.4	119.5	116.5	120.2	124.2	1,071.1	1,195.3
Commercial	178.4	141.9	102.1	80.4	79.4	81.7	84.1	86.8	748.1	834.9
Industrial	7.0	5.0	4.8	4.8	4.9	5.0	5.1	5.2	36.6	41.8
Total	399.0	340.4	275.3	224.7	203.8	203.2	209.5	216.2	1,855.8	2,072.0
Savings										
Residential	6.3	29.8	66.5	105.8	136.1	149.8	157.3	165.5	651.6	817.1
Commercial	8.8	47.9	97.9	128.5	138.7	145.7	152.9	160.9	720.4	881.3
Industrial	1.0	3.0	3.5	3.8	4.0	4.2	4.4	4.7	24.0	28.7
Total	16.2	80.8	167.9	238.1	278.8	299.7	314.6	331.1	1,396.0	1,727.1
Savings as a % of Status Quo										
	4%	19%	38%	51%	58%	60%	60%	60%	43%	45%

Source: Northern Economics, Inc. estimates.

In 2021, the first full year of operations, the savings are approximately \$315 million or a savings from the status quo of about 60 percent. The total for the 2015 through 2021 time period is approximately \$1.4 billion.

It is uncertain if or when GVEA and Flint Hills might connect to the gas distribution system, but at some point in the future if a gas pipeline is built to Fairbanks it may be more cost effective for these two firms to use the piped distribution system rather than continue to truck LNG from the North Slope. While the industrial firms could benefit from being connected to the distribution system, residential and commercial customers could benefit from the greater throughput, which reduces the fixed costs per unit.

Switching to natural gas or propane only occurs when the cost of the gas or propane and the estimated conversion cost are equal to or less than 90 percent of the price of fuel oil adjusted for average oil-fired appliance efficiency, or 110 percent of the cost of wood adjusted for average wood stove efficiency. Based on experience in Southcentral Alaska the price point to switch to gas is higher than the cost of wood due to the convenience factor.

Benefit-Cost Analysis

A benefit-cost analysis (BCA) was undertaken to provide another perspective for decision makers. The BCA focused on the cost differences between the continuation of using primarily distillate fuels and wood for heating and industrial uses, and switching to the use of natural gas and propane. A benefit cost ratio greater than one indicates that the present value of costs for the natural gas and propane alternative is less than the costs of the status quo, indicating that investment in the natural gas and propane alternative should be made. As noted in Table ES- 6 the benefit-cost ratio for the entire project is greater than one, and this ratio is greater than one for all three density areas.

Table ES- 6. Benefit-Cost Analysis Summary for Fuel and Conversion Costs

Alternative	Billions of 2012 \$		Benefit-Cost Ratio
	Present Value of Costs	Present Value of Cost Savings	
Status Quo	10.62	--	--
High Density Area	7.10	--	--
Medium Density Area	2.65	--	--
Low Density Area	0.86	--	--
With Natural Gas/Propane Alternative	5.25	5.36	2.02
High Density Area	3.27	3.83	2.17
Medium Density Area	1.46	1.20	1.82
Low Density Area	0.53	0.33	1.63

Source: Estimates by Northern Economics, Inc.

Note: Costs are discounted using a seven percent discount rate. Additional detail on the benefit-cost analysis is provided in Section 8.

Converting to natural gas and propane provides substantial savings to borough residents and businesses, and these benefits extend over all three density zones. The highest benefit-cost ratio occurs in the high-density area, where the price for natural gas is low enough to achieve high market penetration, and where development densities result in a large number of users per mile of pipeline. The lowest benefit-cost ratio occurs in the low-density zone, where propane is not priced low enough to provide an incentive for residences that use wood for heating to switch to propane, and where the

price differential between propane and heating fuel is less than the price difference between natural gas and heating fuel.

The present value of costs of an alternative using natural gas and propane to meet the heating and industrial demand is estimated at approximately \$5.25 billion in 2012 dollars. This amount includes the cost of the fuels, conversion costs for replacing the existing furnaces or boilers, and the capital and operating costs for the piped distribution system. This estimate also includes the cost of new propane trucks and tanks to serve the low-density area of the borough; similar to the status quo, estimated costs for the high, medium, and low-density areas of the borough are presented in the table. The \$5.25 billion also assumes that the distribution system is operated by a private company, which results in a more conservative comparison since government or cooperatives would be expected to have lower costs, as discussed later in the report (see Sections 4.1 and 7).

The net present value expressed in 2012 dollars of the potential cost savings from converting to lower cost natural gas and propane is estimated at approximately \$5.36 billion over the 50-year study period.

Air Quality

Project air quality engineers prepared an analysis of the potential effects on air emissions from conversion to natural gas-fired space heating systems in the residential and commercial sectors of the three zones noted earlier. This analysis estimates the annual amount of criteria pollutant emissions in each demand zone for each year of the conversion effort.

Criteria pollutants are regulated pollutants under the Clean Air Act, and include:

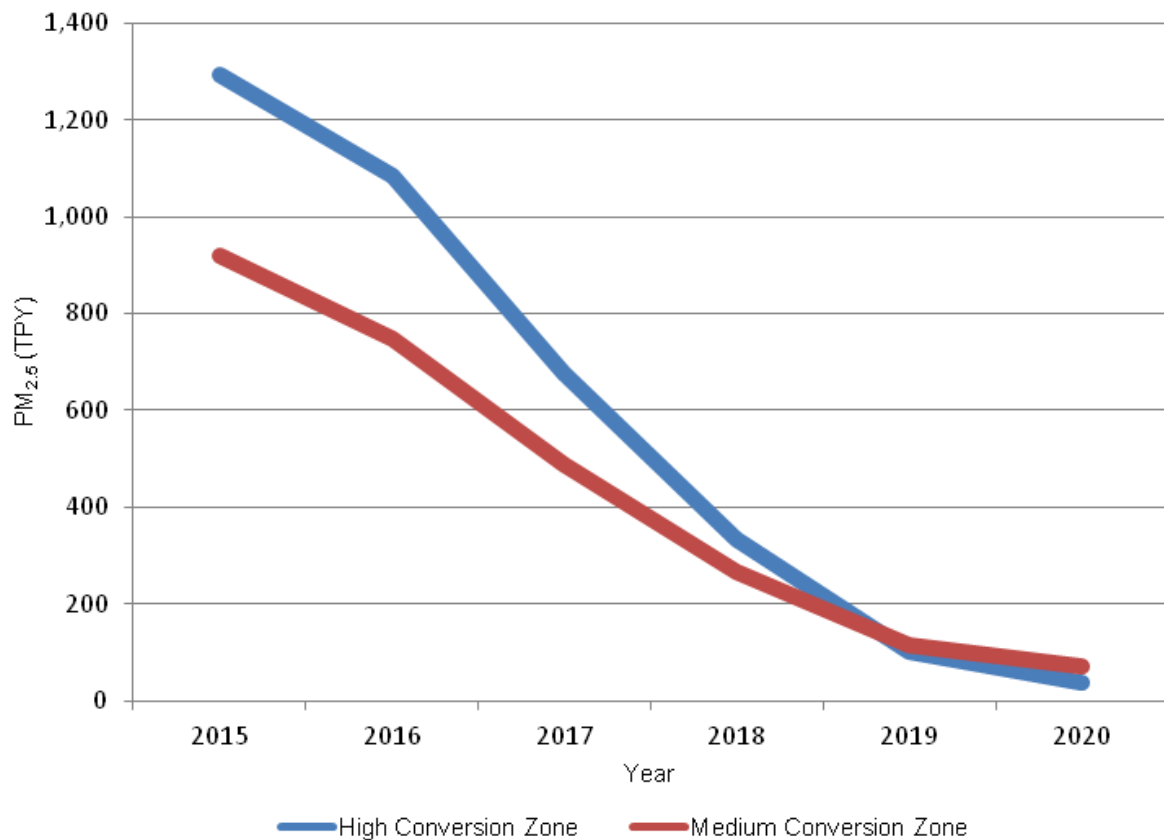
- Oxides of nitrogen (NO_x),
- Carbon monoxide (CO),
- Particles with an aerodynamic diameter less than or equal to 10 micrometers (PM₁₀),
- Particles with an aerodynamic diameter less than or equal to 2.5 micrometers (PM_{2.5}),
- Sulfur dioxide (SO₂), and
- Volatile organic compounds (VOC).

Emissions of each criteria pollutant are expected to decrease substantially based on the conversion scenarios presented in this report.

Of particular concern to the FNSB is the criteria pollutant PM_{2.5}, also known as fine particulate matter. The United States Environmental Protection Agency (EPA) has designated portions of the Fairbanks and North Pole areas as a nonattainment area for PM_{2.5}, as shown in Figure ES-1. The EPA regulates PM_{2.5} because it can cause or aggravate serious health problems, including asthma, bronchitis, and heart attacks. Further, the nonattainment designation negatively affects economic growth due to air quality permitting constraints that apply in nonattainment areas.

The analysis demonstrates that converting to natural gas use for heating will reduce the overall emissions of PM_{2.5} in the Fairbanks area. Figure ES-3 illustrates the estimated change in PM_{2.5} emissions from residential and commercial sources in the high and medium-demand zones. Total PM_{2.5} emissions decrease from approximately 2,200 tons per year to less than 200 tons per year. The analysis makes clear that conversion of residential heating systems from wood-fired and coal-fired to natural gas-fired is essential to achieving reductions in PM_{2.5} emissions.

Figure ES-3. PM_{2.5} Emissions Estimates, High and Medium Demand Areas, 2015 to 2020, in Tons of Pollutant per year.



Source: SLR International

The conversion to natural gas will also reduce NO_x and SO₂ emissions, which are precursors to the formation of secondary PM_{2.5} in the atmosphere. These emission reductions will help bring the Fairbanks area into attainment with the ambient PM_{2.5} air quality standard.

The emissions reductions presented here reflect the changes associated with the piped natural gas systems in the high and medium-demand areas or propane systems in the low-demand area. Emissions from facilities in the industrial sector, as described in Section 2, are not included in this analysis.

If the Fairbanks area converts many of the existing space heating emission units to natural gas combustion, water vapor emissions will likely increase. These additional water vapor emissions do not necessarily mean that ice fog events will become more common because the frequency of the meteorological conditions that trigger ice fog events will not increase. However, the ice fog events that do occur may have slightly longer duration and may cover a slightly larger geographic area.

Decision Points

The purpose of this report section is to identify if there were zones or areas where the costs of converting to natural gas and propane were greater than the costs of using distillates and wood. As noted in the BCA discussion (Section 8), the benefit-cost ratio for each of the three density areas (high, medium, and low) is very positive, so there is no need to phase the project or to not undertake development of the distribution system in any area.

However, the model indicates that wood switching will not occur in the high and medium density areas for several years depending on the specific model assumptions that are used. In most model runs the wood switching does not occur until 2021 or so, when the volume of gas sales has increased to the point where the fixed costs can be spread across greater gas sales volumes. Substantial increases in the amount of grants to the project can move the switching date to an earlier year. Another approach could be to obtain grants that could be used as operating funds and employed to reduce the sales price for the first five or six years until the conversions are generally complete or the sales volumes enable gas to compete with wood.

The model also indicates that propane can displace fuel oil in the low density area but is unlikely to cause residents using wood heat to switch to propane. This outlook may not be an issue since there are relatively few structures in the low density areas and they are widely dispersed. However, it does mean that this group may not benefit from the energy investment available to other residents.

1 Introduction

In November 2011, the Fairbanks North Star Borough (FNSB) solicited proposals from consulting teams to develop an optimized plan for a rapid build-out of the borough's energy distribution infrastructure, and to assess the effect of the build-out on air quality in the FNSB's PM_{2.5} nonattainment area.¹ Northern Economics, Inc. assembled a team of engineers, air quality specialists, and experienced natural gas utility managers and submitted a proposal in December.

1.1 Project Goals

The FNSB set two overarching goals for the project:

- To define a supply-neutral optimized plan for the rapid built-out of the FNSB's energy distribution system—one that delivers propane or natural gas as affordably as possible, to the largest number of borough residents, businesses, and business and residential properties.
- To assess the impact of the proposed infrastructure build-out on air quality in the FNSB nonattainment area.

1.2 Major Findings

Construction and operation of a piped natural gas distribution system in the high-density and medium-density areas of the FNSB (See Figure 2), and a traditional propane distribution system in the low-density areas of the borough, has the potential to reduce fuel costs for space heating of residential and commercial structures from approximately \$524 million in 2021, the first full year of operations, to about \$210 million, a savings of roughly \$315 million annually (See Table ES-5.), a savings of 63 percent compared to the status quo using fuel oil and wood. These estimates will change with different assumptions or if capital costs or commodity costs change, but the magnitude of the savings is so large that it is evident that substantial savings will accrue under almost any future scenario that employs natural gas and propane.

Similarly, converting to natural gas for space heating will reduce the overall emissions of PM_{2.5} in the Fairbanks area by a significant amount (See Figure 22). The conversion to natural gas will also reduce NO_x and SO₂ emissions, which are precursors to the formation of secondary PM_{2.5} in the atmosphere. Combined, these emission reductions will help bring the Fairbanks area into attainment with the ambient PM_{2.5} air quality standard.

1.3 Report Organization

The initial work product was a Preliminary Executive Summary Report, which provided an outline for the report as a whole, summarized initial results, and prepared order of magnitude market demand and gas distribution costs. The Preliminary Executive Summary Report was submitted in January; this document expands upon that initial outline to provide the full report.

¹ The nonattainment area is a designated area in which certain air quality standards are exceeded a specific number of days per year. The FNSB has a nonattainment area for particulate matter 2.5 microns or smaller in size.

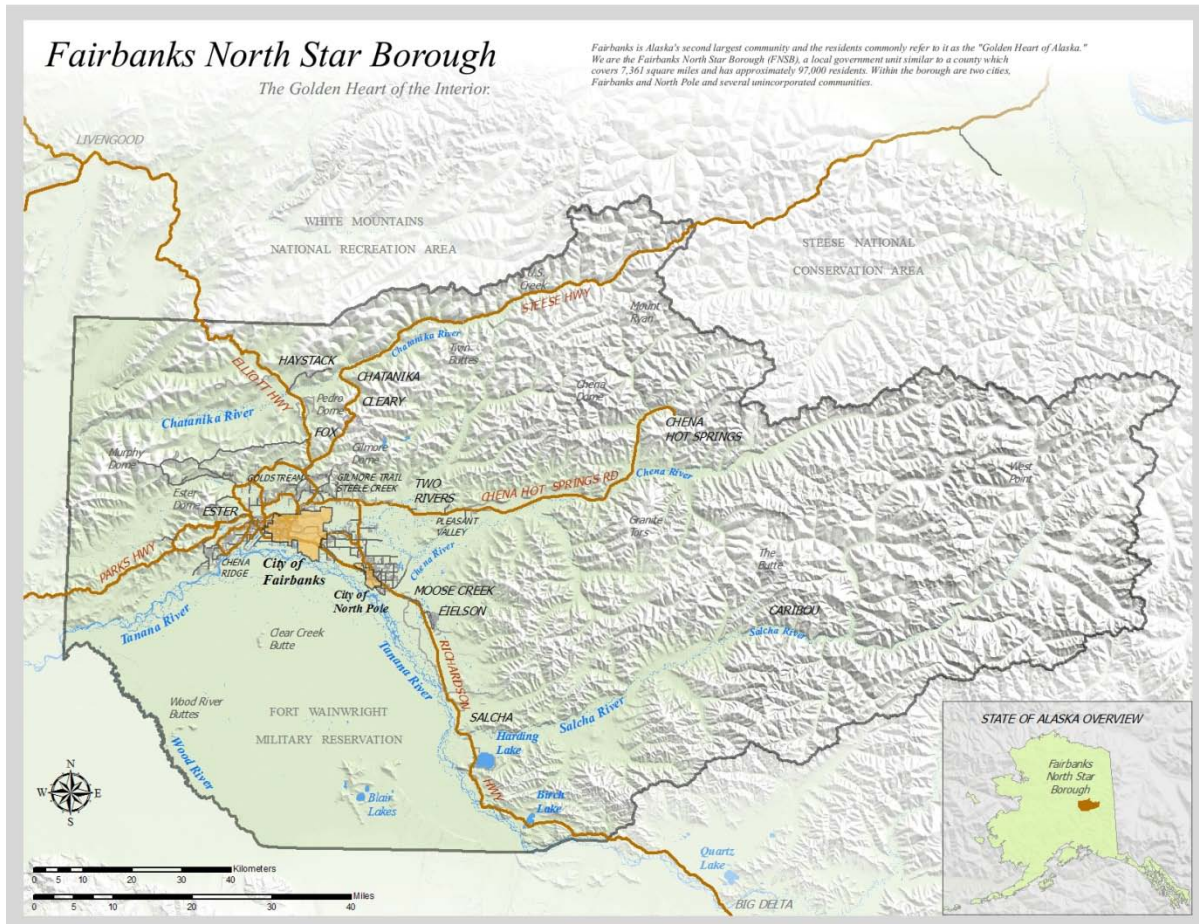
This report is organized into 12 sections:

- Section 1 Introduction: Describes project goals, background for the project, and maps.
- Section 2 Market Estimates: Discusses demand estimates for natural gas and propane.
- Section 3 Conceptual Design: Describes transmission and piping layout.
- Section 4 Business models: Discusses such options as private firms, government ownership, or cooperatives.
- Section 5 SWOT Analysis: Examines strengths, weaknesses, opportunities and threats of potential organizational structures.
- Section 6 Cost of Service, Financial Analysis: Provides estimates of the gas cost to consumers, sustainability of the gas distribution entity, and a benefit-cost analysis.
- Section 7 Consumer Savings: Discusses savings to consumers from conversion to natural gas.
- Section 8 Benefit-Cost Analysis: Shows estimated cost savings to residential, commercial, and industrial users from the conversion to natural gas from other fuels.
- Section 9 Contingencies: Examines major issues that could delay (or accelerate) the potential project.
- Section 10 Air Quality: Discusses the issue of PM_{2.5} and how increased use of natural gas could affect air quality.
- Section 11 Decision Points: Discussion of decision points regarding conversion by zone.
- Section 12 References: Provides a list of works cited for this report.

1.4 Study Area

The study area encompasses all of the FNSB which is shown in Figure 1.

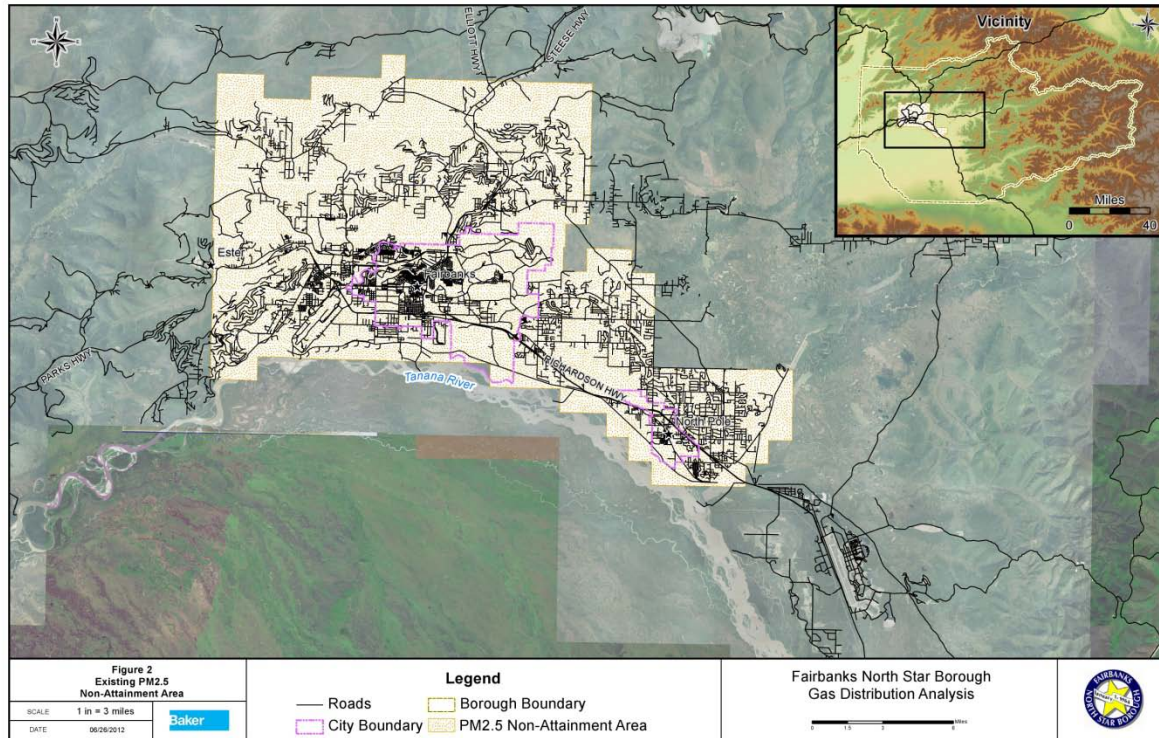
Figure 1. Overview, Fairbanks North Star Borough



Source: FNSB, 2011b.

The borough's air quality nonattainment area is shown as the $PM_{2.5}$ area in Figure 2. This is the area where 2.5 micron and smaller particles exceed the United States Environmental Protection Agency (EPA) air quality standards. Boundaries for the City of Fairbanks and the City of North Pole are also shown in the figure.

Figure 2. Fairbanks North Star Borough PM_{2.5} Nonattainment Area



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

2 Market Estimate

This section provides a revised estimate of the market potential for natural gas or propane within the entire FNSB jurisdiction. This market size (demand) is defined in terms of annual natural gas or propane consumption for space and water heating, power generation, and industrial processing for structures and entities located within the borough's geographic jurisdiction. The market demand estimates are used to size the gas transmission line and other facilities, and they are also key inputs to the financial, benefit-cost, and air quality analyses.

It is common convention for utilities to sell natural gas by volume (cubic feet). However, heating demand is expressed in units of energy (British thermal units, or Btu). This analysis uses a conversion rate of 1,000 Btu per cubic foot of natural gas. Propane is also sold by volume, but is conventionally measured in gallons, with each gallon providing 91,333 Btu of energy. Energy demand for propane is expressed in cubic feet equivalents in this section so that multiple units are not required.

An in-depth review of the GIS database which provides information on the number and size of residential and commercial structures within the FNSB jurisdiction, and estimates of heating loads per type of structure, it is estimated that the market potential for natural gas is 20.5 Bcf per year or an average of 56 MMcfd.

Table 1 provides the estimated annual residential, commercial, and industrial sector demand for natural gas in the FNSB region. The total potential demand represents an energy estimate in numbers of Bcf per year of the total natural gas requirements for:

- Space heating of existing residential, commercial and specific industrial structures, including non-private structures
- Power generation assuming conversion of Golden Valley Electric Association's existing 60 megawatt (MW) combustion unit from burning naphtha to burning natural gas
- Processing needs of the existing refineries in North Pole.

Table 1. Estimated Annual Residential, Commercial, and Industrial Sector Natural Gas Requirements for Heating, Power Generation, and Industrial Processing

Category	Count (# of units)	Area (square feet)	Demand (Bcf/Year)
Residential Sector	25,651	58,431,707	6.4
Commercial Sector			
Taxable Structures	2,447	21,816,488	5.6
Non-Private Structures	136	4,754,085	0.6
Industrial Sector			
Power Generation			3.1
Refinery Processing			4.8
Total	28,234	85,022,003	20.5

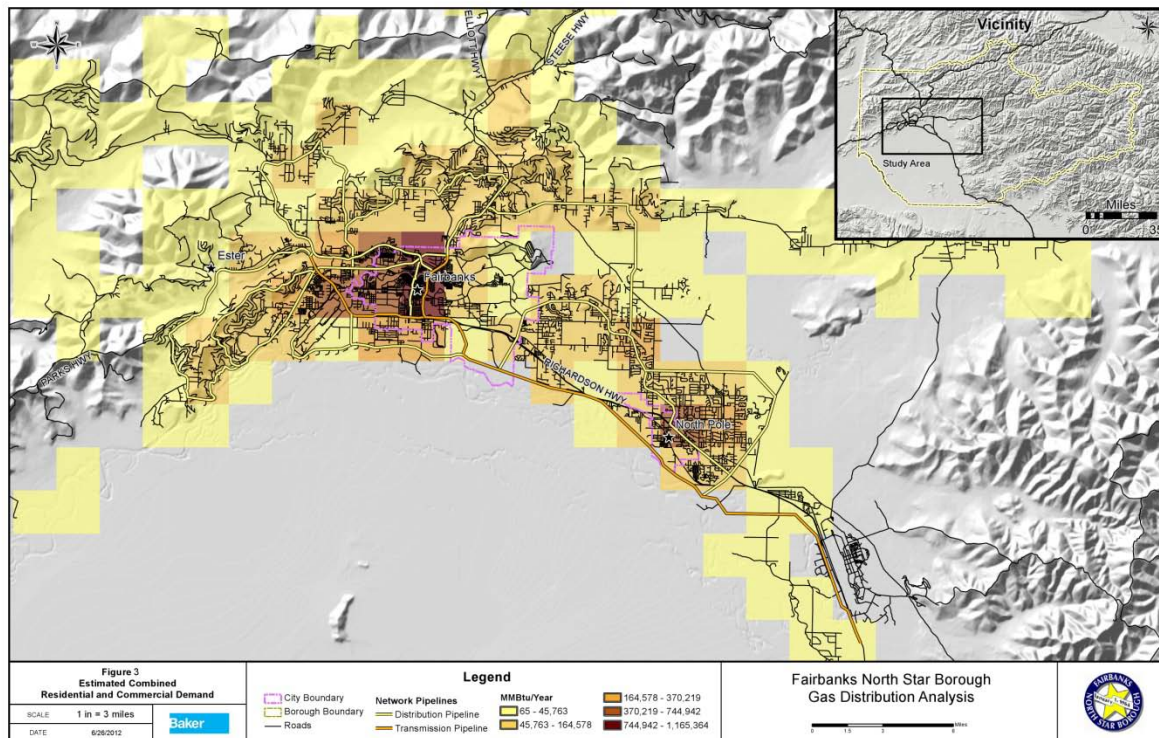
Source: Michael Baker, Jr. and Northern Economics, Inc., adapted from FNSB Property Database.

These estimates were derived using the FNSB Assessing Department's database, which has information on existing taxable structures within the borough; secondary data to determine potential load of non-private structures; and data on potential industrial energy requirements obtained from interviews and published sources.

Note that the total potential natural gas demand for the residential and commercial sectors represents 100 percent market penetration. The probability of conversion to natural gas use for heating and the timing of conversion is incorporated into the benefit-cost analysis (Section 8). Potential future demand and growth in the existing loads are also quantified and discussed in Section 8

Figure 3 shows the estimated heat loads for residential and commercial structures within the borough, based on structural square footage, a key indicator of heat loss and actual (total) heat load, as shown in the prior table, expressed in millions of Btu (MMBtu)/year.

Figure 3. Fairbanks North Star Borough, Residential and Commercial Structural Area



Source: Michael Baker, Jr. Inc., FNSB data files

Market penetration for natural gas in the region has been limited to date due to supply constraints, as ready access to Cook Inlet natural gas has been increasingly challenging. Natural gas in the form of liquefied natural gas (LNG) is currently being transported approximately 300 miles by truck from Point MacKenzie (located west and south of Wasilla) to an LNG storage and liquefaction facility in Fairbanks.

The existing natural gas distribution infrastructure in Fairbanks serves the heating needs of approximately 1,120 residential and commercial customers within the city. As reported in the FNSB's Community Research Quarterly for fall of 2011, Fairbanks Natural Gas (FNG) has 463 residential customers, 622 small commercial accounts, and 34 large commercial customers (Fairbanks North Star Borough, 2011).

In early 2012, the FNSB Assessor's property database identified 28,098 taxable residential units and commercial structures within the borough's jurisdiction. In addition, there are 136 schools and government buildings (non-private structures) that are not listed on the Assessor's database. Combined, there are 28,234 residential and commercial structures within the borough's jurisdiction

(see Table 1). Fewer than five percent of the existing residential and commercial sector units are supplied with natural gas for their heating requirements. In terms of volume, in 2011 FNG sold 841,288 thousand cubic feet (Mcf) of natural gas to all its customers (2011 FNG report to Regulatory Commission of Alaska [RCA]). This volume represents about 7 percent of the total estimated natural gas requirements of the existing residential and commercial structures in the borough.

Most residential and commercial customers in the borough use heating oil for space heating and domestic hot water, though some use propane, wood, or coal. There are a number of coal-based power generation facilities in the region including those that serve the university and the military bases. Golden Valley Electric Association (GVEA), which is the largest power utility in the region, generates power locally using oil, naphtha, and coal. In the core downtown area, Aurora Energy, LLC operates a coal-fired power plant, a system that also provides steam and hot water to approximately 165 customers along four district heating loops (three are hot-water and one is steam).

Access to natural gas and expansion of the existing natural gas distribution infrastructure are necessary in order for the market for natural gas to grow. Environmental concerns related to EPA's designation of much of the borough's residential and commercial sectors as a nonattainment area for PM_{2.5} provide impetus for switching from oil, wood, and coal to natural gas for space heating. Air quality issues are a major concern and economic development in the non-attainment area is currently constrained by potential additional emissions. These issues are addressed in Section 10.

This estimate of market potential for natural gas is the initial step to arrive at the probability-based demand for natural gas in the FNSB. The next step (Section 2.5) removes the demand for customers served by FNG and Aurora Energy, demand from GVEA and Flint Hills, and recreational or seasonal cabins to arrive at the total demand that may be served by a new or an expanded natural gas distribution company. In the third and final step (Section 2.7), a probability-based spreadsheet incorporates the planned construction schedule, conversion costs, potential natural gas prices to the consumer, population change, and other factors to determine annual market demand over the study period (2012 to 2065). This information is also used in the financial analysis and the benefit-cost analysis.

The following sub-sections provide more details on the estimates of the current natural gas demand for the residential, commercial, and industrial sectors, respectively.

2.1 Residential Sector

Residential sector consumption refers to natural gas used in private dwellings (including multi-residential units or apartments) for heating, air conditioning, cooking, water heating, and other household uses.

It is estimated that 6.4 Bcf per year or an average 17.5 MMcfd of natural gas will be required to meet the heating requirements of existing residential structures in the borough. The FNSB Assessor's database identified 25,651 residential units within the borough's jurisdiction, including all the structures identified as: 1) Residential; 2) Resi-Condo; 3) Multi-family; 4) Mobile Home; and 5) Trailer Court.

Of the roughly 25,651 residential structures, only 463 are being served by FNG. (FNSB 2011a) In other words, fewer than two percent of the existing residential structures in the borough are being served by the current FNG distribution system.

Table 2 summarizes market information for the Residential Sector. The estimates include residential customers that already use natural gas for heating (FNG customers) and all the other potential customers classified as residential structures in the Assessor's database. No assumption regarding the

number of these residential structures that would convert to natural gas has been incorporated in these estimates, though changes due to conversion, location, and cost are addressed in other report sections.

Table 2. Residential Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels	25,651
Area, lots, number of acres	90,716
Area, total building square footage	58,431,707
Area, average building square footage	2,278
Natural Gas Requirement per day (average MMcfd)	17.5
Annual Natural Gas Requirement (Bcf)	6.4

Source: Michael Baker Jr. and Northern Economics estimates.

The estimated residential sector load was derived using the following information:

1. Number and area (in square footage) of all taxable, including “exempt” residential structures (such as church residences) identified in the FNSB Assessor’s database;
2. Average base and heating loads as shown in Table 3. Base heating loads consist of natural gas consumed during summer months, with virtually no space heating requirements.

Table 3. Average Base and Heating Loads in Thousand Cubic Feet (Mcf) per Year by Size of Residential Structure

Size Range (Square Footage)	Count (# of structures)	Base Load (Mcf/Year)	Heating Load (Mcf/Year)	Total Load (Mcf/Year)
0 to 499	1,120	15	48	64
500 to 999	2,777	31	97	127
1,000 to 2,499	12,871	48	151	199
2,499 to 5,000	8,192	77	241	318
5,001 to 419,000	691	287	861	1,148

Source: Michael Baker Jr. and Northern Economics estimates; FNSB property database.

Notes:

1. The loads are based on ENSTAR’s natural gas consumption data for Anchorage structures adjusted for Fairbank’s heating degree days.
2. For large residential structures (greater than 5,000 square feet), total base and heating load were estimated using a per square foot factor of 0.13 Mcf per year. Out of the total 25,651 residential structures, the database identified 691 structures that are greater than 5,000 square feet in size.

According to FNG data provided in 2009, their residential customers on average consumed about 190 Mcf per year (Northern Economics, 2010). At that time, total residential sector consumption was about 64,000 Mcf per year. In comparison, the average estimated load across the range of sizes shown in Table 3 is approximately 250 Mcf per year. For structures less than 5,000 square feet, the average estimated load is about 225 Mcf per year.

Without any information regarding the size of residential structures currently served by FNG, it is difficult to compare the results from this study with the 2009 data on average FNG residential sector consumption. The approach used in this study to determine base and heating loads relies on estimated average natural gas consumption for a specific range of home sizes. It is possible that the lower

average consumption by FNG customers is due to a smaller average home size in the area that is currently served by FNG, compared to the average home size for the entire FNSB area.

2.2 Commercial Sector

Commercial sector consumption generally refers to gas used for heating by establishments primarily engaged in the sale of goods and services such as hotels, restaurants, wholesale and retail stores, and other service enterprises. For the purpose of this study, local, state, and federal government agencies, as well as schools (collectively referred to as non-private entities) are also included in the Commercial Sector category.

As shown in Table 4, the estimated commercial sector heating requirement is 6.2 Bcf per year or an average of 16.9 MMcfd. This heating and base load estimate includes commercial customers that are already being served by FNG, as well as the potential commercial sector customers within the borough's jurisdiction that could convert to natural gas.

Table 4. Commercial Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels (taxable)	2,447
Area, lots, number of acres (taxable)	6,688
Area, average building square footage (taxable)	5,078
Area, total building square footage	
Taxable structures	21,816,488
Non-private structures ¹	4,773,808
Natural Gas Requirement per average day (MMcfd)	
Taxable structures	15.2
Non-private structures	1.7
Total	16.9
Annual Natural Gas Requirement (Bcf)	
Taxable structures	5.6
Non-private structures	0.6
Total	6.2

Source: Michael Baker Jr. and Northern Economics estimates, based on FNSB property database and load data provided by ENSTAR.

¹ Note: This value is the sum of square footage for 136 non-private facilities located within the Fairbanks North Star Borough, excluding 16 facilities that are owned by the City of North Pole for which there are no square footage data. Natural gas requirements for the City of North Pole facilities were estimated using actual heating oil consumption in 2010.

The commercial sector's potential natural gas requirements were estimated using the following information:

1. Area (in square feet) of all commercial structures identified in the FNSB Assessor's database (taxable structures);
2. Area (in square feet) of the non-private facilities—including schools, federal and state office buildings, and facilities owned by the City of Fairbanks. The data for the state-owned facilities in Fairbanks were obtained from the Alaska Department of Transportation and

Public Facilities; data for the City of Fairbanks facilities were provided by the City's Property Manager; data for the schools and borough-owned facilities were provided by the borough's Project Manager, Director of Public Works; and data for the federal buildings were obtained from General Services Administration's Operations Manager;

3. Data on base and heating load per square foot for specific types of commercial customers.

ENSTAR provided information on actual natural gas consumption for various types of businesses listed in their database of Anchorage customers. Examples include natural gas requirements for facilities such as government buildings, malls, retail stores, schools, parking garages, warehouses, office buildings, museums, and dry cleaning facilities. The estimated natural gas consumption for specific types of facilities was provided on a per-square-footage basis. This per-square-foot load estimate was then multiplied by the square footage data as noted in items 1 and 2. Finally, the load was further adjusted upward to account for the difference in the heating degree days between Anchorage and Fairbanks. This methodology was used to derive heating requirements for 2,447 taxable and 136 non-private structures.

There are 16 facilities that are owned by the City of North Pole for which actual fuel (heating oil) consumption data were provided; square footage data were not available. The data were obtained from the Director of City Services for the City of North Pole. For these facilities, potential natural gas requirements were estimated using the equivalent Btu content of heating oil.

The estimated natural gas requirements for Fairbanks Memorial Hospital were obtained from previous estimates provided by FNG as published in the Interior Issues Council Report (In-State Gas Pipeline Supply Options Study, 2009).

Note that FNG currently already serves 622 small commercial customers and 34 large commercial customers, a total of 656 commercial customers. (FNSB 2011a)

There are 2,447 commercial establishments identified in the Assessor's database and an additional 136 non-private structures identified during this research. These numbers imply that roughly 25 percent of the current commercial sector market for natural gas is already being met. It should be noted, however, that there may be other non-private structures that may have been missed in the attempt at an inventory of non-private facilities.

As expected, market penetration in the commercial sector is higher compared to the residential sector. Economies of scale with respect to conversion costs are achieved with the commercial establishment's higher heating loads.

2.3 Industrial Sector

Industrial sector consumption refers to two types of natural gas use—fuel for electricity generation and fuel for industrial processing needs. The estimate of the total industrial sector demand for natural gas is about 7.9 Bcf per year, or an average of 21.7 MMcfd. This amount represents the estimated industrial sector natural gas requirements. However, GVEA and Flint Hills are proposing to liquefy and transport LNG from the North Slope direct to their facilities. Hence, the amount of natural gas they would require is not expected to be part of the volume that would be transported through the natural gas distribution system (See Section 2.5).

Note that it is unlikely that existing facilities that use coal for heating and power generation would switch to natural gas in the near future. These existing coal-based facilities include Eielson Air Force Base, Fort Wainwright, Aurora Energy, and the Central Heat and Power plant at the University of

Alaska Fairbanks.² If these facilities convert to natural gas, it is estimated that they will require about 9 Bcf of natural gas per year. However, this potential demand is not included in the total estimated industrial sector demand of 7.9 Bcf per year but the conceptual design of the natural gas transmission lines does allow for these coal-based facilities to be served in the event that they convert in the future.

2.3.1 Electricity Power Plant Load

Power sector demand is estimated to be about 3.1 Bcf per year. Unlike the residential and commercial sectors, the estimated demand for the power sector only represents a portion of the total power sector market. The demand estimate reflects 20 percent of the total existing generation capacity of GVEA.

GVEA is the primary utility that provides electricity in the region and it utilizes a diverse mix of fuel including oil, naphtha, coal, natural gas, and hydroelectric. The utility serves about 44,000 customers in the Fairbanks, Delta Junction, Nenana, Healy, and Cantwell areas.

The GVEA combustion turbine (GT3) at their North Pole facility is the most likely to convert to natural gas (IIC, 2009). The GT3 is a 60 MW LM6000 combined cycle unit that currently fires naphtha, a clean burning fuel, produced at the Flint Hills refinery located nearby. Based on current data provided by GVEA, the GT3 unit consumes 24.2 million gallons of fuel per year. Given a heat content of 127,500 Btu per gallon of naphtha, the estimated natural gas requirement for GT3 is about 3.1 Bcf per year.

Note that the steam turbine generator at the North Pole expansion facility is double-sized to prepare for a possible power plant expansion. Adding another 60 MW of generating capacity could double the power sector natural gas demand to 6.2 Bcf per year. Furthermore, the original 120 MW capacity North Pole plant that has the GT1 and GT2 units could also be retrofitted with natural gas. However, currently there are no plans to retrofit these units to natural gas due to design issues.

2.3.2 Industrial Processing Load

The estimated load for industrial processing refers to the natural gas requirements of the two existing refineries in the region.

Flint Hills Resources' North Pole refinery is located southeast of Fairbanks in North Pole. The refinery is the largest in Alaska with a crude oil processing capacity of 220,000 barrels per day. The facility consumes about 64,000 barrels of North Slope crude oil per day to produce various petroleum products including gasoline, jet fuel, heating oil, diesel fuel, gasoil and asphalt for supply to Alaska markets. The refinery uses a portion of the crude stream to fire boilers and the distillation tower for the production of liquid fuels. (IIC 2009)

The Petro Star refinery is also located in North Pole. This refinery has a capacity of 22,000 barrels per day, producing kerosene, diesel, and jet fuels. The refinery uses both crude oil and non-condensable gases to fuel its crude oil refining process. (IIC 2009)

Both refineries are expected to switch to use of natural gas to meet their processing needs. It is estimated that the two refineries will require a total of 4.8 Bcf of natural gas per year or 13.2 average MMcfd for their processing needs. However, as noted earlier, Flint Hills and GVEA are expected to meet their needs independent of the natural gas distribution system.

Note that Flint Hills Refinery recently announced that it will be closing its No. 1 crude oil refining unit due to challenging economic conditions faced by the refinery (Alaska Journal of Commerce,

² Note that the Central Heat and Power Plant at UAF also uses some natural gas and oil besides coal for generation of power and heat.

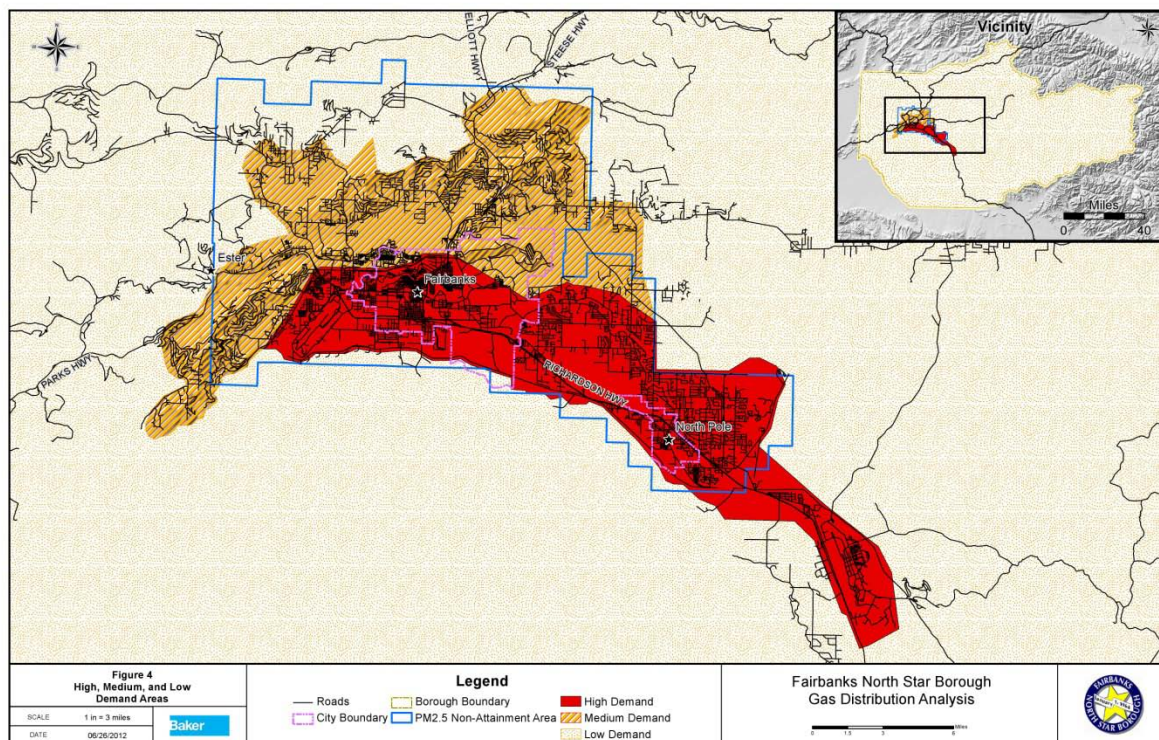
April 2012). The company will continue operating its remaining No. 2 crude unit to produce jet fuel, gasoline, asphalt, and other products to meet all its contractual commitments. The company noted that the refinery faces the problem of burning crude oil, which is costly at current prices, to provide energy for its refining operations. This study assumes that availability of cheaper natural gas in the future would bring the refinery operations back to 2011 levels.

In summary, the total industrial sector load is estimated to amount to 7.9 Bcf per year or an average of 21.7 MMcfd—3.1 Bcf per year for power generation plus 4.8 Bcf per year for refinery processing. If the coal-based power and heat facilities were to convert to natural gas, the potential natural gas requirement will increase by 9 Bcf per year, to a total of 16.9 Bcf per year.

2.4 Low, Medium, High Demand Borough Areas

Figure 4 displays the three demand zones within the FNSB, along with the boundary of the PM_{2.5} zone of non-attainment. The demand zones were created based on the density of development within the borough as identified through a geographic information system analysis, and the corresponding demand estimates for different structure types. The high-demand area is colored red, the medium-demand is noted with orange diagonal lines, and the low demand-area is the outlying area.

Figure 4. Map of Fairbanks North Star Borough with Three Zones of Demand



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

Pipeline construction for the high demand area is assumed to be completed by September 2015. However, residential and commercial sector conversion from heating oil is anticipated to occur over a period of five years; it is unlikely to achieve 100 percent market penetration in the first year that natural gas is made available. For the medium-demand area, construction is assumed to be finished by September 2016 with ongoing conversion similar to the high-demand area. Homes and commercial

buildings in the low-demand area are assumed to continue to use existing energy supplies, such as fuel oil, propane, or wood. The potential for air-propane and compressed natural gas is discussed in Section 3.4.

Table 5 summarizes the natural gas requirements (in Bcf per year) of the residential, commercial, and industrial sectors in the low, medium, and high demand areas.

Table 5. Estimated Natural Gas Requirements in the High, Medium, and Low Demand Areas by Category

Category	High Demand	Medium Demand	Low Demand	Total
	Bcf/Year			
Residential	3.27	2.28	0.84	6.38
Commercial	5.58	0.43	0.16	6.18
Taxable Structures	5.06	0.34	0.16	5.56
Non-Private Structures	0.52	0.09	0.01	0.61
Industrial	7.90	0.00	0.00	7.90
Power Generation	3.1	0	0	3.1
Refinery Processing	4.8	0	0	4.8
Total	16.75	2.71	1.00	20.46

Source: Michael Baker Jr. and Northern Economics estimates.

2.5 Adjusted Natural Gas Demand

The sections above presented the estimated natural gas requirements of the residential, commercial, and industrial sector in the region. The results indicated that the total market potential for natural gas in the region is approximately 20.5 Bcf per year assuming that all residential and commercial structures in the region would use natural gas for space heating and other base load requirements (e.g., cooking, water heating), and that the estimated industrial sector load will be transmitted through the expanded local distribution system. It is unlikely, however, that this total market potential will be realized as soon as natural gas becomes available in the region. Rather, it is more likely that penetration of natural gas in the total energy market in the region will vary by sector depending on factors such as the economics of conversion.

This section presents the adjusted market demand for natural gas in the region, this time making adjustments to account for the following:

1. Natural gas use by FNG customers. FNG currently has 463 residential customers and 656 commercial customers. Since FNG customers already consume natural gas, the total market potential is reduced by current consumption of natural gas in the region (already existing). In 2011, FNG sold 841,288 Mcf (or 0.84 Bcf) of natural gas to its residential and commercial customers (FNG's 2011 RCA filing), the adjusted market demand for natural gas therefore takes into account this amount.
2. Energy consumption by Aurora Energy customers. This study assumes that Aurora Energy will continue to use coal to generate energy to support its existing steam heat and hot water heat customers. Aurora customers are also assumed to remain Aurora customers and not switch to natural gas for their energy requirements. Currently, Aurora Energy has 47 residential customers and 133 commercial customers, all of which are located in the high-demand zone. Given the estimated annual average natural gas requirements for residential

and commercial customers, the annual market potential for natural gas is adjusted by approximately 350,000 Mcf per year (or 0.35 Bcf per year).

3. Industrial sector consumption. Flint Hills and Golden Valley Electric Association are currently working on a project that will bring liquefied North Slope gas to the Fairbanks North Star Borough for use in power generation at the GVEA power plant and processing at the Flint Hills refinery in the North Pole. The proposed project is expected to deliver natural gas directly to the power plant and the refinery. This study therefore assumes that these entities' natural gas requirements (as discussed in the previous section) will not be part of the initial volume of natural gas that will be distributed through the expanded local distribution system in the region (as envisioned in this study). The annual market potential for natural gas is reduced by approximately 7.6 Bcf (3.1 Bcf for GVEA and 4.5 Bcf for Flint Hills).
4. Natural gas or propane requirement for seasonal, recreational, or occasional-use housing units. The 2010 Census reported that there were 1,676 vacant housing units in the FNSB in April of 2010 due to seasonal, recreational, or occasional use. This study assumes that the majority of these units are in the low-demand area, and that these are primarily dry cabins (no running water or anything that can be destroyed by the cold since heating costs are too high in the Interior winter). Market demand is adjusted by reducing the heat demand of the 4,278 residential units in the low-demand zone by the estimated heat demand of the 1,676 vacant units.

In summary, these adjustments resulted in an estimated annual market demand of 11.5 Bcf; a reduction of 9 Bcf from the estimated market potential of 20.5 Bcf per year as shown in Table 6. The potential market that will be served by the piped distribution system is also shown in the table. The remaining volume of the adjusted market demand not served by the piped distribution system is anticipated to be serviced by propane or propane-air systems.

Table 6. Adjusted Residential, Commercial, and Industrial Sector Market Demand for Natural Gas or Propane in the Fairbanks North Star Borough

Category	Total Estimated Market Potential	Adjusted Market Demand	Potential Market Served by Piped Distribution System
	Bcf/Year		
Residential Sector	6.4	6.1	5.6
Commercial Sector	6.2	5.1	4.9
Industrial Sector	7.9	0.3	0.3
Total	20.5	11.5	10.8

Source: Northern Economics estimates.

Table 7 and Table 8 show the adjusted number of residential and commercial structures in the region.

Table 7. Adjusted Number of Residential Structures

Item	Count
Total Number of Residential Structures	25,651
Number of FNG Residential Customers	463
Number of Aurora Energy Residential Customers	47
Number of Vacant Housing Structures	1,676
Adjusted Number of Residential Structures	23,465

Source: Northern Economics estimates.

Table 8. Adjusted Number of Commercial Structures

Item	Count
Total Number of Commercial Structures	2,583
Number of FNG Commercial Customers	656
Number of Aurora Energy Commercial Customers	133
Adjusted Number of Customers	1,794

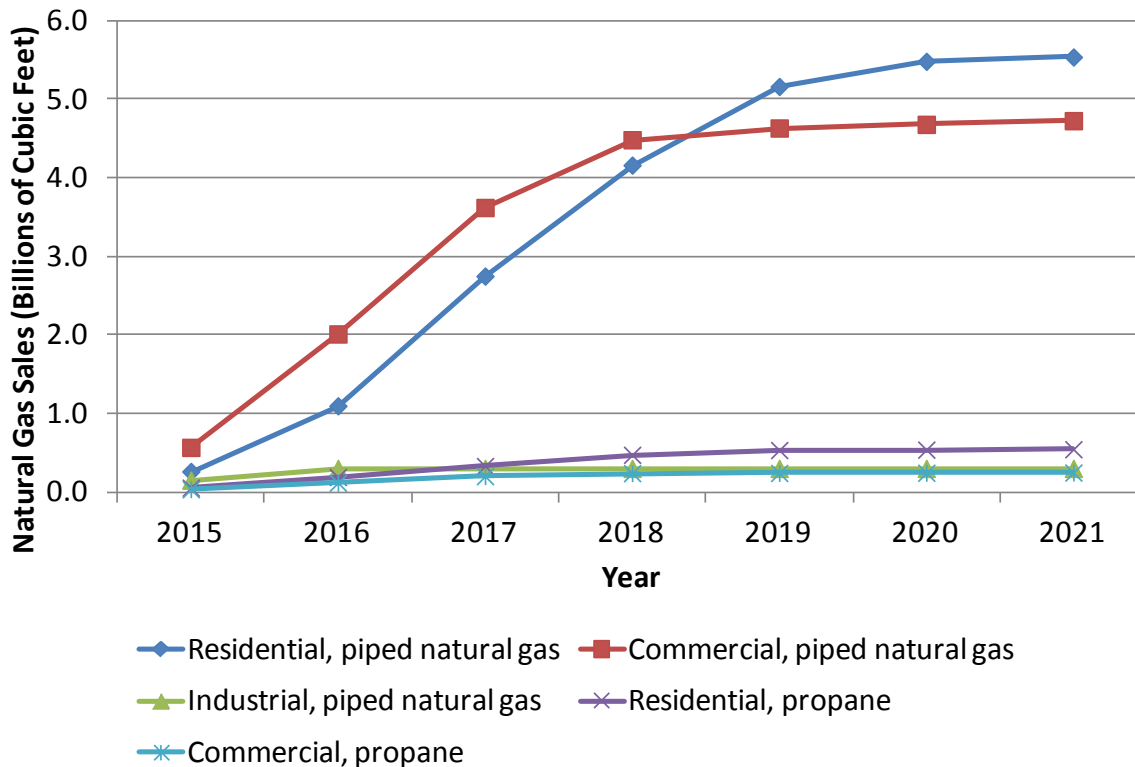
Source: Northern Economics estimates.

2.6 Projected Natural Gas and Propane Sales, 2015 to 2020

As discussed later in Section 6, the costs of natural gas and propane delivered to the consumer and the costs of conversion were compared to the costs of other heating fuels and the cost of boiler or furnace replacement on a 30-year cycle to determine if FNSB residents and businesses would switch to natural gas or propane. If the costs of natural gas and propane, plus the conversion costs were less than or equal to 90 percent of the cost of fuel oil the consumer was assumed to switch to natural gas and propane. If the costs of natural gas or propane, plus the conversion costs, were less than or equal to 110 percent of the cost of wood, the consumer was assumed to switch to natural gas or propane. The assumption that consumers would switch to a higher priced fuel in the case of wood is based on experience in the Susitna Valley when natural gas became available. Consumers switched to natural gas for the convenience factor and to avoid the disadvantages of heating with wood. In addition, a conversion rate was established for residential and commercial customers based on the experience in Southcentral Alaska.

Figure 5 shows the projected sales of natural gas and propane by user type. During initial project years, most of the change in demand is expected to be due to the adoption rate of natural gas and propane.

Figure 5. Projected Sales of Natural Gas and Propane by User Type, 2015–2021



Source: Northern Economics

Total energy demand is projected to grow about one percent annually from a starting point of about 11.4 Bcf in 2021. This growth rate generally follows increases in population and employment growth estimated by the ADOLWD.

2.7 Market Sensitivity Analysis

To account for potential variability in the assumptions used in the market demand estimates, the study used a simulation to evaluate the effect of changes in inputs on the cost of service, gas demand, benefit-cost ratio, and consumer savings. By conducting a simulation, the study team was able to determine the factors with the most impact on key outputs of the model and confirm that results of the analysis are robust given these changes.

The essence of simulation is the use of probability-based estimates and running several iterations of the model to evaluate the likely range of outcomes. The excerpt below is from the software package that the study used (Palisade Software’s @RISK):

@RISK uses a technique called “simulation” to combine all the uncertainties you identify in your modeling situation. You no longer are forced to reduce what you know about a variable to a single number. Instead, you include all you know about the variable, including its *full range of possible values* and *some measure of likelihood of occurrence for each possible value*. @RISK uses all this information, along with your Excel model, to analyze every possible outcome. It’s just as if you ran hundreds of thousands of “what-if” scenarios all at once! In effect, @RISK lets you see the full range of what could happen in your situation. It’s as if you could

“live” through your situation over and over again, each time under a different set of conditions, with a different set of results. [Emphasis added].

The study conducted a simulation using 10,000 iterations to gain a better understanding about significant variables and ranges of outcomes. A discussion of the simulation’s findings for the cost of service is found in Section 6.3.

Variables modeled in the simulation included:

- **Distribution costs for natural gas by distribution system.** Capital expenditures ranged from \$282.8 million to \$606.0 million, with a most likely value of \$404.03 million. As discussed in Section 6.3, distribution costs were the most significant factor in the cost of service for a private operator, and the second most significant for a government-run or cooperative utility.
- **Grant funding available for a government-run or cooperative utility.** If the gas utility were to be run by a government entity or a cooperative, it would have access to grant funding that a private company would not. The study team modeled grant funding and allowed the simulation to vary the grant based on a percentage of capital expenditures, ranging from 0 percent to 75 percent. This was the most significant factor in the price of service for a government-run or cooperative utility, as discussed in Section 6.3.
- **Percent change in the number of households by geographic service area.** Starting from 20,863 households in the high and medium areas, and 2,602 households in the low areas, in 2015, the study applied a variable growth rate (most likely of about 1.0 percent, with a range of 0.4 percent to 1.6 percent) for later years based on historic growth rates of structures in the FNSB taken from the Assessor’s database.
- **Percent change in the number of commercial structures by geographic service area.** Starting from 1,705 structures in the high and medium-demand areas, and 89 structures in the low-demand area, in 2015, the study applied a variable growth rate (*most likely* was about 1.0 percent, with a range of 0.41 percent to 1.6 percent) for later years which is the same as above.

Additional factors which were kept as fixed in the model included:

- **Price of natural gas delivered to Fairbanks.** The study assumed a Fairbanks city gate price of \$10.00 per million British thermal units (MMBtu) in 2015 and escalated the cost of gas of \$3.51 in 2015 based on 75 percent of the annual change in the EIA’s mid-petroleum price forecast for subsequent years. Other costs (\$6.49 per MMBtu) were escalated at the general inflation rate.
- **Percent change in employment by geographic service area.** Employment changes are dependent on detailed cost and construction schedule that will be developed as the project is approved. More specific details are contained in Section 7 of this report.
- **Demand per residential customer by geographic service area.** The study used an average demand of 250 MMBtu per residential structure each year, based on average demand data for residential structures provided by ENSTAR and adjusted for the heating degree days in Fairbanks.
- **Demand per medium and large commercial customer by geographic service area.** The study used an average demand of 2,533 MMBtu per commercial structure each year, based on average demand data for commercial structures provided by ENSTAR and adjusted for the heating degree days in Fairbanks.

- **Industrial demand by geographic service area assuming diesel displacement.** The study kept demand level over time, at 300,000 MMBtu.
- **Start year of build-out in the Fairbanks region.** The start year was not varied. It is driven by the project's schedule and was accelerated.
- **Annual build-out rate.** The annual build-out rate was not varied. It is driven by both conversion rates and the accelerated construction schedule and is discussed further in Section 3 of this report.
- **Conversion costs.** The study did not vary conversion costs through the simulation. It developed a weighted average conversion cost per structure instead, based on a range of estimated conversion costs and an estimated distribution of system types and ages.

2.7.1 Energy Efficiency and Conservation

Energy conservation can clearly reduce residential and commercial energy requirements. As a result, in 2008, the Alaska Legislature established the Home Energy Rebate Program, to provide incentives for homeowners to retrofit homes with better insulation, new furnaces, and other improvements that generated energy savings.

According to a recent publication by the University of Alaska Anchorage Institute of Social and Economic Research (ISER), approximately 16,500 Alaskan homeowners participated in the program from April 2008 to September 2011, or about 10 percent of statewide residences (ISER 2012). The average reported spending per household was \$10,963 with rebates of approximately 60 percent of that amount.

The following shows the estimated average annual savings in energy costs by type of weatherization improvement:

- | | |
|------------------------------------|-----------------------|
| • More efficient furnaces, boilers | 52 percent of savings |
| • More insulation: walls, doors | 14 percent of savings |
| • Sealed air leaks | 14 percent of savings |
| • Replace water heaters | 6 percent of savings |
| • Insulation: ceiling, foundation | 10 percent of savings |
| • Replace, fix windows | 5 percent of savings |

The ISER study suggested that the weatherization program resulted in a 15 to 20 percent reduction in fuel consumption among ENSTAR customers in Anchorage.

Fairbanks households accounted for 14 percent of all Alaska houses that were weatherized or 2,310 units. This number is approximately 13 percent of total current single-family residences in the FNSB, based on Appraiser's data (FNSB, 2012). Multiple family structures, triplexes, duplexes, cottages, cabins, and mobile homes are not included in this housing stock number.

Older homes in all regions of Alaska tended to be participants in the rebate program, likely due to less energy-efficient design and construction, especially for those homes built during the 1970s and 1980s (ISER 2012). Given the current stock of homes in the FNSB, with approximately 13,500 Fairbanks single-family homes built in the three decades from 1960 through 1980, and given that 2,310 homes already participated in the weatherization program, there could be about 10,000 or more homes that could benefit from the program and reduce energy consumption.

As natural gas distribution lines are extended through the high and medium density zones, homeowners that elect to burn natural gas could increase savings over current fuel oil costs by converting home heating and adding additional weatherization such as more insulation, tighter windows and doors, and combining hot water units with new higher-efficiency heating systems.

As noted by ISER and others, it is hard to draw a conclusion related to weatherization in Fairbanks and how it might reduce demand for natural gas. For purposes of this analysis, analysts made a simplifying assumption and used a constant demand for each type of structure, but varied the usable energy conversion rate (efficiency) from 0.85 to 0.95 for sensitivity analysis.

3 Conceptual Design

This report section provides information on the design of the pipeline distribution system, the cost estimate for the system, the schedule from design through construction, and a discussion of potential systems for the low density zone in the FNSB. Project team engineers used the demand estimates to prepare a conceptual pipeline design for the primary and discontinuous zones identified in Section 2. the prior report section.

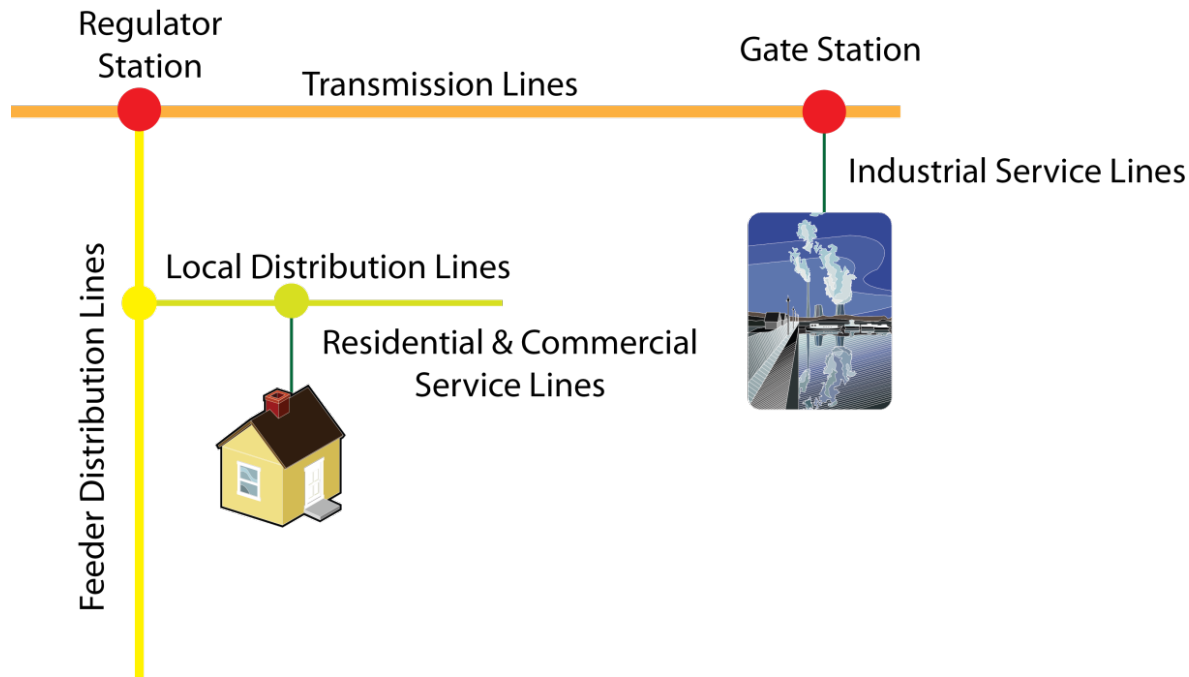
3.1 Pipeline Layout

The piped natural gas distribution system concept layout provides service to the high and medium-demand locations, which includes residential, commercial, and industrial users. The system is laid out assuming it will tie into the existing FNG distribution system. The concept system consists of the following elements:

- **Transmission lines** providing natural gas to feeder distribution lines and industrial users
- **Feeder distribution lines** providing natural gas to local distribution lines
- **Local distribution lines** providing natural gas to service lines
- **Service lines** providing natural gas to individual residential and commercial user service connections
- **Pressure regulating stations** which drop the high pressure of the transmission lines to lower service line pressure

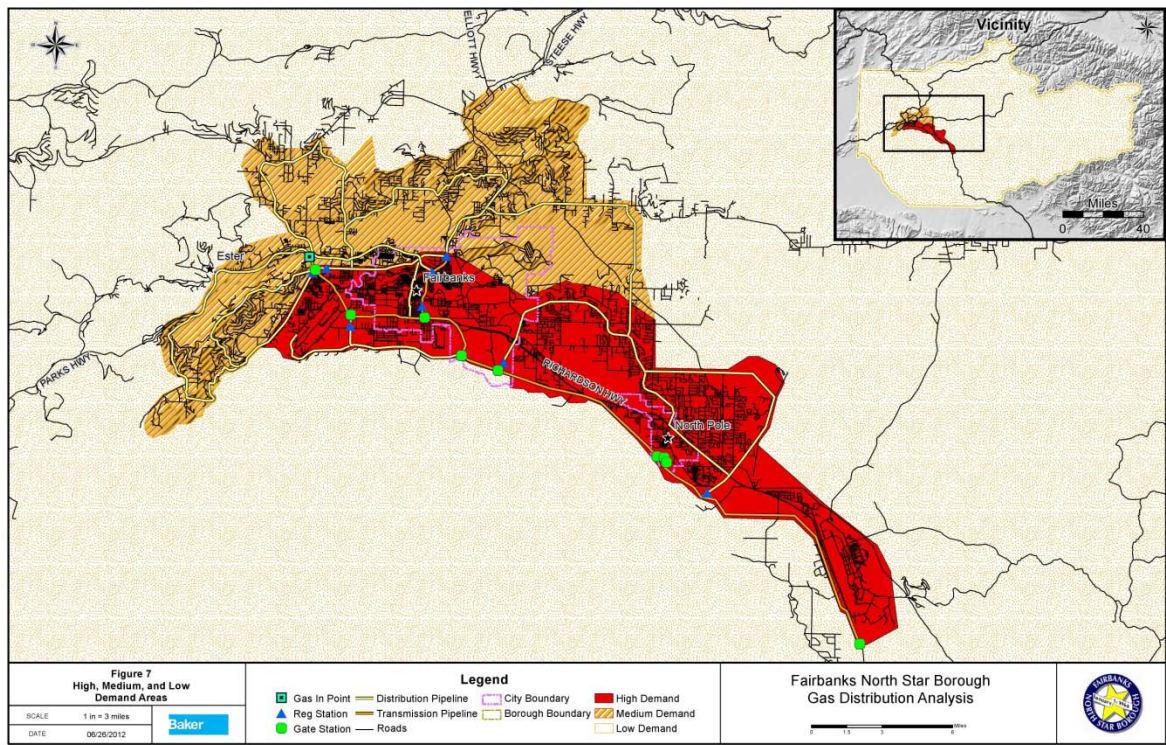
A schematic characterizing the relationship between the different types of lines is shown in Figure 6, while Figure 7 illustrates the piped natural gas distribution system layout in relation to the high, medium, and low-demand areas of the borough. Each of the system elements is described in more detail following Figure 7.

Figure 6 Schematic Pipe Relationship



Source: Michael Baker, Jr. Inc.

Figure 7. Conceptual Distribution System Layout



Source: Michael Baker, Jr. Inc.

Transmission Lines. The system includes two transmission lines. One line starts at an assumed tie-in point located west of Fairbanks near the intersection of the Parks Highway and Geist Road. The line runs southeast along the Parks Highway to the Mitchell Expressway, where it turns to the east until intersecting the Richardson Highway. It then runs southeast along the Richardson Highway for about two miles before veering south to Saddle Avenue. The line continues along Saddle Avenue until rejoining the Richardson Highway south of North Pole. The line ends at Eielson Air Force Base. A 10-inch diameter steel pipe with a total length of 31.9 miles is proposed. Future potential industrial users serviced by this line include University of Alaska Central Heat and Power Plant Coal Plant, Aurora Energy's Chena Power Plant, Fort Wainwright, PetroStar Refinery, Flint Hills Resources Refinery, and the GVEA North Pole plant. As noted earlier, with the exception of the PetroStar Refinery, none of these entities are expected to use the piped natural gas distribution system in the near term.

The other transmission line consists of an 8-inch diameter steel pipe that connects with the other transmission line at the intersection of the Mitchell Expressway and the Richardson Highway. The line runs north along the Richardson Highway and continues north along the Steese Highway until terminating at the Johansen Expressway, where it connects with two feeder distribution lines. The length of this line is estimated at 3.1 miles.

Feeder Distribution Lines. The feeder distribution lines are configured to provide service to Fairbanks and the outlying areas extending to Ester, the Goldstream Valley, and North Pole. The distribution lines run along the major roadways, including Chena Ridge Loop Road (also known as Chena Pump Road), Chena Ridge Road, Sheep Creek Road, Farmers Loop Road, Chena Hot Springs Road, Nordale Road, and Badger Road. The feeder distribution system is configured as a loop system, maintaining flow from multiple directions to minimize service interruptions. Six-inch diameter plastic pipe is proposed for the feeder distribution lines, which are estimated to total 118.2 miles of pipe.

Local Distribution Lines. The local distribution piping provides service to individual residences and commercial users. The layout is based on the local street network. Two-inch diameter plastic pipe is proposed for the local distribution lines with an estimated 804.4 miles of pipe.

Service Lines. Service lines connect individual users to the distribution system. Residential customers will be serviced with a 5/8-inch diameter plastic line. Commercial customers will be serviced with a 1-inch diameter plastic line. The estimated total is 325.3 miles of pipe.

Pressure Regulating Stations. The system uses two types of pressure-regulating stations to reduce the pressure from the transmission lines. Gate stations reduce the transmission line pressure to a user-specified pressure. Gate stations are provided for higher pressure feeder distribution lines and industrial users. Nine gate stations are proposed for the system. Regulator stations reduce the pressure from the transmission line to 60 pounds per square inch (PSI) for the lower pressure distribution and service lines. Regulator stations are located where the lower pressure feeder distribution lines connect with the transmission lines. Nine regulator stations are proposed for the system.

3.2 Initial Pipeline Cost Estimate

3.2.1 Preliminary Pipeline Cost Estimate

Table 9 summarizes the Class 4 Estimate for the piped gas distribution system. The total estimated costs range from \$282.8 million to \$606 million. This estimate is based on limited information and analysis (see section 3.2.2). A detailed Basis of Estimate and Cost Estimate are attached as Appendix A.

Table 9. Total Cost Estimate

Item	Estimated Cost Range (\$Millions)
Phase 1, High-Demand Area	
Engineering, Permitting & ROW Services	8.1 to 17.3
Construction	153.5 to 328.9
Total	161.6 to 346.2
Phase 2, Medium-Demand Area	
Engineering, Permitting & ROW Services	5.9 to 12.7
Construction	115.3 to 247.1
Total	121.2 to 259.8
Total Phase 1 and Phase 2	282.8 to 606.0

Source: Michael Baker Jr. Corporation 2012

3.2.2 Basis for Initial Estimate

Total Installed Cost (TIC) estimates are developed with varying accuracy ranges at different stages in a project. For this project, with design at a conceptual level of 1–15 percent complete, the Association for the Advancement of Cost Engineering assumes an expected accuracy range of +50/-30 percent and labels it a Class 4 estimate. This initial construction cost estimate uses a factored approach. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location, and constructability.

Separate estimates were developed for the Phase 1, high-demand locations (build-out in years 1–5) and the Phase 2, medium-demand locations (build-out in years 2–6). It includes major materials, installed pipe, engineering, and permitting costs. Provisions for unknown costs are included in the estimate. Unknown costs account for the uncertainty due to the lack of detailed design and project development for the current level of estimate. The unknown costs are estimated at 30 percent of the installed costs for this estimate. All costs are in 2012 dollars.

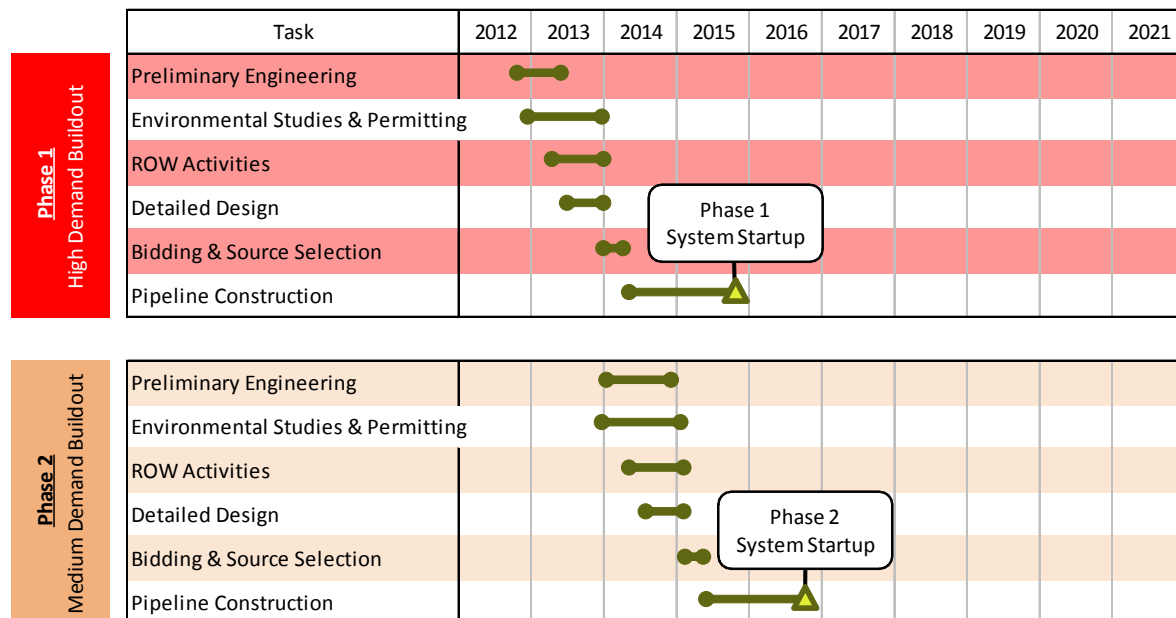
The initial estimate is composed of four elements:

1. **Transmission Lines.** This element includes the costs of installing the 10- and 8-inch diameter steel transmission pipe. Other costs covered in this element include cathodic protection, gate stations, and pigging equipment. All transmission lines will be installed during Phase 1 construction.
2. **Distribution Feeder Lines.** This includes the costs of installing the 6-inch diameter plastic distribution pipe. Regulator station costs are included in this element of the estimate. Distribution feeder lines will be installed during Phase 1 and Phase 2 construction.
3. **Local Distribution Lines.** This element includes the cost of installing the 2-inch diameter plastic distribution pipe. Distribution lines will be installed during Phase 1 and Phase 2 construction.
4. **Service Lines.** This element includes the costs of installing the small diameter (5/8 to 1 inch) plastic pipe which connect to the residential or commercial structures. Service lines will be installed during Phase 1 and Phase 2 construction.

3.3 Preliminary Development Plan and Schedule

The project development plan identifies the major tasks required to build an operational piped natural gas distribution system. Tasks include engineering, environmental studies and permitting, right-of-way (ROW) acquisition, procurement, and construction. Figure 8 shows a concept development plan schedule for the project. The schedule is broken into two phases. Phase 1 addresses the high-demand area, which is expected to be completed within the first four years. Phase 2 addresses the medium-demand area, which is expected to be completed within years two to five. For both phases, preconstruction activities such as engineering, environmental studies, permitting, ROW acquisition, and procurement are planned for the first two years. Construction and conversion activities are planned for the last three years of each phase.

Figure 8 Proposed Concept Project Schedule



Source: Michael Baker Jr. Corporation 2012

Note: Gas will flow in 2015 (Phase 1), while conversion continues.

A description of activities that occur during each major task is provided below.

Preliminary Engineering. Activities under this task will include existing data collection, concept pipeline layout, and engineering field reconnaissance. The pipe network will be modeled to determine the size of pipe needed. Field surveys and utility locates will be accomplished to support detailed design. The preliminary engineering task is expected to last approximately one year.

Environmental Studies and Permitting. Construction and operation of the gas distribution lines in the FNSB may require federal, state, and local permits. If federal permits are required, completion of the National Environmental Policy Act (NEPA) process and formal public and agency scoping may be necessary. Wetland, raptor, fisheries, and cultural resources studies may be required if information on potential effects on those resources does not exist for the project area. These studies must be conducted during the growing season. This task is expected to last approximately one year.

ROW Activities. This task will include surveying and mapping existing property boundaries and then identifying land status and ownership. Land ownership must be determined prior to finalizing the

list of necessary ROW permits. Temporary land use permits from federal and state land owners may be required for staging and temporary construction areas. ROW permits, easements, or acquisition efforts will then be completed. This task is expected to last approximately nine months; it could take longer depending on the complexity of any required ROW acquisition.

Detailed Design. Detailed design will include finalizing the pipe layout, sizes, and associated infrastructure. Because of the long lead time required for fabrication, pipe and major equipment will be ordered when this task is approximately 70 percent complete. The detailed design task is expected to last approximately six months.

Bidding and Source Selection. Once the design is finalized, the project will be advertised for bid and a contractor selected. This task is expected to last approximately three months.

Pipe Distribution System Construction. Construction will begin when the required permits are in place, ROW activities are complete, and a contractor has been selected. Construction is expected to last three years.

3.4 Propane or Compressed Natural Gas Zones

Borough areas outside of the high and medium-demand zones primarily depend on fuel oil, wood, and propane for cooking and heating. For the most part, these borough areas consist of low-density neighborhoods with scattered homes and businesses. Though it is difficult to discern from the available data, wood (17.2 percent) and fuel oil (67.3 percent) appear to be the largest heating fuel sources in the low-density zone (Fairbanks Home Heating Study 2010).

As a basis of comparison, Figure 9 illustrates a high density residential area in the northwest part of the area, while Figure 10 illustrates a low density area, also on the west of Fairbanks and at the same scale as Figure 9.

[illegible]

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Figure 10. Fairbanks North Star Borough, Gas Distribution, Representative Low Density Area



Source: Google Maps, © 2012 Google, Accessed May 2012

Several lower-density areas have developed as neighborhoods, and they are within the potential reach of natural gas lines when the lines are extended. However, natural gas connections cost money for transmission and distribution pipes, as well as connections from distribution pipes to homes or other buildings. Experienced natural gas utility managers in Anchorage suggest 10 to 12 service connections per mile are a target for economical operations. Fewer service connections per mile of distribution pipe, however, means greater cost per connection and higher cost per residence as capital costs are spread over fewer gas customers.

As noted, the FNSB contains pockets of more densely populated neighborhoods outside of the high or medium-density zones. Since these neighborhoods may be targets of opportunity by natural gas utilities, they can be prepared for natural gas by piping homes in the area and heating homes with mixtures of propane and air or possibly compressed natural gas (CNG). These neighborhood “pockets” exist along the Goldstream road, the Murphy Dome and Ester Dome roads, and the Old Nenana Highway.

The potential for propane and CNG use is discussed more thoroughly in the following sub-sections.

3.4.1 Propane

Current propane uses within the Fairbanks North Star Borough include cooking, heating, clothes drying, appliances (refrigerators), lighting, and recreational use (small to medium bottles for picnics, hunting trips or recreational vehicle use), consistent with similar uses in the rest of the United States.

One Fairbanks propane distributor noted a 50-mile operational radius for his firm in the Lower 48 states, but up to a 150-mile radius in Alaska, a further indication of low-density rural locations and higher delivery costs. Propane from Fairbanks is routinely dispatched to Denali National Park, Delta Junction and north to Livengood.

Propane Characteristics

Propane characteristics include:

- BTU per gallon 91,333 BTU
- Boiling point -44 degrees F
- Weight of one gallon 4.24 pounds (liquid)

One gallon of propane contains approximately 66 percent of the heat in a gallon of fuel oil, propane's primary competing fuel in the FNSB.

Winter temperatures routinely fall below boiling point temperature of -44 degrees in the borough. Solutions to keep propane flowing when this occurs include sheds or outbuildings that may be heated with electric lights or warming blankets that help insulate outside fuel tanks.

Propane-air mixtures

Propane may be mixed with air to produce a combined vapor mixture that has properties similar to natural gas. These systems draw liquefied propane gas (LPG) from a storage tank, add air with a blender and then inject the combined fuel stream into a vaporizer. Output from the vaporizer burns the same as natural gas. Figure 11 illustrates a LPG-air vaporizing system in northern Canada.

Figure 11. LPG Feed Tanks and Vaporizing Unit, Nunavut, Northwest Territories, Canada.



Source: Alternate Energy Systems, Inc., Peachtree City, Georgia, used with permission

These systems are currently used in China to provide a transition fuel while natural gas lines are being extended. Areas under development are prepared with natural gas piping and burn an air-propane mixture for up to 10 years before natural gas arrives (Alternate Energy Systems, 2012).

Pinedale, Wyoming developed a city-wide propane-air (PA) system in 1975 that currently provides energy to approximately 1,200 customers in a three-mile radius of town center (Pinedale Natural Gas, 2012). As the PA system developed, the company, Western Utilities, extended its connections several miles and connected to natural gas, switching from propane with minimum disruption in 1994. The original PA system served 200 customers over the 19 years it operated. Since converting to natural gas, the system now serves 1,200 customers. There are similar conversions pending at Wendover, Utah and Yreka, California. These examples are considered possible models for rural parts of the FNSB.

Subdivision development, with consolidated utility connections placed at the same time as roads and lots are improved for sale is an ideal candidate for a PA system. The capital costs for this piping would be spread over a larger number of lots, and these utilities would be ready for connection to a natural gas pipeline as they are extended. Until that time, PA mixes could be provided on a neighborhood basis with addition of a vaporizing unit and perhaps a storage system. However, as one FNSB resident noted, many residences in low-density parts of the borough are widely distributed with few located in subdivision-like clusters. In addition, there are a number of “dry cabins” with few if any utilities. For most residences and commercial buildings in the low density area a traditional propane system with a tank and truck delivery is the most likely scenario if propane were available at a price below that of fuel oil.

The possibility of residents in low-density areas within the FNSB switching to a propane system will be the decision of individual homeowners, based on their current heating system. As noted, fuel oil is currently more common and more cost-efficient than propane, based on prices reported by the borough in November 2011, and residents could incur several thousand dollars in capital costs to install a new propane heating system. The high cost of installation, along with higher fuel costs and lower efficiency suggest there is no short-term incentive for residents in low-density areas to switch from fuel oil to propane.

However, it seems reasonable that low-cost propane from the North Slope or elsewhere could substitute for fuel oil. Studies by ANGDA and others indicate that propane can be obtained on the North Slope at very reasonable prices compared to current prices for propane. This analysis assumes that lower-cost propane will be available from the North Slope or elsewhere in the state. Team members feel most homeowners would need at least a 10 percent reduction in equivalent heat cost before considering a switch from fuel oil. As noted earlier, the convenience factor of propane compared to wood could result in customers switching to propane if the cost were less than 10 percent higher than the cost of heating with wood.

3.4.2 Compressed Natural Gas

CNG, if available, competes with both LNG and propane. It is not generally used in the borough, though it is possible with the right infrastructure and delivery systems. (CCHRC 2009).

Three CNG systems currently exist in Alaska, all providing motor fuels for transportation. The systems at Barrow and in Anchorage (the latter shown in Figure 12) both provide CNG for buses, vans, and other passenger vehicles. The system in Fairbanks, operated by FNG, is intended to provide similar commercial and retail sales in the future but currently serves only its in-house CNG fleet. No system for using CNG as a source for space heating currently exists in Alaska.

Figure 12. CNG Fueling Hose, with Storage Tanks, Anchorage, Ditch Witch.



Source: Northern Economics, Ditch Witch, Anchorage.

CNG costs are approximately half of the per-gallon gasoline equivalent. A recent purchase of approximately eight gallons cost \$20, or \$2.50 per gallon, compared with over \$4.00 per gallon for gasoline.

Vehicles using CNG often burn gasoline as well, with the two fuels switching as required; dual-fuel vehicles can use either carburetors (preferred) or injectors. A driving radius of approximately 50 miles can be achieved with one refill of CNG.

CNG has limited potential for heating structures in the low-density areas of the FNSB. It requires in-place piping and a storage facility, much like PA systems discussed in the prior section. CNG is typically stored at 2,500 pounds PSI compared to the 200 pounds PSI for propane. Costs for individual CNG tanks and storage would be significant compared to propane. At this time the team believes conversion to CNG for space heating is less likely than PA systems.

4 Business Models

The primary goal for expanding the natural gas distribution system is to reduce energy costs (space heating and electric power) for businesses and residences in the FSNB as soon as possible. Once achieved, planners anticipate the secondary goals of stimulating economic development and improving air quality will follow. The purpose of this section is to evaluate business organization options to minimize the cost of natural gas service to residences and businesses, and maximize the number of residences and businesses that are served within five years.

4.1 Business Organization Options

There are three general business organizations that could be implemented for the FNSB Natural Gas Distribution System: 1) Private Company; 2) Non-Profit or Public Entity such as Cooperative or Municipal Utility; 3) Public/State Partnership. These three organizational models are described below using the following business parameters:

- Financial Characteristics—Capacity to raise capital or assume debt sufficient for the project plan with particular emphasis on:
 - Cost of capital
 - Cost-effectiveness of raising capital
- Organizational Characteristics:
 - Level of ratepayer control in business decisions
 - Operations and management of natural gas system
 - Transparency of governance
 - Stability
- Regulatory Requirements:
 - State and local regulatory requirements
 - Income and other tax

4.1.1 Private Company

This business organization option is based on the rules and regulations of a private utility corporation operating in Alaska such as ENSTAR Natural Gas Company and/or FNG. The company could be owned by shareholders or a private equity firm, controlled by a board of directors, and directed by management staff. Generally, a utility corporation in Alaska is regulated by the state through the Regulatory Commission of Alaska (RCA). The RCA certifies the utility to provide service for a specific geographic area and can choose to regulate the tariffs and rate of return allowable to the company.

The cost of service for a regulated natural gas utility is generally determined by the reimbursement for operating costs and the rate of return on asset equity allowed by the RCA. This provides incentive for the utility company to be efficient in its operation and investment to avoid costs that could be disallowed by the RCA. All gas utilities are subject to the standards for operations and maintenance set and enforced by the U.S. Department of Transportation's Office of Pipeline Safety.

Generally, the State of Alaska cannot extend tax exempt bonds or grants to a private company. Presently, the only options for a private company to gain tax-exempt funding in Alaska for a natural gas distribution system would be through the use of Alaska Railroad bonds and the recent House Bill 289 (LNG Storage Facility Incentive Bill).

Recent developments in bond markets, including a drop by Moody's on the rating of Alaska Railroad bonds because of potential federal funding cuts to the railroad, make it unlikely that a private company could gain tax-exempt funding in the near term.

Other considerations related to the cost-of-service for a private company include the requirement for profit and return on investment. Private companies are subject to property and income taxes. Permitting requirements for a private company such as obtaining ROWs and environmental clearance would be similar to the other business organization options. However, a private company might be required to complete more due diligence and risk mitigation related to schedule and construction permits in order to gain the necessary financing from banks.

4.1.2 Non-Profit Organization

4.1.2.1 Municipal Utility or Cooperative

This business organization is a way to organize potential ratepayers or "the public" to participate in providing an essential service. These non-profit organizations are eligible to receive tax-exempt funding from the state and federal governments.

In Alaska, most electric power is provided by public power associations or cooperatives such as GVEA. GVEA and other electric associations were organized through federal legislation that supported electrification projects in the rural U.S. There is no equivalent federal program for natural gas utilities, and there are only a few natural gas utility cooperatives in the U.S.

In a cooperative organization, ratepayers are members that invest in the utility system and can share in the return on that investment based on their consumption. The organization is controlled by a board of directors elected by the members. A utility cooperative is regulated to serve by the RCA and is not tax exempt, but pays income taxes on a different basis than private companies.

In a municipal utility, a local government provides electric or natural gas utility service along with other government services. Anchorage Municipal Light and Power is an example of a municipal utility in Alaska. A municipal utility in Alaska is also regulated by the RCA, whose regulations can include service area definition, tariff rules and regulations, service quality criteria, and establishment of recurring rates and charges.

As a government agency, a municipal utility is exempt from income and other property taxes. There can be additional funding options available to a municipal utility as it has the authority to create bonds for infrastructure projects. This authority is limited by taxpayer approval and the bonding capacity of the municipality. Regulatory risk and permitting requirements would be the same or lower than for a private company as a municipal utility might be able to coordinate permissions and ROWs within the government agency more easily than those organizations outside the government.

4.1.2.2 Local Improvement District

Another option for a municipal or borough government is to create a Local Improvement District (LID). A LID is usually created for the purpose of acquiring, installing or constructing capital improvements, all or a portion of the costs of which may be paid by assessments against the property benefited. LIDs may be initiated either by a petition of benefiting property owners or by a local

government. LIDs have been used in the Matanuska-Susitna Borough to pave roads and finance natural gas main lines and in Anchorage to construct water and sewer lines. Some of the specifics of a LID being used to finance construction of a natural gas distribution are outlined below based on recent natural gas LIDs implemented in the Matanuska-Susitna Borough.

From the gas utility perspective, LIDs are like any other main line extension project, with two notable exceptions:

1. The borough, rather than the individual property owner is the customer. The gas utility collects the main extension deposit from the borough and makes refunds of the deposit/Free Main Allowance (FMA) to the borough (over a 10-year period). The borough, in turn, pays off special assessment debt related to the project and makes refunds to the property owners.
2. The borough pays the main extension deposit after the project is complete rather than before construction begins. The borough must remit the deposit following construction so the special assessment requirements are met.

From the customers' perspective, a LID has two key advantages over a traditional utility line extension program:

1. A LID allows a property owner to finance the extension of a natural gas main line over a 10-year period, rather than remitting the full cost up front. The borough sells special assessment bonds and pays them off over 10 years, as participants pay off their assessments and the gas utility refunds the FMAs. Property owners are charged interest at prime plus approximately 1.5 percent (the interest percentage is bid each year among local banks)—historically a much better rate than most individuals can negotiate on their own.
2. A LID also spreads the cost of the project to all “benefiting properties”—even those without improvements. In a direct main extension, only property owners willing to participate provide financing for the cost of a main line extension. In a LID, all properties that benefit, even vacant lots, pay an equal share of the cost/assessment (a benefit includes an increase in property value), thus lowering the overall cost to the other participants.

The LID model can also be used to assist customers in financing the cost of heating system conversion. A form of the LID model has been used by counties in Colorado to create “special districts” that are used to finance renewable energy systems on homes.

4.1.3 Public–State Partnership

There is a spectrum of options for partnership arrangements with the State of Alaska depending how the state invests in the distribution system and the level of ownership the state retains after it is built. Some of the options include:

- Direct appropriation—the state funds the distribution system through legislation. The agreement between the agency that would own or operate the distribution system and the state would be determined in the legislation. This option would allow the state to invest in the state’s infrastructure and reap the benefits of economic development associated with that investment.
- The state uses its bonding authority to obtain a lower interest rate for the utility owner for financing of system. The bonding options include:
 - General Obligation Bonds

-
- Bonding by a state authority such as Alaska Gas Distribution Corporation, Alaska Housing Finance Corporation, or the Alaska Railroad Corporation that has more bonding capacity than the City of Fairbanks or the boroughs and could allow access to tax-exempt bonds.
 - Loan guarantee—state provides loan guarantee for the owner operator to reduce payment risk and cost of capital for the investment.
 - The state acts as an investor in the project and retains some ownership to gain return on its investment. Agencies such as Alaska Industrial Development and Export Authority (AIDEA) can retain ownership in infrastructure projects with favorable terms for repayment. These agencies can also offer technical assistance such as joining the Board of Directors to ensure that the infrastructure investment is operated and maintained to protect the state’s investment.

To better define the state partnership options that would be feasible for the FNSB gas distribution system, the study has developed two state partnership scenarios for the FNSB:

1. State Loan Support—the state provides a loan guarantee or bonds to support a financing program by FNSB. FNSB creates a municipal utility that would own and operate the system.
2. Joint Venture between FNSB and AIDEA to finance construction of system—create a joint venture for construction of all or part of the natural gas distribution system that would be financed by AIDEA. Ownership of system would pass to FNSB and system operation would be arranged through an operating agreement with a qualified operator.

The capacity of FNSB to raise the capital necessary for the proposed natural gas distribution system depends on the capital required and the bonding capacity of the borough at the time of construction. As of FY 2011, FNSB had about \$130 million in outstanding bonds. The debt service on the majority of these general obligation bonds is partially reimbursed by the State of Alaska because they fund school construction. Also, the ratio of net bonded debt to assessed value for FNSB is the lowest it has been for 10 years at 1.51 percent. Given the current debt status of FNSB, it could be a strong partner with the state with relatively low credit risk. However, it is unlikely that FNSB could independently fund the entire system. Therefore, an arrangement with the state where FNSB either pledges or directly finances a portion of the system costs (\$100 million) and the state uses other bonding mechanisms such as the Bond Bank Authority or a loan guarantee to finance the rest of the system is more feasible. With the state’s current bond rating, this arrangement would support the lowest cost of service.

The natural gas distribution system should be able to qualify for AIDEA’s Development Finance Program, which requires that a project: “prove to be economically advantageous to the state and to the general public welfare and must contribute to the economic growth of the state”. This program allows AIDEA to own “development projects” as a method of financing. AIDEA can finance a project with both debt and “cash”. Most AIDEA program borrowers have customarily been issued long-term, fixed-rate loans, with an average maturity of just over 20 years. Actual experience for the AIDEA portfolio is that loans are paid off substantially before they are due—averaging between six and seven years. However, AIDEA ownership comes with some strict regulatory requirements that could restrict the operation and implementation of the natural gas distribution system.

One option to reduce the regulatory requirements is to create a joint venture between AIDEA and FNSB for the construction of the natural gas distribution system and have FNSB retain ownership and operation of the system after it is completed. This arrangement has the advantage of using lower cost capital financing of the state and avoiding some of the regulatory requirements that would be involved in having AIDEA as an owner of the natural gas distribution utility.

The results of the quantitative analysis of business structures options found that the difference in cost of capital, taxes, and profits account for about six to eight percent of the overall cost to consumers. Therefore, on a cost basis alone, the difference between business models is not likely to be the determining factor driving customers to switch over to natural gas.

4.2 Regulatory Issues

The regulation of the business organization that would own and operate the natural gas distribution system is summarized in Table 1. Different aspects of the organization such as ratemaking and governance are regulated by different entities depending on the ownership structure of the organization. Regulation of a state partnership organization is the most uncertain at this time because it will depend on the regulatory requirements included the legislation creating the partnership.

Table 10. Regulatory Structure for Business Organization Options

Regulatory Aspect	Private Company	Non-Profit (Municipal/Cooperative)	State Partnership
Permission to serve	RCA Certification	RCA Certification	RCA Certification
Consumer Protection	RCA representation	Board of Directors RCA representation	State agency and/or RCA representation
Ratemaking	RCA has the option to regulate rates.	RCA has the option to regulate rates.	Legislative or agency oversight. Structure of regulation and requirements are uncertain.
Operations and Maintenance	Federal Office of Pipeline Safety standards and oversight.	Federal Office of Pipeline Safety standards and oversight.	Federal Office of Pipeline Safety standards and oversight.
Taxes	Subject to income and property tax.	Municipal—tax-exempt. Cooperative—not tax-exempt but pays income taxes on a different basis than private companies.	Tax-exempt.
ROW permission and permitting	Must obtain permission for ROWs from landowner and land-use plan.	Municipal utility model could have lower effort for ROW and land use plan changes.	Municipal utility model could have lower effort for ROW and land use plan changes.

Source: Alaska Energy Board

5 SWOT Analysis

A SWOT analysis for each of the four business organizations discussed above (Private Company, Municipal Utility or Cooperative, Local Improvement District, and State Partnership) is included in Table 11 through Table 14. The SWOT analysis is based on the ability of the organization to meet the primary goal of achieving the lowest cost energy to the most residences and business in the Fairbanks area as soon as possible.

Some of the specific aspects considered in the SWOT analysis based on preliminary system design and costs estimates include:

- Meeting a capital investment requirement in the range of \$283 million to \$606 million to complete high and medium-demand areas, with a median investment requirement of about \$404 million.
- Complete build-out of system within 5 years.
- Likelihood that air quality goals will be achieved. One of the keys to achieving PM_{2.5} attainment is switching solid fuel (coal/wood) heating systems to natural gas. This will probably require a cost of service for natural gas near \$15 per MMBtu (the cost of wood fuel for heating).

The SWOT and cost of service analysis indicate that a state partnership organization, especially with the support of grants or loan guarantee arrangements, could substantially improve project returns and end-user affordability. This business organization is the most likely to result in end-user costs near the \$15 MMBtu target to promote solid fuel switching. With the monetary backing and financial support of the state, the state partnership is also most likely to achieve the trifold community goals of lowest costs, broadest service area, within five years or less.

Table 11. SWOT Analysis: Private Company

STRENGTHS	OPPORTUNITIES
<ul style="list-style-type: none"> • Ability to raise capital needed for initial distribution system investment and future expansion. • Can use debt or equity to raise capital. • Cost of capital depends on size and strength of corporation. • Highest internal incentive to have efficient system operations and reliability to maximize return on distribution system investment. Supports investment in in-house technical expertise for system operation and maintenance. 	<ul style="list-style-type: none"> • New utility company in Fairbanks would strengthen local business infrastructure, create local jobs, and provide opportunities for outside investment in local community. • Potential for sales tax income to borough generated by private company gas sales.
WEAKNESSES	THREATS
<ul style="list-style-type: none"> • Highest cost of service option because corporation requires profit and return on distribution system investment. • Lowest level of transparency and ratepayer control in decision-making. • Lowest level of economic development depending on where corporate profits and investment return reside. • Subject to income and property tax. 	<ul style="list-style-type: none"> • Little incentive to include low-density market or reduce natural gas cost of service any lower than cost of diesel fuel. If cost of natural gas service does not induce switching from wood heating, PM_{2.5} attainment is less likely. • Stability and future of corporation as well as return on distribution system investment depends on the success of the management team.

Table 12. SWOT Analysis: Municipal Utility or Cooperative

STRENGTHS	OPPORTUNITIES
<ul style="list-style-type: none"> • Potential for lowest cost of service because: <ul style="list-style-type: none"> ○ Qualifies for state grant funding or loan guarantee to reduce cost of capital. ○ No profit requirements. ○ No income or property tax requirements for municipal utility. 	<ul style="list-style-type: none"> • Qualifies for funding partnership with the state as grant or loan guarantee. • With lowest cost of service—highest potential for solid fuel switching and air quality attainment. • Business organization with the highest potential for ratepayer control and participation especially for cooperative model where ratepayers are owners.
WEAKNESSES	THREATS
<ul style="list-style-type: none"> • Individual cooperative or municipality/borough may not have the bonding capacity necessary to construct the system. • Lack of technical expertise in the cooperative or government organization may limit the operating or construction arrangements possible. 	<ul style="list-style-type: none"> • Potentially weakest leadership and management structure especially with ratepayer board members. Could weaken the stability of the organization. • Potentially least flexible of the business organizations because of the board approval and regulatory requirements for raising capital or making decisions. May make future expansion of the system more difficult.

Table 13. SWOT Analysis: Local Improvement District

STRENGTHS	OPPORTUNITIES
<ul style="list-style-type: none"> • Use of the borough's special assessment bonding capability allows property owners to acquire access to natural gas without depleting savings or assuming the liability of a high interest home improvement loan (if the homeowner could qualify). • Have been used in Matanuska-Susitna Borough, Anchorage and other Alaska municipalities. 	<ul style="list-style-type: none"> • The borough can benefit through increased property values and associated property taxes. • The borough can benefit from taxes on gas utility facilities. For example, the gas utility has been one of the Matanuska-Susitna Borough's largest taxpayers.
WEAKNESSES	THREATS
<ul style="list-style-type: none"> • Petition process and special assessment requirements may limit the implementation of LIDs in a region. • The borough assumes risk of repayment for construction of natural gas system. • LIDs are best implemented when city gate natural gas prices are low; likely below the prices that are feasible for Fairbanks. • New restrictions have been imposed on LIDs in Alaska. 	<ul style="list-style-type: none"> • If property values decline or homeowners are unable to make special assessment payments, borough could have difficulty repaying special assessment bonds or experience decrease in bond rating for borough and increase cost of capital for other borough projects.

Table 14. SWOT Analysis: State Partnership

STRENGTHS	OPPORTUNITIES
<ul style="list-style-type: none"> • Lowest cost of capital and highest investment capacity with backing of State of Alaska • Lowest cost of service. 	<ul style="list-style-type: none"> • Leverage state investment to achieve economic development and energy independence goals for state and borough. • Access to technical support and experience from state agencies such as AIDEA. Can participate as board members. • Potential access to state royalty gas in-kind.
WEAKNESSES	THREATS
<ul style="list-style-type: none"> • Regulatory requirements could limit state participation to construction. A limited joint venture formed between the state and the borough for the construction of the system would reduce regulatory risk associated with operating and maintaining the system. • Complicated ownership structure would reduce management and expansion options. May have to gain approval by board of directors, state regulators, and others for significant management decisions. • Highest level of oversight and bureaucracy of all of the business model options. 	<ul style="list-style-type: none"> • Uncertain regulatory requirements depending on the structure of the partnership and oversight required by legislature.

6 Cost of Service, Financial Analysis

Prior report sections provide information on market quantities and prices (historical and current), while capital cost estimates bracketed lower and upper estimates about the likely costs of engineering, permitting, and construction of the pipe distribution system.

This section provides both information on cost of service, and financial analysis of a hypothetical organization established to operate and sell natural gas in the FNSB. Cost of service is the first major topic, followed by financial analysis, including pro forma (projected) financial statements (i.e., balance sheet and income statement).

Project analysts and economists developed an electronic spreadsheet model to illustrate and analyze how market demand and cost estimates could be used to estimate cost of service. A key factor, recognizing the uncertainty of certain assumptions and cost estimates, is a sensitivity analysis conducted on selected model components, discussed further in section 6.3.

6.1 Cost of Service

The Federal Energy Regulatory Commission (FERC) addresses pipelines that transport gas between states, but FERC definitions and concepts guide intra-state gas lines as well, including financial statements submitted by Alaska utilities to in-state regulators.

Cost of service (COS) estimates use guidelines from FERC for calculations. However, within Alaska, the Regulatory Commission of Alaska (RCA) issues certificates and requirements for public utilities; including two natural gas utilities. The RCA does not issue guidelines for calculating the COS for natural gas utilities (3AAC52.010), though it does publish regulations for electric power COS calculations (3AAC48.500), as well as tariffs for natural gas service.

The basic approach adopted by FERC is that pipeline rates should be based upon on the cost of providing service, noting "...just and reasonable rates require a balancing of equities between the interests of the pipeline and its ratepayers" (FERC, 1999).

The RCA provides oversight of in-state gas lines, including the system proposed in Section 3 of this report. In general, the RCA uses the same financial information to analyze costs of service to consumers, both public and private, residential and commercial. The initial figures are called the *rate base*, which is defined as:

- Gross plant (or capital costs of pipelines, plus compressors, etc.)
- Accumulated depreciation (if any)
- = Net plant
- Accumulated deferred income taxes (if any)
- + Working capital
- = Rate base.

Cost of service consists of the rate base, defined above, times the overall rate of return, plus the items listed below, minus revenue credits:

- = Return
- + Operation and maintenance expenses
- + Administrative and general expenses
- + Depreciation expense
- + Non-income taxes
- + Income taxes
- Revenue credits
- = Total Cost of Service

Note that conversion costs from fuel oil to natural gas for individual residences and commercial entities are not included in this formula, but they are addressed in other sections of this report.

After market demand and conversion costs were finalized, team members developed a spreadsheet model to project potential (pro forma) costs of service and projected financial performance.

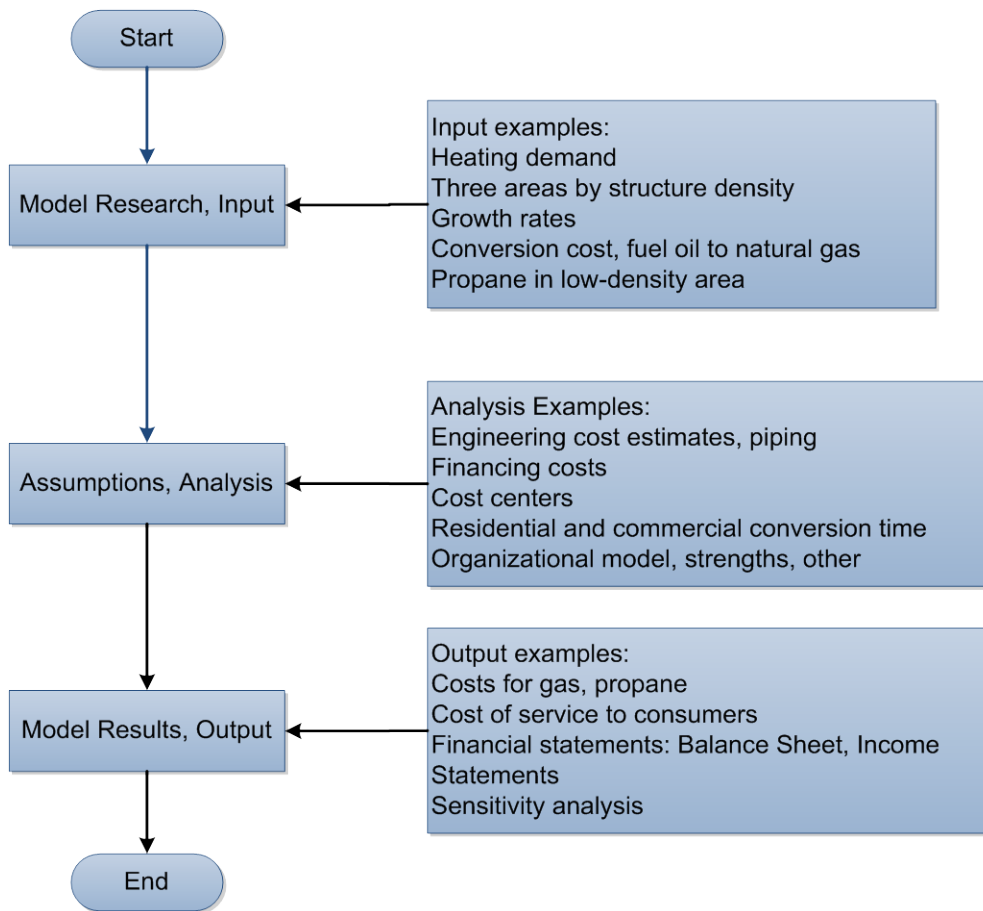
This section provides information about the model, certain key assumptions, conversion costs, and output, including estimated cost of service and basic financial statements.

6.2 Base Model, Cost of Service, Financial Analysis

Team analysts selected a spreadsheet model to 1) provide flexibility in modeling, 2) enable export of data to the sensitivity analysis software, and, perhaps most important, 3) provide transparency as to the variables and data used. An electronic version of the model accompanies final submittal of this report to the client project managers. Key model assumptions, analysis, and output are discussed in the next several sections.

Figure 13 illustrates three basic model sections (input, analysis, and output) and some of the key variables that are included (or generated) in each.

Figure 13. General Flowchart of Cost of Service and Financial Analysis



Source: Northern Economics, Inc.

6.2.1 Model Inputs

Key model variables include demand, both within and outside of the piped distribution area, as well as growth and conversion rates. These items are discussed in the following sub-sections.

Number of Residential and Commercial Structures

FNSB GIS databases formed the basis for estimates of the number of residential and commercial structures. The piped distribution area contains an estimated 20,863 residential structures and 1,794 commercial structures after adjustments are made to subtract the homes, businesses and non-private buildings (schools, government office) that are currently heated by FNG and Aurora Energy, LLC. Of these structures approximately 80.4 percent use distillates for heating with the balance of 19.6 percent heating with wood and other sources.

Over the 50-year period included in the gas model (the financial model is 20 years, reflecting loan terms), the average annual growth is 1.004 percent as derived from analysis of the FNSB Assessor's Database and the growth in housing stock from the earliest known building (1902) to those built in 2011.

For sensitivity purposes, the lower and upper annual average growth rates are 0.41 percent and 1.6 percent, respectively.

Annual Consumption per Structure

Heating consumption per year by type of structure (residential, commercial) is based on experienced heat requirements for similar buildings in Anchorage, and adjusted to Fairbanks using heating degree days. Team engineers and analysts compared the estimated results to actual heat requirements for specific buildings as noted by Aurora Energy LLC in a 2009 presentation. There are differences between estimates and actual amounts for each structure of about plus or minus five to ten percent but the differences tend to offset each other with the sum of the differences being relatively minor.

Fuel Efficiencies

Table 15 summarizes fuels available within the FNSB, and their characteristics. As noted below, natural gas and propane boilers or furnaces are estimated to have an average efficiency of 90 percent and a lower range of 85 percent and an upper range of 95 percent, representing furnace and boiler efficiencies reported by contractors and suppliers, both in Fairbanks and Anchorage. Oil-fired boilers and furnaces are assumed to have efficiencies of approximately 85 percent, and wood-fired units are estimated at 68 percent efficiency.

Table 15. Fuel Types, Price, Heat, Efficiency, and Ranking by Heat Cost

Fuel	Average Price (\$)	Units	Gross Heat (Btu)	Efficiency (%)	Mid-point (%)	\$/100,000 BTU	Useful BTU/\$1	Rank
Electricity	0.1976	kWh	3,413	95 - 100	98	5.938	16,840	11
District Hot Water	27.0300	MMBtu	1,000,000	95 - 100	98	2.772	36,071	7
District Steam	10.5000	MMBtu	1,000,000	95 - 100	98	1.077	92,857	1
Fuel oil (#2)	4.0500	gallon	135,000	80 - 90	85	3.529	28,333	8
Current natural gas	23.3500	Mcf	1,000,000	85 - 95	90	2.594	38,544	5
Propane, small vol.	4.3500	gallon	91,333	80 - 90	85	5.603	17,847	10
Propane, heating	3.0500	gallon	91,333	85 - 95	90	3.710	26,951	9
Wood, pellets	295.000	ton	16,000,000	68	68	2.711	36,881	6
Wood, birch	250.000	cord	20,500,000	68	68	1.793	55,760	3
Wood, spruce	250.000	cord	15,000,000	68	68	2.451	40,800	4
Coal, stoker	110.000	ton	15,200,000	55	55	1.316	76,000	2

Source: Northern Economics

Note: Efficiency is based on Annual Fuel Utilization Efficiency (AFUE) or estimates from the Cold Climate Housing Research Center or federal EPA (primarily wood).

Rankings shown in the last (rightmost) column reflect BTU per \$1 spent on energy, from the highest ranking (district steam) to the lowest ranking (electricity).

Energy Required

Energy required for structures in the piped distribution areas is calculated for residential and commercial structures by high and medium density areas, and then summed. In 2021 residential demand is estimated at about 5.5 Bcf and commercial demand is estimated at approximately 4.7 Bcf.

Industrial demand includes demand from the PetroStar refinery which is estimated at 0.3 Bcf per year.

Residential, Commercial Conversion Costs

Table 16 shows three sets of cost estimates for residential conversion to gas. The estimates vary considerably, depending on the extent of the conversion. At the low end, FNG (2005) gives a conversion cost of \$1,000–\$1,500 to replace an oil-fired gun with a gas-fired gun. At the high end, Laabs (2012) provided cost estimates for a complete replacement, reaching upwards of \$12,000–\$20,000 for a boiler replacement, chimney upgrade (or replacement) and other hydronic (or forced air) connections.

Table 16. Cost Estimates for Residential Conversion to Natural Gas

Source	Notes	Cost Estimate (\$)
Fuhs (2010)	Space heater with flush mount exhaust, on-demand hot water heater, and 250 gallon buried tanks—to be refilled about once per month, depending on season	3,000
Fairbanks Natural Gas (2005)	Replacement of gun, residential	1,000–1,500
Laabs (2012)	Furnace replacement, mobile home	6,000–8,000
	Chimney replacement (if needed), mobile home	500–700
	Furnace replacement, residential	8,000–15,000
	Chimney replacement (if needed), residential	2,500–5,000
	Boiler replacement or conversion from oil to gas, residential	12,000–20,000
	Burner conversion with boiler brushed out, residential	3,500–6,500

Source: Northern Economics, Inc. from sources noted.

The cost for converting commercial systems is specific to the structure that is being converted and sources could not provide a reliable number of commercial structures. For modeling purposes, the average per square foot cost of converting a residential structure was applied to the average size of commercial buildings as determined from the Assessor’s data base.

Natural Gas Sales in High and Medium Density Areas

Total natural gas sales (market demand) for residential, commercial, and industrial consumers in the piped distribution area in 2021 is estimated at approximately 10.8 Bcf (See Table 6). Conversion rates for residential structures transitioning from other fuels to natural gas in the high density zone are expected to occur over five years at the following rates:

- 10 percent
- 25 percent
- 25 percent
- 25 percent
- 12 percent

If the delivered price of natural gas plus conversion costs is less than or equal to 90 percent of the fuel oil price 97 percent of the residential structures are anticipated to switch to gas and 100 percent of commercial users. Similar percentages apply to conversions from wood heat if the gas price plus conversions costs is less than or equal to 110 percent of the wood cost.

Commercial conversion rates are estimated to occur over four years at the following rates:

- 15 percent
- 35 percent
- 35 percent
- 15 percent

The medium density zone has the same conversions rates but conversions do not begin until 2016, which is the first year that natural gas is expected to flow in this area.

Low-Density Area

Team analysts applied similar energy analysis for consumers (residential and commercial) in the low-density areas, using propane instead of natural gas. Total propane sales for residential and commercial consumers in 2021 is estimated at approximately 0.8 Bcf.

The most likely scenario includes external propane tanks, 250 gallons of capacity or greater, traditional truck delivery of propane, and propane sourced from the Alaska North Slope or another location with propane prices lower than current sources.

If the delivered price of propane plus conversion costs is less than or equal to 90 percent of the fuel oil price 95 percent of the residential structures in the low density area are anticipated to switch to propane and 100 percent of commercial users. Similar percentages apply to conversions from wood heat if the propane price plus conversion costs is less than or equal to 110 percent of the wood cost.

Total Natural Gas and Propane Sales in FNSB

The model provides estimates of total natural gas required by residential, commercial, and industrial segments for the two zones that are piped for distribution. For the low-density zone, estimates suggest how much residential and commercial segments switch to propane. All estimates are expressed by year from Year 1 (2015) to Year 50 (2065). Total sales of natural gas and propane within the FNSB are projected at approximately 11.4 Bcf in 2021 and increasing slightly more than 0.1 Bcf per year.

Natural Gas Price

The price of natural gas at the Fairbanks city gate is assumed to approximate \$10 per MMBtu in 2015. A portion of that price is the cost to purchase the gas and the remainder is other costs that would be incurred to move the gas from its source to the city gate.

Operations and maintenance costs

Operations and maintenance costs were drawn from financial statements of FNG and ENSTAR, as reported to the RCA. The model uses a linear interpolation of operations and maintenance costs based on gas volumes for FNG and ENSTAR. This results in a cost per MMBtu that changes with the general inflation rate and total gas volumes handled. In 2015, this cost is approximately \$0.49 per MMBtu.

Administrative and general overhead

These are based on public figures for FNG and ENSTAR, as reported to the RCA. The model uses a linear interpolation of administrative and general overhead costs based on gas volumes for FNG and ENSTAR. This results in a cost per MMBtu that changes with the general inflation rate and total gas volumes handled. In 2015, this cost is approximately \$2.55 per MMBtu.

Depreciation, Distribution System

Depreciation expenses are based on the mid-case engineering estimate of \$404 million to develop the piped distribution systems. Depreciation expenses are expressed on a per-MMBtu basis using total natural gas sales for the piped area, as projected each year for 20 years (to 2035).

Capital costs

Capital costs are those prepared by team engineers and included and discussed in Section 3.0 of this report. Lower case costs are estimated at \$283 million and upper case costs are \$606 million.

Grants

Certain types of business models, such as government-owned utilities, or cooperatives, qualify to receive grants funds from local, state, or federal governments; private utilities do not qualify. The mid-case estimates of grants for government-owned utilities or cooperatives is 50 percent with a range of zero to 70 percent. If grants are not available then the cost of service becomes closer to, but still less than that of a private firm.

Business Structure

This model feature is a toggle that essentially flags the analysis as private or other, with private firms not qualifying for grants, and incurring higher interest rates (for loans) and also paying taxes, something public organizations avoid.

Debt Service

This part of the model uses the net amount of capital costs, less grants (if any), as a loan amount, with interest rates of 6.0 percent for private firms and 4.5 percent for others. Loans are assumed to extend for 20 years, the number of years covered by the financial analysis.

Aggregate amounts per year for debt service are summed and expressed as a cost per MMBtu.

General Inflation Rate

A general inflation rate of 2.5 percent is used for those cost items that do not have specific inflation factors.

Taxes

The combined federal and state corporate income tax rate is 40.2 percent. However, the effective corporate income tax rate is often lower than this combined rate due to various tax credits and other factors that can reduce the tax liability. However, private entities would incur property taxes which, when considered with the lower effective tax rate, suggest that the overall (income and non-income) tax rate would be in the vicinity of 40.2 percent.

Profit or Retained Earnings

Profit represents the amount of cash left over for a firm once operating expenses and the cost of debt are subtracted from revenues. Retained earnings represent the equity or excess asset value after subtracting out liabilities. For a private firm, starting equity would be the amount of cash invested in the distribution system. For a public firm, grant funding would be used to establish retained earnings. The model assumes all profits are reinvested in the firm, resulting in retained earnings that increase over time. Alternatively, a firm could choose to distribute retained earnings in the form of dividends

and returns of capital (for a private firm), distribution of earnings to members (for a cooperative), or through transfers to other funds (for a government entity).

6.2.2 Model Outputs

Model outputs include total estimated demand and sales, for both the piped and low-density areas, along with projected costs of service, debt (loan) service, and pro forma financial statements. More specific information is noted below.

Cost of Service for Natural Gas Pipeline Distribution System

The cost of service represents the price to the consumer. This estimate assumes the same rate for all users whether they are in a high density area or a low density area, and whether the user is a residential, commercial, or industrial entity. Estimated costs and selling value per MMBtu are shown in Table 17 for a private organization and Table 18 for a public (or cooperative) organization.

Table 17. Pro Forma Cost of Service for Natural Gas Distribution System Private Organization, in \$/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Natural gas price (\$/MMBtu), well head	3.51	3.52	3.63	3.72	3.82	3.91
Other cost (\$/MMBtu), growth rate	6.49	6.51	6.72	6.89	7.06	7.23
Operations & maintenance cost (\$/MMBtu), base rate	0.49	0.50	0.51	0.53	0.54	0.55
Admin & General Overhead, base rate	2.50	2.55	2.60	2.66	2.72	2.78
Depreciation, distribution system, total and \$/MMBtu	6.78	2.20	1.21	0.90	0.80	0.77
Subtotal	19.77	15.28	14.68	14.70	14.94	15.25
Debt service and return on equity, \$/MMBtu, piped system	0.79	3.13	3.10	3.07	3.04	3.01
Total cost per MMBtu	20.56	18.41	17.77	17.77	17.97	18.26
Total selling value with 20% margin over cost	24.67	22.09	21.33	21.32	21.57	21.91

Source: Northern Economics

Table 18. Pro Forma Cost of Service, Piped, Public Organization, in \$/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Natural gas price (\$/MMBtu), ANS, well head	3.51	3.52	3.63	3.72	3.82	3.91
Other cost (\$/MMBtu), growth rate	6.49	6.51	6.72	6.89	7.06	7.23
Operations & maintenance cost (\$/MMBtu), base rate	0.49	0.50	0.51	0.53	0.54	0.55
Admin & General Overhead, base rate	2.50	2.55	2.60	2.66	2.72	2.78
Depreciation, distribution system, total and \$/MMBtu	6.78	2.20	1.21	0.90	0.80	0.77
Subtotal	19.77	15.28	14.68	14.70	14.94	15.25
Debt service, \$/MMBtu, piped system	0.35	1.39	1.38	1.37	1.35	1.34
Total cost per MMBtu	20.12	16.67	16.06	16.07	16.29	16.59
Total selling value with 10% margin over cost	22.13	18.34	17.66	17.68	17.92	18.25

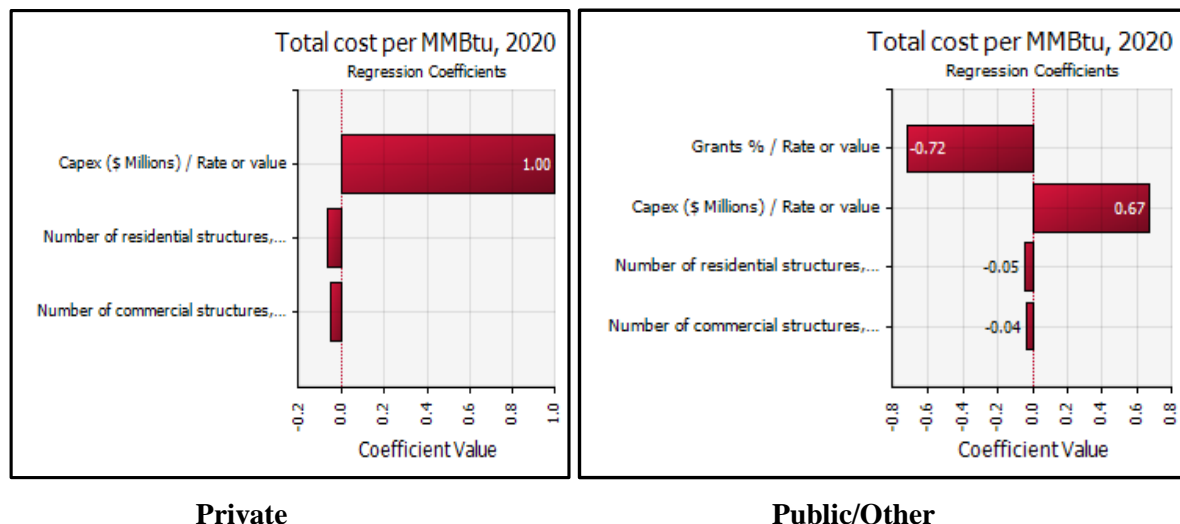
Source: Northern Economics

As shown above, the cost of service for a private organization is higher than the cost of service for a public organization. This is generally due to the higher costs incurred by private entities for financing and taxes.

6.3 Cost of Service Sensitivity Analysis

The total cost per MMBtu of delivered gas is most sensitive to the distribution system's capital cost and grant funds received (only for a government-run or cooperative utility). Figure 14 shows a tornado diagram for the year 2020 highlighting the relative importance of these factors. The growth rates for the number of residential and commercial structures have a small initial effect, but their importance increases over time.

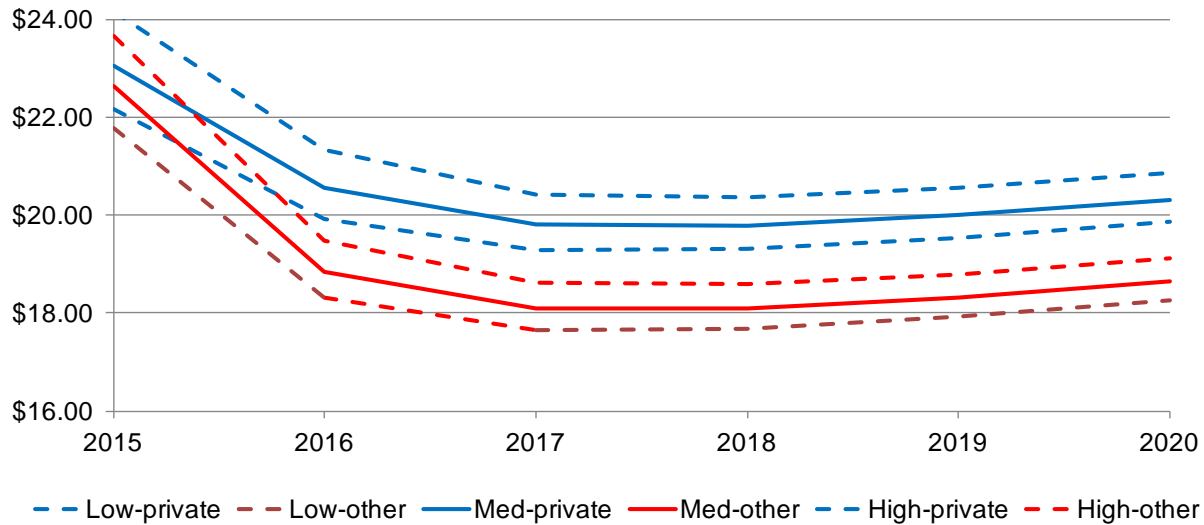
Figure 14. Cost of Service Tornado Diagram, 2020



Source: Northern Economics, Inc.

Figure 15 shows cost of service estimates from 2015 through 2020 for private and non-private (other) entities. The results shown here are taken from the sensitivity analysis and represent various probabilities for the outcomes. The cost of service lines shown in the chart do not match with the cost of service discussed in the preceding tables because the sensitivity analysis is based on a simulation rather than a static model. The declining cost of service is a result of the gradual conversion over time; as residential and commercial structures convert to natural gas, the total cost of service drops. The low estimates represent the probability that the costs of service will be at or below this price for 25 percent of the model runs. The medium estimate (Med) anticipates that the cost of service will be at or below this price for 50 percent of the model runs, and the high estimate anticipates that the cost of service will be below this price for 75 percent of the model runs. As noted earlier, some of the reasons why the private entity has a higher cost structure include taxes, higher financing costs, and the availability of grants for the public entities and cooperatives.

Figure 15. Cost of Service Estimates with Margin, Low, Medium, High, by Organization, 2015 to 2020.



Source: Northern Economics, Inc.

The cost of service for propane consumers in the low-density area of the FSNB is estimated at approximately \$24 per MMBtu in 2015, assuming that lower priced propane is available from the North Slope or elsewhere in the state. A propane distributor that was owned and operated by a public entity or cooperative would have many of the same advantages as a public or cooperative pipeline distribution system entity. Figure 15 indicates that after the initial years, the cost advantage for a public entity is about nine percent. Applying this same percentage to the cost of service for a private propane distributor suggests that a public entity might have a delivered cost of about \$21.80 per MMBtu.

6.4 Pro Forma Financial Statements

Financial statements serve as metrics for management primarily, but they also serve others, such as lenders (banks), owners (stock holders), and regulators (RCA).

Many rules and formulas govern how financial statements are prepared, from the Generally Accepted Accounting Principles published by the Financial Accounting Standards Board or those prepared for government entities published by the Government Accounting Standards Board.

There are two main types of financial statements, whether prepared for a business organization or a public entity: balance sheets and income statements.

Balance sheets list an organization's owned assets (e.g., buildings, pipelines, vehicles) at a given point in time (a snapshot) and also any liabilities incurred from owning the assets. A typical example is a pipeline or a building hypothetically purchased for \$100,000 and paid for with \$70,000 of loans (debt) and with \$30,000 of stockholder's funds (equity).

By contrast, income statements record revenues and expenses generated by the organization and its assets over a given period of time (much like a video, not a snapshot). Typically, balance sheets are published at the end of a fiscal year, and income statements record twelve months of revenues and expenses between published balance sheets. The well-known *bottom line* refers to the amount remaining after expenses are subtracted from revenues, also known as net income.

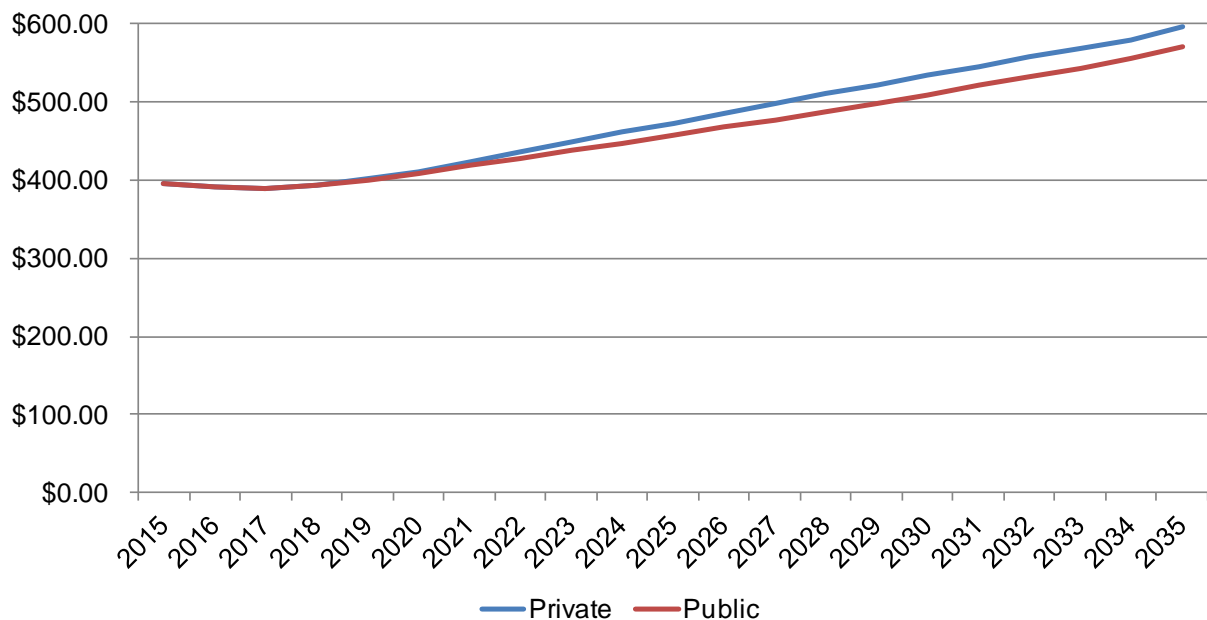
For purposes of this analysis, both balance sheet figures and the amounts estimated as revenues and expenses are forecasts (pro formas) and do not represent any actual transactions. Both statements are simplistic and consolidated to highlight key figures and potential amounts for relative comparison and evaluation.

6.4.1 Balance Sheet

Two analyses of total assets generate the differences between public and private organizations, as shown in Figure 16 below. With the same margin on natural gas sales, public corporations accumulate total assets more quickly than private firms due to lower borrowing rates, their ability to seek and apply grant funding, and their exemption from paying income taxes. The figure assumes a private firm would have a higher margin on the gas it sells to account for its higher costs.

This figure assumes that the public organization retains its earnings over time, rather than distributing its earnings to cooperative members or transferring them to other funds within a municipal or borough government. Likewise, the figure assumes a private firm would retain all earnings rather than distribute dividends to its stockholders.

Figure 16. Pro Forma Total Assets, Private vs. Public Organization, \$Millions



Source: Northern Economics

6.4.2 Income Statement

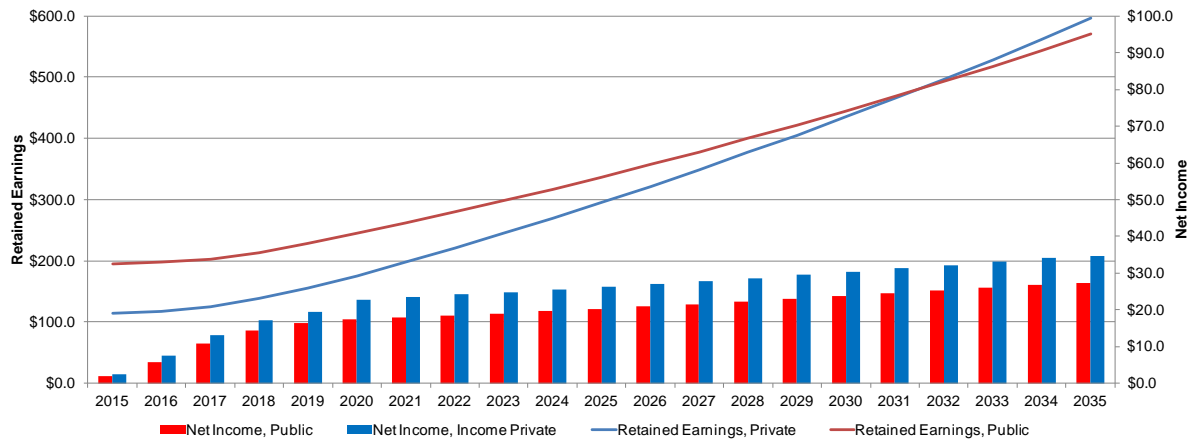
Figure 17 shows pro forma net income and retained earnings for both private and public entities. Private companies need to generate more revenue than public entities since they will typically have a higher interest rate on their debt, and private firms also incur taxes which reduce the amount that they can invest in the future.

Public firms can accept grant funding (in the model a base estimate is 50 percent) and their debt load is lower as a result. Public firms also have a higher net income since they do not pay income taxes.

The figure shows the higher net income of a public firm and the corresponding higher retained earnings, relative to a private firm, over time. In 2015, the gap in retained earnings between the two

types of organizations is approximately \$80 million, a situation that reverses over the following 20 years due to the private firm's higher margin, resulting in \$25 million more in retained earnings for the private firm in 2035. The initial difference of \$80 million reflects the 30 percent equity a private firm would invest up front versus the 50 percent grant funding with which a public firm would build the distribution system. The difference in net income is very small (\$400,000) in 2015 and grows to about \$7 million by 2035, reflecting the higher margin charged by a private firm, which it uses to cover the higher costs of debt and income taxes.

Figure 17. Pro Forma Net Income and Retained Earnings, Private vs. Public Organization, \$Millions



Source: Northern Economics

7 Consumer Savings

The natural gas and propane alternative results in substantial savings for residents and businesses in the borough compared to the status quo. Table 19 shows the estimated annual fuel costs for the status quo and the natural gas and propane alternatives for the 2015 through 2022 time period, and the resultant cost savings.

Table 19. Fuel Costs and Savings

Alternative/ Sector	2015	2016	2017	2018	2019	2020	2021	2022	Total 2015- 2021	Total 2015- 2022
	(Millions of Nominal \$)									
Status Quo										
Residential	219.9	223.3	234.9	245.2	255.6	266.3	277.5	289.7	1,722.7	2,012.4
Commercial	187.3	189.8	200.0	209.0	218.0	227.3	237.1	247.7	1,468.5	1,716.2
Industrial	8.0	8.0	8.3	8.6	8.9	9.2	9.5	9.8	60.6	70.4
Total	415.1	421.2	443.2	462.8	482.6	502.9	524.1	547.3	3,251.8	3,799.1
Natural Gas/Propane										
Residential	213.5	193.5	168.4	139.4	119.5	116.5	120.2	124.2	1,071.1	1,195.3
Commercial	178.4	141.9	102.1	80.4	79.4	81.7	84.1	86.8	748.1	834.9
Industrial	7.0	5.0	4.8	4.8	4.9	5.0	5.1	5.2	36.6	41.8
Total	399.0	340.4	275.3	224.7	203.8	203.2	209.5	216.2	1,855.8	2,072.0
Savings										
Residential	6.3	29.8	66.5	105.8	136.1	149.8	157.3	165.5	651.6	817.1
Commercial	8.8	47.9	97.9	128.5	138.7	145.7	152.9	160.9	720.4	881.3
Industrial	1.0	3.0	3.5	3.8	4.0	4.2	4.4	4.7	24.0	28.7
Total	16.2	80.8	167.9	238.1	278.8	299.7	314.6	331.1	1,396.0	1,727.1
Savings as a % of Status Quo										
	4%	19%	38%	51%	58%	60%	60%	60%	43%	45%

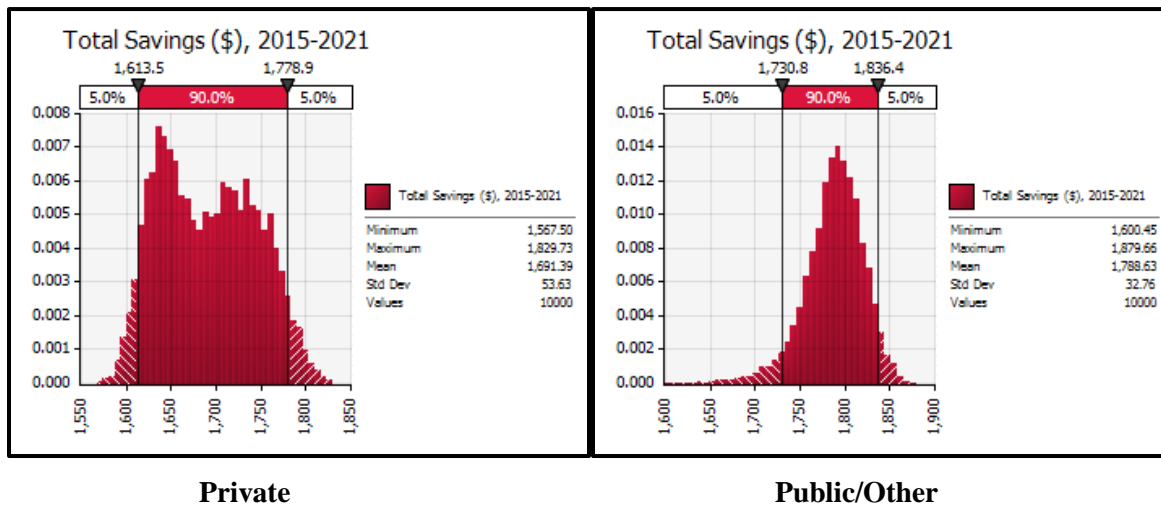
Source: Northern Economics, Inc. estimates.

In 2021, the first full year of operations, the savings are approximately \$315 million or a savings from the status quo of about 60 percent. The total for the 2015 through 2021 time period is approximately \$1.4 billion.

It is uncertain if or when GVEA and Flint Hills might connect to the gas distribution system, but at some point in the future if a gas pipeline is built to Fairbanks it may be more cost effective for these two firms to use the piped distribution system rather than continue to truck LNG from the North Slope. While the industrial firms could benefit from being connected to the distribution system, residential and commercial customers could benefit from the greater throughput, which reduces the fixed costs per unit.

A probability-based sensitivity analysis was conducted on consumer savings for both a private entity and a non-private entity for the 2015-2021 time period. As shown in Figure 18 the mean estimate of consumer savings is similar for each entity. The private entity has mean savings of approximately \$1.69 billion and the public entity has mean savings of approximately \$1.79 billion. As with the other comparisons of private and public entities, the public entity has slightly better performance than a private entity.

Figure 18. Sensitivity Analysis for Consumer Savings



Source: Northern Economics, Inc.

8 Benefit-Cost Analysis

In addition to a financial analysis the study team also conducted a Benefit-Cost Analysis to show the cost savings to residential, commercial, and industrial users from the conversion to natural gas from other fuels, primarily distillates or wood. Broadly defined, a BCA is an assessment of all the quantifiable benefits, minus all quantifiable costs of a project. The difference between the two is the BCA ratio, and indicates whether, overall, the project is a net positive or negative.

Benefit-Cost Methodology

BCA helps decision-makers determine if a project generates more benefits than costs; if it does, the ratio is 1.0 (or better). For example, if a pipeline costs \$100,000 but it generates \$150,000 of benefits over its lifetime, the ratio is 1.5 ($\$150,000/\$100,000$).

Further, since a project lifetime can extend far into the future, money has a time value: dollars in the current year are considered to have more value than dollars in the future, especially if the BCA is looking at a 50-year project lifecycle. Economists and analysts use a concept called Net Present Value (NPV) to measure benefits and costs at the same point in time, to avoid vast differences in potential cash flows. NPV calculations determine present values using an interest rate (or, more precisely, a discount rate) to bring future streams of cash values to a common (current) time.

Benefit-Cost Calculations versus Financial Analysis

A BCA differs from a financial analysis because costs are recognized in the year in which the total expenditure occurs, not the year in which the debt repayment is made. Thus, projects that require large upfront capital expenditures prior to any revenues being generated have to overcome that disadvantage compared to a project that had lower initial capital costs but potentially higher costs in the future.

A BCA also differs from a financial analysis in the numbers that are used for each method. A BCA includes the cost savings from society's point of view (i.e. before taxes and financing costs, which are mere transfers between different groups in society). These costs are relevant from the project sponsor's point of view and should be analyzed in the financial analysis since they will have an impact on whether the investor will be willing to participate in the project or not.³

However, in a BCA, whether the project is beneficial for society is driven by the net present value of cost savings from the project itself, and not the way the project might be financed. Otherwise, a "bad" project could look good simply by virtue of its sponsors having access to concessional funding on terms more favorable than what the financial markets offer. Conversely, a "good" project may look "bad" only because its sponsor is unable to secure more favorable loan conditions available elsewhere in the market. For this reason it is important to consider both BCA and financial analysis as complements in the decision-making process.

The BCA compares the present value of a stream of costs associated with a project compared to the present value of a stream of costs without the project. The benefit-cost ratio is calculated by dividing the net present value of the project alternative into the net present value without the project. The larger the ratio, the better the project is ranked. In practice, any project that is greater than 1.0 is deemed worthy of funding although, in the presence of budget constraints, higher ranked projects may use all of the available funds and preclude the project from being funded despite a benefit-cost ratio higher than 1.0.

³ Different debt to equity ratio and different debt arrangements (rates of interest and/or maturities) will generate different financing costs for the project's owners.

Benefit-Cost Analysis of Fuel Conversion

The study conducted the BCA of cost savings to users from conversion to natural gas from other fuels using the mid-estimates from the financial and cost of service task (see Section 6.2.1) as inputs. The study then conducted a sensitivity analysis for the BCA ratio, the results of which are discussed in Section 8.1.2.

The BCA also addresses, in a preliminary manner, the benefits due to emissions reductions—focusing on reductions in fine particulate matter—and the benefits from reductions in other greenhouse gas emissions. Obviously, these are more difficult to calculate and require subjective analysis.

8.1.1 Natural Gas/Propane Distribution System

Table 20 presents the results of the BCA comparing the status quo (distillates and wood remain as the primary fuels for heating and industrial demand in the FNSB), and an alternative that would see natural gas available via a piped distribution system in high- and medium-density areas of the FNSB, and propane or PA available in the low-density areas of the borough. CNG was evaluated early in the analysis but was found to be more expensive than propane due to the costs for tanks capable of meeting pressures of 2,500 pounds per square inch and was dropped from further consideration.

The natural gas could come from the North Slope, Cook Inlet, or other potential discoveries in the Interior. Similarly, lower cost propane could be available from the North Slope or other potential discoveries in the state. Additional details on the assumptions and data used in this BCA are presented later in this section.

Table 20. Summary With and Without a Natural Gas/Propane Distribution System

Alternative	Billions of \$		Benefit-Cost Ratio
	Present Value of Costs	Present Value of Cost Savings	
Status Quo	10.62	--	--
High Density Area	7.10	--	--
Medium Density Area	2.65	--	--
Low Density Area	0.86	--	--
With Natural Gas/Propane Alternative	5.25	5.36	2.02
High Density Area	3.27	3.83	2.17
Medium Density Area	1.46	1.20	1.82
Low Density Area	0.53	0.33	1.63

Source: Estimates by Northern Economics, Inc.

Note: Costs are discounted using a seven percent discount rate. Benefit-cost ratio is calculated as cost of status quo (savings or benefits) divided by the cost of the natural gas/propane alternative.

Converting to natural gas and propane provides substantial savings to borough residents and businesses, and these benefits extend over all three density zones. The highest benefit-cost ratio occurs in the high-density area, where the price for natural gas is low enough to achieve high market penetration, and where development densities result in a large number of users per mile of pipeline.

The lowest benefit-cost ratio occurs in the low-density zone, where propane is not priced low enough to provide an incentive for residences that use wood for heating to switch to propane, and where the price differential between propane and heating fuel is less than the price difference between natural gas and heating fuel.

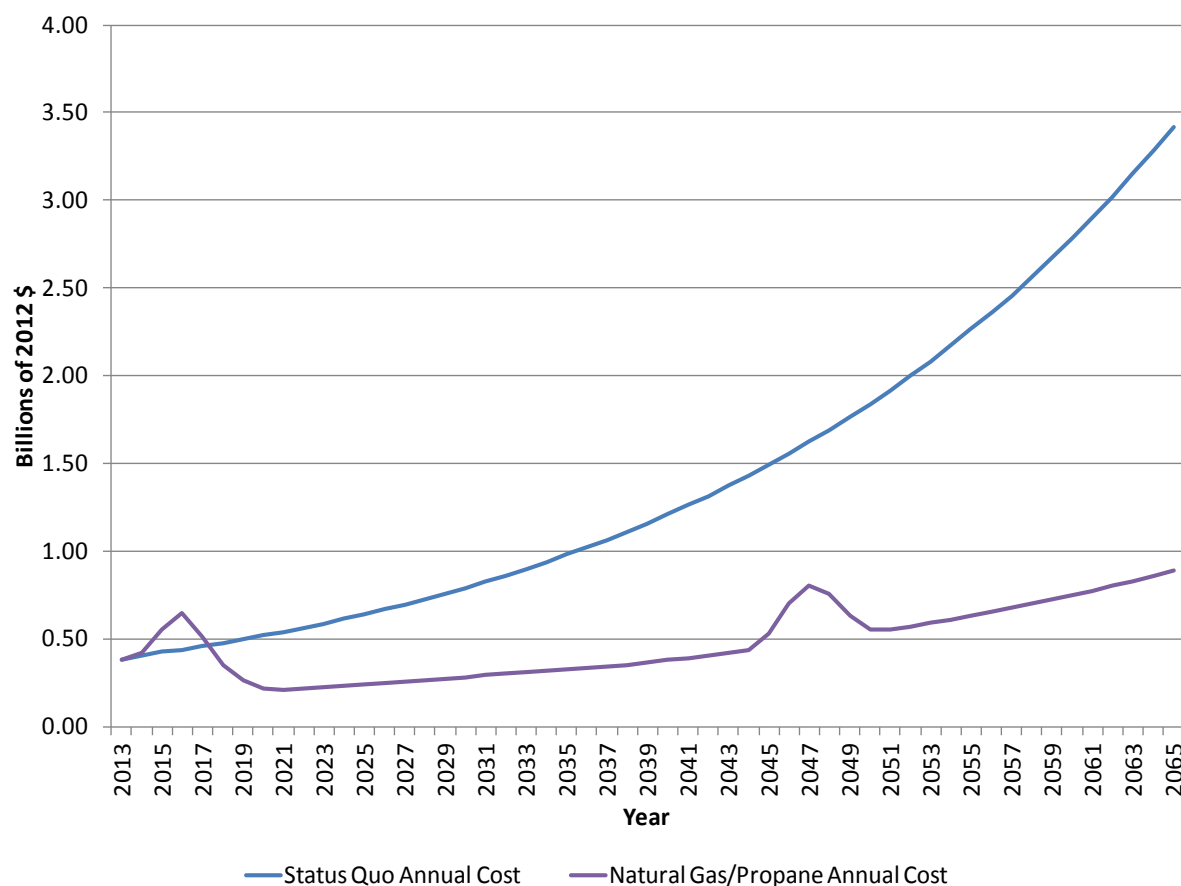
The present value of costs in the status quo for the 50-year study period through 2065 for the entire FNSB is estimated at approximately \$10.62 billion in 2012 dollars. This amount includes the cost of the fuels, and replacement of existing furnaces and boilers on a 30-year schedule. Replacement of industrial facilities was not modeled because these facilities are anticipated to be replaced on the same schedule with either alternative, which means they would cancel each other out in the cost savings and benefit-cost ratio. The estimated cost disaggregated for the high, medium, and low-density areas of the borough are also presented in the table.

The present value of costs of an alternative using natural gas and propane to meet the heating and industrial demand is estimated at approximately \$5.25 billion in 2012 dollars. This amount includes the cost of the fuels, conversion costs for replacing the existing furnaces or boilers, and the capital and operating costs for the piped distribution system. This estimate also includes the cost of new propane trucks and tanks to serve the low-density area of the borough; similar to the status quo, estimated costs for the high, medium, and low-density areas of the borough are presented in the table. The \$5.25 billion also assumes that the distribution system is operated by a private company, which results in a more conservative comparison since government or cooperatives would be expected to have lower costs, as discussed earlier in the report (see Sections 4.1 and 7).

The net present value expressed in 2012 dollars of the potential cost savings from converting to lower cost natural gas and propane is estimated at approximately \$5.36 billion over the 50-year study period.

Figure 19 presents the estimated annual costs for each alternative. These amounts are first estimated in nominal dollars assuming a 2.5 percent general inflation, and then discounted back to 2012 dollars using a 7.0 percent nominal discount rate as suggested by the federal Office of Management and Budget.

Figure 19. Estimated Annual Costs Under Status Quo and Alternative Project



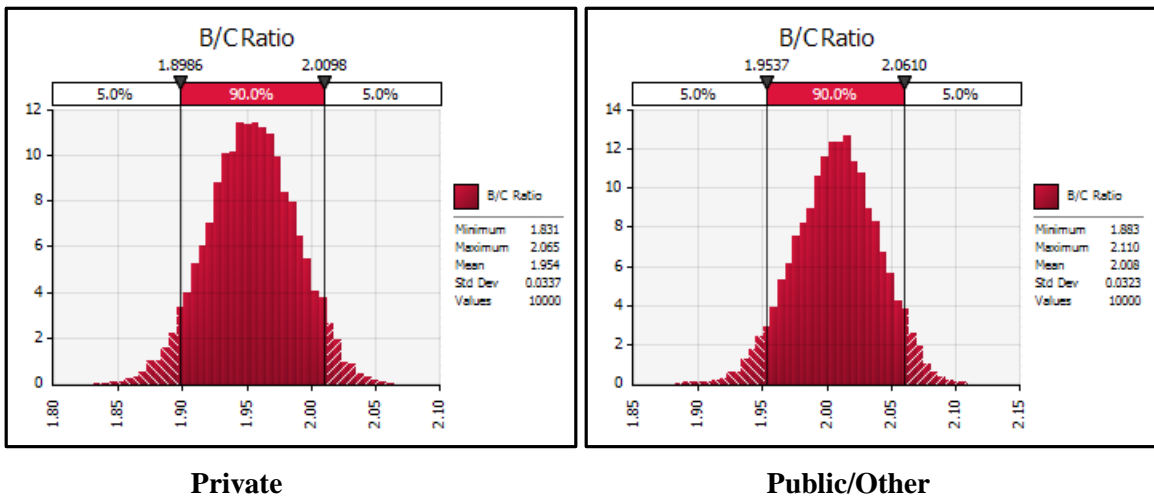
Source: Northern Economics, Inc.

The conversion alternative has higher costs in the initial years due to the capital expenditures for the piped distribution system and the propane delivery system, as well as the conversion of existing furnaces and boilers to natural gas or propane-fired units. However, once those costs are incurred, the lower fuel costs quickly result in the natural gas/propane conversion alternative being much less expensive for borough residents and businesses. The increase in costs for the conversion alternative in the 2045 to 2050 time period is for replacing the furnaces and boilers which were installed in the 2015 to 2020 time period and which are assumed to have a 30-year operating life from the time when the structure is converted to use natural gas or propane. The status quo alternative also has boiler or furnace replacement but those have been installed over many years and thus 1/30 (30-year replacements) of the housing stock is assumed to have boilers or furnaces replaced each year.

8.1.2 Benefit-Cost Ratio Sensitivity Analysis

A probability-based sensitivity analysis was conducted for the benefit-cost ratio. As noted earlier, a benefit-cost ratio that exceeds one indicates that from a societal perspective the investment should be undertaken. The benefit ratios are very robust for both the private and public entities, and even with the sensitivity analysis the ratios remain well above one. The public entity has a slightly higher mean benefit-cost ratio of about 2.01 while the private sector entity has a mean ratio of about 1.95.

Figure 20. Sensitivity Analysis of Benefit-Cost Ratio



Source: Northern Economics, Inc.

9 Contingencies

The Request for Proposals identified a number of tasks to be addressed in the Contingencies Section of the report. These tasks included:

- Listing any and all assumptions and critical parameters for the work
- Sensitivity analyses focused on the effects of changes in assumptions or parameters
- Identify and characterize the tasks required to prepare the FNSB for implementation of a distribution system design

In preparing this report the Consultant Team came to the conclusion that the assumptions should be placed in context of the items for which they were used rather than be listed in a section that did not provide context for them. Similarly, the sensitivity analyses were considered to be more useful in proximity to the analytical results. Implementation of a distribution system design is addressed in subsections of this section.

The following paragraph provides the reader with the relevant report sections where the assumptions and sensitivity analyses are discussed in the report.

- Listing any and all assumptions and critical parameters for the work
 - 2 Market Estimate
 - 3.1 Pipeline Layout
 - 3.2.1 Basis for Initial Estimate
 - 6.2.1 Model Inputs
 - 8.1.1 Natural Gas/propane Distribution System
- Sensitivity analyses focused on the effects of changes in assumptions or parameters
 - 2.7 Market Sensitivity Analysis
 - 6.3 Cost of Service Sensitivity Analysis
 - 7 Consumer Savings
 - 8.1.2 Benefit-Cost Ratio Sensitivity Analysis

9.1 Implementation

An important early issue is identifying what organization is best suited to meet FNSB's needs. A private firm may be able to respond more quickly, and that response should be carefully compared to the ultimate costs between the private and public forms of organization. Cost-of-service estimates suggest a private entity will have a higher cost of service under the given assumptions of debt financing, interest rates, and income taxes.

The ability of one or the other types of organizations to obtain financing may heavily weight this decision, especially if grant finances can be obtained or if some form of public corporation can be established. Financial sensitivity analysis suggests actual capital costs are the most influential factor for project financial success.

9.2 Pre-Construction Tasks

Baker engineers developed the main tasks required to prepare the FNSB for implementation of a distribution system design, as discussed in the following sections.

9.2.1 Preliminary Engineering and Detailed Design

The initial efforts will include preparing an RFP, soliciting proposals, and selecting an offeror to provide professional services related to the natural gas distribution line development. The professional services are expected to include engineering, surveying, environmental studies, permitting, right-of-way activities, and construction bid package preparation. The entire solicitation and selection effort could last four months.

Potential impacts to the schedule for this effort could include funding limitations and protracted negotiations. Funding limitations could prevent all of the professional services work from being contracted under a single solicitation. Multiple solicitations or contract amendments may extend the project schedule. Potential funding limitation impacts can be mitigated by developing a plan to address a scenario requiring multiple solicitations or contract amendments.

Protracted negotiations for professional services could also extend the schedule. Multiple iterations of fee proposals and scopes of work may create delays. The potential schedule impacts can be mitigated by developing a clear and explicit RFP and scope of work as well as an independent cost estimate before beginning negotiations.

The preliminary engineering and detailed design efforts are expected to last one year. Potential impacts to this schedule include changes in scope or anticipated construction funding. The schedule impacts can be mitigated by minimizing changes to the scope and ensuring that the proposed design is consistent with available construction funding.

9.2.2 Permitting, Environmental Studies

Permitting the construction and operation of the gas distribution lines in the FNSB could take a year if the preparation of a NEPA document is required. Federally funded or permitted projects require completion of a NEPA document. For this project, an Environmental Assessment is likely sufficient. Long lead time permits with the ability to impact the schedule include Bureau of Land Management (BLM) ROW and temporary land use permit, U.S. Army and U.S. Air Force construction permits, Bureau of Indian Affairs (BIA) Revocable Use Permit and ROW to cross Native allotments, and U.S. Army Corps of Engineers Section 404/10 permit for wetlands and stream crossings.

The BLM is the federal land owner and will issue permits for construction through Eielson Air Force Base and Fort Wainwright Army Post. Military Base and Post Commanders must approve project construction, and a change of command during permitting could significantly impact the schedule. The BIA Revocable Use Permit must be obtained prior to conducting field work on Native allotments. This permit and the ROW across allotments require input from the original allottee or all of their heirs if the allottee has passed away. Locating heirs can be time consuming and should be considered long lead time permits.

Wetland, raptor, fisheries and cultural resources studies may be required if information on potential effects on those resources does not exist for the project area. These studies must be conducted during the growing season. If winter construction is proposed, then a winter fisheries study may be required. These usually occur in February or March. Generally, field studies will require land owner permits or permission. Surveys using a drill rig or loader usually take longer to permit than surveys conducted with hand-held equipment.

9.2.3 Rights-of-Way Activities

ROW activities are estimated to last about nine months. This duration assumes that the new pipeline will follow existing roads and can be placed within existing utility easements or within new easements within existing road ROW. The only new ROW required will be for the gate and regulator stations. The siting of the stations is somewhat flexible, and consequently they can be located to minimize ROW acquisition efforts. The schedule for this activity could be adversely impacted if any new ROW requires an eminent domain or condemnation process where ROW is acquired from an unwilling land owner. Condemnation could extend the duration of this effort to two years or longer.

9.2.4 Contract Negotiation

There are several main steps required for successful contract negotiation, presented below.

Bidding and Source Selection

Construction bidding and source selection activities could last about three months. Potential schedule impacts include funding limitations, inaccurate construction cost estimates, and a limited pool of contractors and fabricators. Funding limitations and inaccurate construction cost estimates together could create delays if the construction bids come in much higher than the available funding (which should be based on construction cost estimates). High bids may require the project to be de-scoped to meet available funding, which will extend the time required to complete the construction bidding and source selection activities.

A limited pool of contractors and fabricators could also delay the project. This risk is likely limited to the large diameter steel transmission pipeline and the gate and regulator stations. This work requires specialized skills, and the pool of available resources is more limited than it is for the smaller diameter plastic pipe. Several North Slope projects currently under development could further limit the pool of contractors and fabricators available to the project.

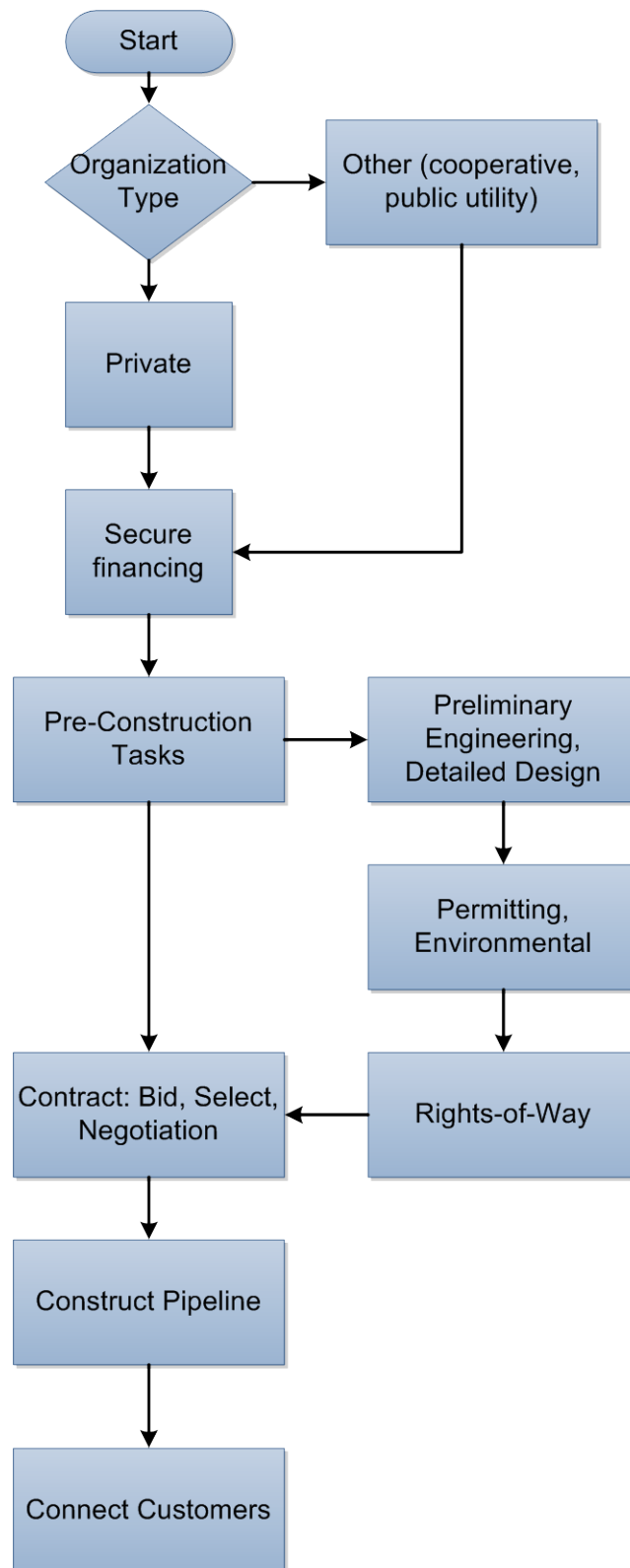
9.3 Pipeline Construction

Pipeline construction is expected to last about one and one-half years. This duration assumes that construction will begin in the spring of year one and continue through to the fall of year two, with a period of winter shutdown as required. Potential schedule impacts include changed site conditions, weather delays, and limited contractor resources.

Changed site conditions could result from numerous sources such as unanticipated soil conditions, frozen soils, contaminated soils, and unknown utilities. Unusual weather, including excessive rain, snow, or cold could delay the project. Alternatively, unusually dry and warm weather could also allow a contractor to complete the work more quickly. Another item that could impact the schedule is if the selected contractors have other contracts that could limit their resources available to the project.

Figure 21 provides a graphic representation of the process described above.

Figure 21. Potential Gas Distribution System Flowchart



10 Air Quality

Conversion of heating system fuels such as wood, oil, and coal to natural gas will reduce the emissions of criteria air pollutants in the Fairbanks area. Criteria pollutants are regulated pollutants under the Clean Air Act, and include oxides of nitrogen (NO_x), carbon monoxide (CO), particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM₁₀), particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers (PM_{2.5}), sulfur dioxide (SO₂), and volatile organic compounds (VOC).

An analysis has been prepared to estimate the annual amount of criteria pollutants emitted from the heating systems for existing residential and commercial buildings in the FNSB. Emissions from facilities in the industrial sector, as described in Section 2, are not included in this analysis. Table 21 provides a summary of the estimated current emissions from these sources, distributed between the high, medium, and low-demand areas as described in Section 2.4. Note that the high and medium-demand zones together approximate the area designated as the PM_{2.5} nonattainment area.

Table 21. Summary of Existing Emission Estimates in the FNSB, by Zone

Zone	Category	NO _x (tpy)	CO (tpy)	PM ₁₀ (tpy)	PM _{2.5} (tpy)	SO ₂ (tpy)	VOC (tpy)
High	Residential	399	12,672	1,505	1,294	452	9,592
	Commercial	347	203	59	54	534	10
	Total	746	12,875	1,564	1,348	986	9,602
Medium	Residential	278	8,815	1,047	900	315	6,672
	Commercial	61	36	10	10	94	2
	Total	339	8,851	1,057	909	409	6,674
Low	Residential	83	2,679	318	274	96	2,028
	Commercial	24	114	6	5	36	4
	Total	108	2,793	324	279	131	2,033
Overall	Residential	760	24,166	2,871	2,467	863	18,292
	Commercial	433	353	75	68	664	16
	Total	1,193	24,519	2,946	2,536	1,526	18,308

Source: SLR International Corp 2012

Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

The residential emissions estimates were calculated using data from the 2010 Fairbanks Home Heating Survey report, prepared by Sierra Research for the Alaska Department of Environmental Conservation. This survey estimated the number of residential heating devices, types of fuel used, and amount of fuel used in the PM_{2.5} nonattainment area. Four categories of fuel are used for space heating in residential buildings: wood, oil, coal, and natural gas. The oil category includes fuel oil, diesel, and kerosene. The same fuels are used for space heating in commercial buildings. Fuel combustion efficiency varies depending on the type of heating device used and the fuel being combusted. Existing emissions were calculated by applying the fuel use ratios to the demand estimates discussed in Section 6.2.1 (in terms of Btu of natural gas input), adding the existing natural gas consumption to the fuel use tally, adjusting the demand for each fuel based on the average combustion efficiency of that fuel compared to natural gas, and converting the heat input demand into fuel consumption for each of the fuel categories. Demand in the low zone is discussed in Section 6.2.1 in terms of propane. The heat demand in this zone was originally calculated in terms of Btu of

natural gas input; therefore, the low zone demand numbers did not require additional adjustment prior to the emission calculations.

Annual emission estimates were calculated using an EPA reference document, AP-42, Compilation of Air Pollutant Emission Factors, Section 1 (EPA 2010). Emission estimates for PM₁₀ and PM_{2.5} may differ from the PM emissions in the analyses being prepared as part of the PM_{2.5} State Implementation Plan (SIP). The FNSB and the contractor preparing the SIP analyses, Sierra Research, are currently in the final stages of development of Alaska-specific PM emission factors. These emission factors are based on source testing of commonly used heating devices and locally available fuels in the FNSB. Preliminary discussions indicate that the Alaska-specific PM emission factors may be substantially lower than the PM emission factors provided in AP-42.

The same method described above was used to calculate the emission estimates for the commercial sources, except the fuel type use data were provided by Sierra Research (Sierra Research 2010). Wood was not included in the fuel type use data for commercial sources. The calculation method assumes that the fuel use ratio is the same in the high, medium, and low-demand zones.

10.1 Non-attainment Area

Particulate matter is a pollutant of special concern in the Fairbanks area. Exceedances of the ambient air quality standard for PM_{2.5} have been measured in Fairbanks. As a result, EPA has designated portions of the Fairbanks and North Pole areas as a nonattainment area for PM_{2.5}. This nonattainment area is portrayed in Figure 2. Because of the very small size of the particle, PM_{2.5} can reach deeply into human respiratory systems and cause or aggravate serious health problems, including asthma, bronchitis, and heart attacks. PM_{2.5} can be emitted directly from sources of combustion and can also form when gases emitted by combustion react in the air (EPA 2012).

The nonattainment designation for the Fairbanks area is a cause for concern for several reasons. First, the local population is at increased risk for respiratory and circulatory health problems. Secondly, the designation negatively affects economic growth in the area. Air quality permits for any commercial or industrial activity cannot be obtained if the activity will increase the amount of PM_{2.5} emissions over current amounts. Because of this restriction, growth of existing commercial and industrial activity will likely not occur, and new commercial and industrial activities will likely not take root in the Fairbanks area, until EPA is satisfied that compliance with the ambient PM_{2.5} standard is attained and a plan is in place to maintain compliance with the ambient standard.

Natural gas conversion in Fairbanks will reduce the emissions of PM_{2.5} from residential and commercial facilities. The conversion to natural gas will also reduce NO_x and SO₂ emissions, which are precursors to the formation of secondary PM_{2.5} in the atmosphere. The reduction will help bring the Fairbanks area into attainment with the ambient PM_{2.5} air quality standard. The reduction in emissions is discussed further in Section 10.2.

10.2 Potential Impacts, Conversion to Natural Gas

SLR International Corp's analysis estimates the change in emissions resulting from conversion of the three demand zones to natural gas over a period of six years. The emissions calculations assume that the rate of conversion for each original fuel type is the same except in the low-demand zone, where demand modeling indicates that residential wood burners will likely not begin converting to propane prior to 2021. In the low-demand zone, the emissions calculations assume that residential conversions from coal and oil occur at the same rate, while residential conversion from wood combustion does not occur during the six years of the scenario. The emission calculations also assume that the existing use

of natural gas supplied by FNG remains constant during the years of the analysis. Results of the analysis are shown in Table 22 through Table 24.

Table 22. Estimated Annual Emissions (tpy) After Conversion in the High-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO _x	Residential	399	391	355	279	216	172	160
	Commercial	347	330	281	227	199	198	199
	Total	746	721	636	506	415	369	360
CO	Residential	12,672	12,166	10,268	6,389	3,093	795	152
	Commercial	203	199	187	172	165	166	168
	Total	12,875	12,366	10,454	6,562	3,258	961	319
PM ₁₀	Residential	1,505	1,445	1,221	761	371	99	23
	Commercial	59	54	40	24	16	15	15
	Total	1,564	1,499	1,260	785	387	114	38
PM _{2.5}	Residential	1,294	1,242	1,049	655	320	86	21
	Commercial	54	49	37	23	15	14	15
	Total	1,348	1,292	1,086	678	335	101	36
SO ₂	Residential	452	434	366	227	109	27	4
	Commercial	534	471	301	112	14	1	1
	Total	986	905	668	340	123	28	5
VOC	Residential	9,592	9,207	7,763	4,816	2,309	563	73
	Commercial	10	10	10	11	11	11	11
	Total	9,602	9,217	7,774	4,826	2,320	574	84

Source: SLR International Corp 2012

Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 23. Estimated Annual Emissions (tpy) After Conversion in the Medium-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO _x	Residential	278	280	249	200	158	129	122
	Commercial	61	62	50	40	35	35	35
	Total	339	343	299	240	193	164	157
CO	Residential	8,815	8,904	7,250	4,714	2,560	1,060	644
	Commercial	36	36	33	30	29	29	30
	Total	8,851	8,940	7,283	4,745	2,589	1,089	673
PM ₁₀	Residential	1,047	1,058	862	562	306	129	80
	Commercial	10	11	7	4	3	3	3
	Total	1,057	1,068	869	566	309	132	82
PM _{2.5}	Residential	900	909	741	483	264	112	69
	Commercial	10	10	6	4	3	3	3
	Total	909	919	747	487	267	114	72
SO ₂	Residential	315	318	259	168	91	37	22
	Commercial	94	95	53	20	2	0	0
	Total	409	413	312	188	93	37	22
VOC	Residential	6,672	6,740	5,482	3,555	1,917	777	460
	Commercial	1.8	1.8	1.8	1.9	1.9	1.9	1.9
	Total	6,674	6,741	5,484	3,557	1,919	779	462

Source: SLR International Corp 2012

Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 24. Estimated Annual Emissions (tpy) After Conversion in the Low-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO _x	Residential	83	81	74	67	60	58	58
	Commercial	24	20	17	13	12	12	12
	Total	108	101	91	81	72	70	70
CO	Residential	2,679	2,665	2,588	2,509	2,428	2,410	2,434
	Commercial	114	12	11	10	10	10	10
	Total	2,793	2,677	2,599	2,519	2,438	2,420	2,444
PM ₁₀	Residential	318	320	321	321	321	323	327
	Commercial	6	3	2	1	1	1	1
	Total	324	324	323	322	322	324	328
PM _{2.5}	Residential	274	275	276	276	276	278	281
	Commercial	5	3	2	1	1	1	1
	Total	279	278	278	277	277	279	281
SO ₂	Residential	96	88	68	47	26	18	18
	Commercial	36	28	17	5	0	0	0
	Total	131	116	85	52	26	18	18
VOC	Residential	2,028	2,047	2,064	2,081	2,098	2,117	2,139
	Commercial	4	1	1	1	1	1	1
	Total	2,033	2,048	2,065	2,081	2,098	2,118	2,139

Source: SLR International Corp 2012

Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 25 through Table 27 provide the overall estimated percentage change in emissions for residential and commercial facilities in each of the demand zones. The slight increases in VOC emissions in the commercial sector in the high and medium-demand zones are caused by the increased combustion of natural gas. The slight increases in residential PM₁₀, PM_{2.5}, and VOC emissions in the low-demand zone are due to continued combustion of wood fuel.

Table 25. Change in Emissions Due to Conversion in the High-Demand Zone

Category	NO _x	CO	PM ₁₀	PM _{2.5}	SO ₂	VOC
	(%)					
Residential	-60	-99	-98	-98	-99	-99
Commercial	-43	-18	-74	-73	-100	8
Total	-52	-98	-98	-97	-99	-99

Source: SLR International Corp 2012

Table 26. Change in Emissions Due to Conversion in the Medium-Demand Zone

Category	NO _x	CO	PM ₁₀	PM _{2.5}	SO ₂	VOC
	(%)					
Residential	-56	-93	-92	-92	-93	-93
Commercial	-43	-18	-74	-73	-100	8
Total	-54	-92	-92	-92	-95	-93

Source: SLR International Corp 2012

Table 27. Change in Emissions Due to Conversion in the Low-Demand Zone

Category	NO _x	CO	PM ₁₀	PM _{2.5}	SO ₂	VOC
	(%)					
Residential	-30	-9	3	3	-82	5
Commercial	-51	-91	-85	-83	-100	-85
Total	-35	-12	1	1	-86	5

Source: SLR International Corp 2012

Table 28 shows the percent reduction in emissions by fuel type for residential structures in the high and medium-demand zones, demonstrating that conversion of residential heating systems from wood-fired to natural gas-fired has a greater effect on emissions reductions of all pollutants except NO_x and SO₂. The emissions of these two pollutants are reduced more effectively by conversion of oil-fueled systems to natural gas. In the residential sector, conversion from wood-fired systems to natural gas-fired systems results in 95 percent of the PM_{2.5} emission reductions.

Table 28. Contribution to Emission Reductions from Residential Structures, By Fuel Type In the High and Medium-Demand Zones

Fuel Type	NO _x	CO	PM ₁₀	PM _{2.5}	SO ₂	VOC
	(%)					
Wood	27	83	95	95	4	99
Oil	55	0	1	2	83	0
Coal	18	17	3	3	13	1

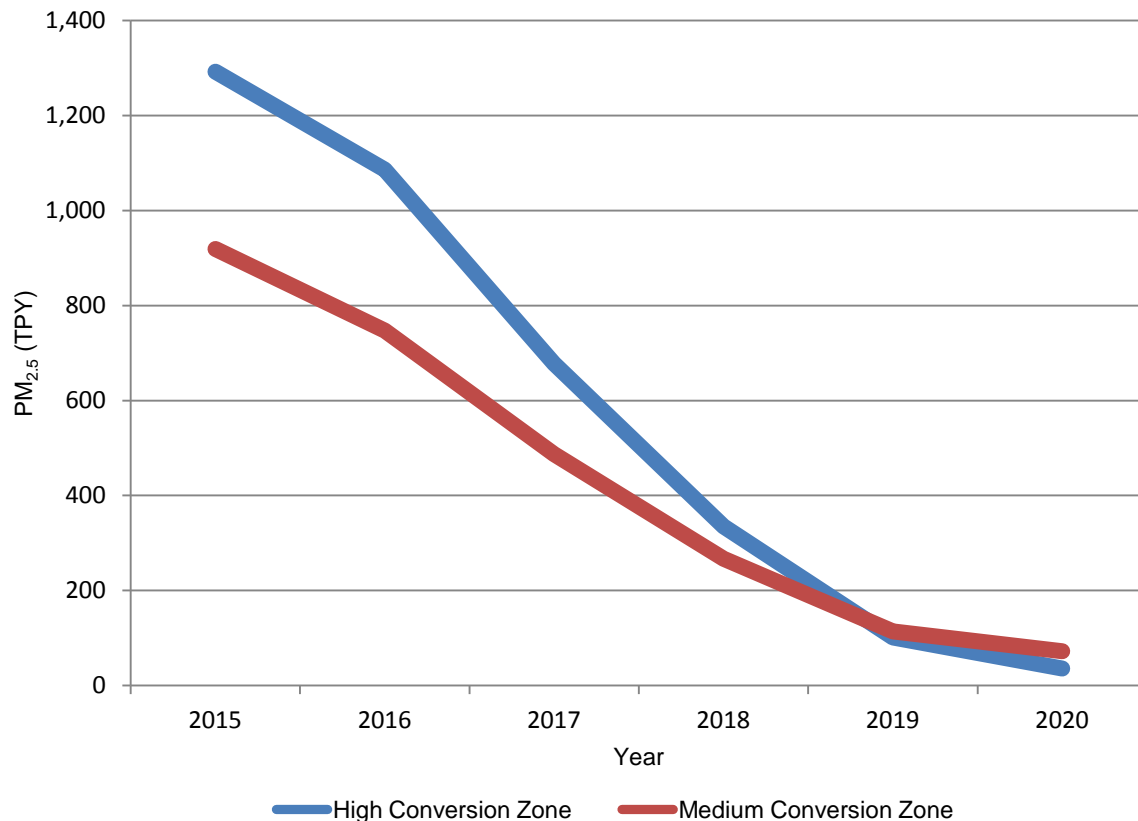
Source: SLR International Corp 2012

Note: Percent reductions for each pollutant may not total 100 percent due to rounding.

SLR also prepared a brief companion analysis to estimate the change in emissions if residential and commercial structures in the high and medium-demand zones that use wood or coal for space heating do not convert to natural gas-fired systems as anticipated in the model. The analysis assumed zero growth in the use of wood and coal fuels, and that conversion from oil-fueled to natural gas-fired systems occurs as the demand model predicts. PM_{2.5} emissions from the commercial sector would still decrease significantly because the majority of commercial structures are heated with oil-fueled systems. However, PM_{2.5} emissions from the residential sector would decrease by less than one percent in this scenario. This companion analysis makes clear that conversion of residential heating systems from wood-fired and coal-fired to natural gas-fired is essential to achieving reductions in PM_{2.5} emissions.

The main analysis demonstrates that converting to natural gas use for heating will reduce the overall emissions of PM_{2.5} in the Fairbanks area. Figure 22 illustrates the estimated change in PM_{2.5} emissions from residential and commercial sources in the high and medium-demand zones.

Figure 22. PM_{2.5} Emissions Estimates, High and Medium-Demand Areas, 2015 to 2020, in Tons of Pollutant per Year.



Source: SLR International

The conversion to natural gas will also reduce NO_x and SO₂ emissions, which are precursors to the formation of secondary PM_{2.5} in the atmosphere. These emission reductions will help bring the Fairbanks area into attainment with the ambient PM_{2.5} air quality standard.

The emissions reductions presented here reflect the changes associated with the piped natural gas systems in the high and medium-demand areas and propane systems in the low-demand area.

10.3 Ice Fog Implications

Ice fog is a weather condition that can occur during winter cold snaps of approximately -30 degrees Fahrenheit and colder. The Fairbanks area normally experiences several cold periods each winter during which ice fog forms and limits visibility. Ice fog forms when water vapor is emitted into very cold air that has a relative humidity at or close to 100 percent. The water vapor cools rapidly and forms tiny ice particles, which make up the fog. Because Fairbanks already experiences ice fog events each winter, SLR prepared an analysis to determine the amount of additional water vapor that would be emitted during combustion of natural gas compared to other fuels used in the local area. SLR

determined the moisture content of wood, wood pellets, oil, natural gas, and coal, and developed approximate chemical formulas for each fuel. Combustion of fuel produces water vapor and carbon dioxide. A ratio of water vapor produced per the amount of fuel combusted can be obtained by balancing the chemical equation of combustion for each fuel.

Natural gas-fired boilers and furnaces appropriate for residential and commercial use are classified as either condensing units or non-condensing units. Condensing units do not emit as much water vapor in the exhaust because the vapor is condensed and drained from the unit. Initial research indicates that condensing units may not be the better option for use in the Fairbanks area due to the low but constant rate of water drainage, which can produce ice dams in drain or sewer lines, and due to the intake air temperature requirements of these units. This analysis does not account for condensation of water vapor prior to exhaust.

SLR determined that natural gas combustion will produce a greater mass of water vapor per heat input than oil, coal, and wood pellets. The results of this analysis are provided in Table 29.

Table 29. Water Vapor Emission Analysis

Fuel Type	Heating Value (MMBtu/ton)	Water Produced Per Mass of Fuel (%)	Water Produced per Fuel Input (ton water/MMBtu fuel)
Oil	37.4	138	3.7
Coal	15.3	60	3.9
Wood Pellets	13.9	60	4.3
Natural Gas	48	225	4.7
Wood	5.0	68	13.5

Source: SLR International Corp 2012

If the Fairbanks area converts many of the existing space heating emission units to natural gas combustion, water vapor emissions will likely increase. These additional water vapor emissions do not necessarily mean that ice fog events will become more common, because the frequency of the meteorological conditions that trigger ice fog events will not increase. However, the ice fog events that do occur may have slightly longer duration and may cover a slightly larger geographic area.

The local exceedances of the ambient PM_{2.5} air quality standard (excluding wildfire smoke events) occur during these same cold snaps. Carl S. Benson stated it clearly that “the air pollution over Fairbanks during cold spells couldn’t be worse, because the mechanisms for cleaning the air are virtually eliminated while all activities which pollute the air are increased.” (Benson 1965). Conversion to natural gas-fired space heating systems to lower PM_{2.5} emissions in the Fairbanks area in pursuit of achieving attainment with the ambient air quality standard for PM_{2.5} is not expected to have a significant negative effect on ice fog events.

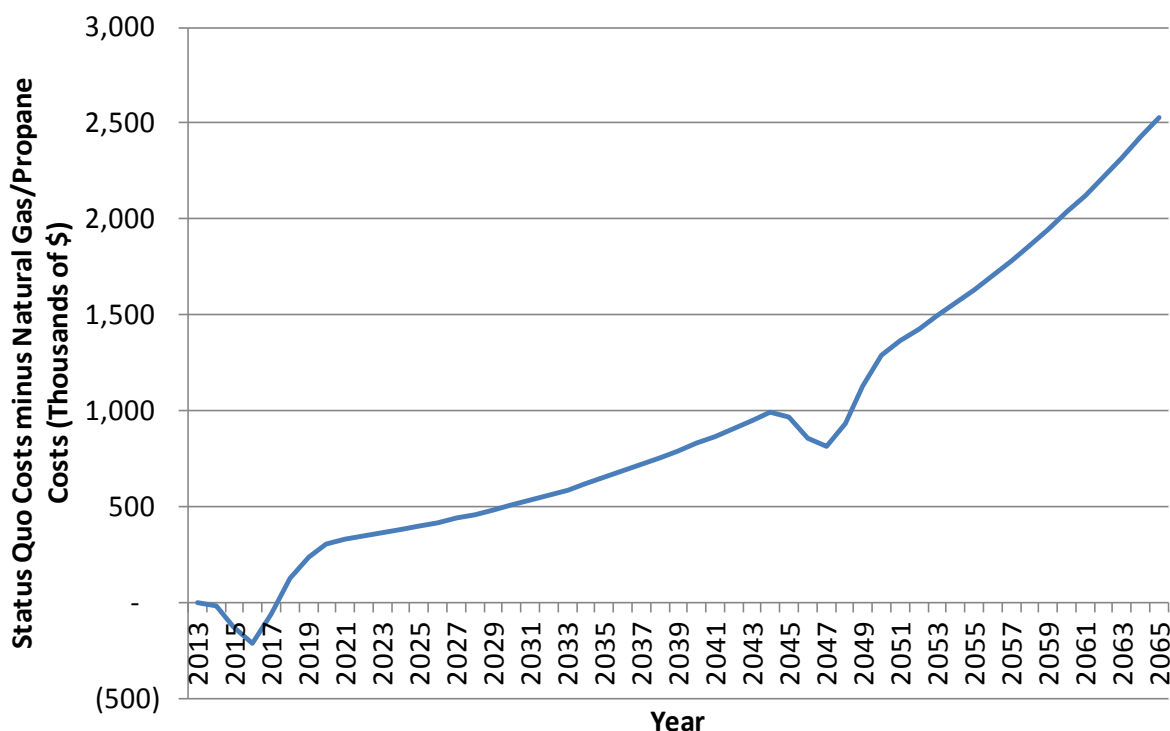
11 Decision Points

The purpose of this report section is to identify if there were zones or areas where the costs of converting to natural gas and propane were greater than the costs of using distillates and wood. As noted in the BCA discussion (Section 8), the benefit-cost ratio for each of the three density areas (high, medium, and low) is positive, so there is no need to phase the project or to not undertake development of the distribution system in any area.

The large number of assumptions and variables employed in the modeling effort, and the potential management responses to changes in costs make it difficult to identify points where decisions would be made to not proceed with the project. For example, if the cost of natural gas exceeded \$10 per MMBtu in 2015 sponsors of the gas distribution system could seek to obtain additional grants to reduce capital expenditure or seek grants to be used as operating funds and subsidize the cost to the consumer until sufficient volumes of gas reduce the per unit cost. Similar responses could be undertaken to mitigate other adverse changes in assumptions or costs.

On a borough-wide basis the costs of converting to natural gas/propane are less than the costs of continuing with the status quo through 2065. As is typical of any project with large upfront capital investments the costs associated with the conversion to natural gas/propane are greater in the initial years and then in later years the fuel cost savings associated with natural gas/propane result in lower costs to local residents and businesses compared to distillates and wood. Figure 23 shows the net difference (annual status quo costs less natural gas/propane costs) in the stream of costs for the two different fuel alternatives. The cumulative net value turns positive in 2018 and continues to increase over time. The drop beginning in 2045 is replacing all of the gas-fired boilers and furnaces that were converted in the 2015 to 2020 time period.

Figure 23. Cost Differential Between Alternatives



Source: Northern Economics, Inc.

The model indicates that wood switching will not occur in the high and medium density areas for several years depending on the specific model assumptions that are used. In most model runs the wood switching does not occur until 2021 or so, when the volume of gas sales has increased to the point where the fixed costs can be spread across greater gas sales volumes. Substantial increases in the amount of grants to the project can reduce the date by two or three years but another approach would be to obtain grants that could be used as operating funds and employed to reduce the sales price for the first five or six years until the conversions are generally complete or the sales volumes enable gas to compete with wood.

The model also indicates that propane can displace fuel oil in the low density area but is unlikely to cause residents using wood heat to switch to propane. This may not be an issue since there are relatively few structures in the low density areas and they are widely dispersed. However, it does mean that this group may not benefit from the energy investment available to other residents.

12 References

- Alaska Department of Labor and Workforce Development, Research and Analysis Section, 2011. Average Monthly Employment Estimates by Industry, Fairbanks North Star Borough (MSA).
- Alaska Department of Labor and Workforce Development, Research and Analysis Section, 2011. Alaska Population Projections, 2010 – 2035. Available at <http://labor.alaska.gov/research/pop/projected/pub/popproj.pdf>. Accessed June 15, 2012.
- Benson, Carl S. 1965. Ice Fog: Low Temperature Air Pollution. Geophysical Institute of the University of Alaska.
- Cold Climate Housing Research Center (CCHRC). 2009. Preliminary Economic Analyses of Several Options for Delivering Natural Gas from a Local CNG Hub to Households in the Fairbanks North Star Borough. November 11, 2009.
- Fairbanks Natural Gas (FNG). 2005. Customer Service (web page). Available at <http://www.fngas.com/service.html>. Accessed January 29, 2012. Page last updated 2005.
- Fairbanks North Star Borough, Community Research Center (FNSB). 2011a. *Community Research Quarterly*, Volume XXXIV, No.1, 2011.
- Fairbanks North Star Borough (FNSB). 2011b. Overview Map. Available at: ftp://co.fairbanks.ak.us/Maps/Maps/FNSB_Overview_Map.pdf
- Fuhs, Paul. Propane Production, Transportation and Utilization in Rural and Urban Alaska. Prepared for the Alaska Natural Gas Development Authority. December 2010.
- Interior Issues Council: In-State Natural Gas Distribution Task Force (IIC). 2009. In-State Natural Gas Options Study. February 5, 2009.
- Institute of Social and Economic Research (ISER). Snapshot: The Home Energy Rebate Program. May 2012.
- Laabs, Scott. Commercial Project Manager, Altrol, Inc. 2012. Personal communication with Northern Economics, Inc. January 29, 2012.
- National Research Council, 2009. Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. National Academies Press
- Northern Economics, Inc. et al. 2010. In-State Gas Demand Study. Prepared for TransCanada Alaska Company, LLC. January 2010.
- Risk Management Association (RMA). 2011. RMA annual statement studies. Industry default probabilities and cash flow measures. 2011/2012.
- Sierra Research. 2010. 2010 Fairbanks Home Heating Survey report. Prepared by for the Alaska Department of Environmental Conservation. June 21, 2010.
- Szymoniak, N. and S. Goldsmith. *Preliminary Economic Analysis of North Slope Propane and Review of June Alaska Propane Opportunities Conference*. Institute of Social and Economic Research. Prepared for ANGDA: the North Slope Propane Opportunity Consortium Meetings. September 24, 2009.
- U.S. Department of Transportation, 2012. TIGER Benefit-Cost Analysis Resource Guide. Available at <http://www.dot.gov/tiger> Accessed May 2012.

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- U.S. Environmental Protection Agency (EPA), 2010. Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Available at <http://www.epa.gov/oms/climate/regulations/scc-tds.pdf> Accessed May 2012.
- U.S. Environmental Protection Agency (EPA). 2012a. Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I, January 1995, as updated through 2012.
- U.S. Environmental Protection Agency (EPA). 2012b. Particulate Matter. Available at: <http://www.epa.gov/air/particlepollution/health.html>.
- U.S. General Services Administration (GSA), 1997. Office of Real Property, Office Space Use Review, Current Practices and Emerging trends.
- Ward, Charles. 2012. University of Alaska Fairbanks. Power plant fuel consumption and power generation data prepared at the request of Northern Economics. January 17, 2012.

Appendix A. Project Maps

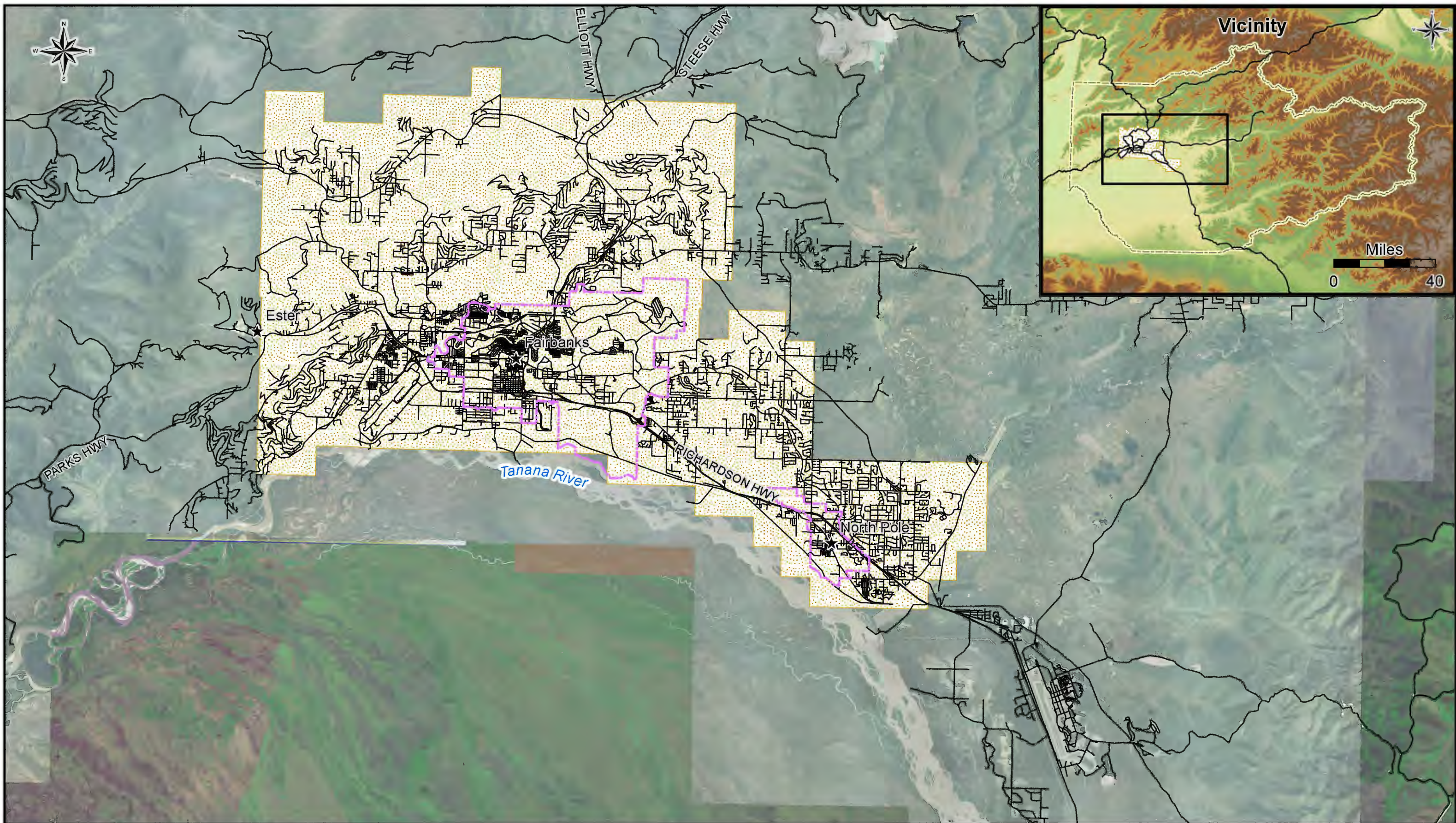


Figure 2
Existing PM2.5
Non-Attainment Area

SCALE 1 in = 3 miles

DATE 06/26/2012

Baker

Legend

— Roads

— Borough Boundary

City Boundary

PM2.5 Non-Attainment Area

**Fairbanks North Star Borough
Gas Distribution Analysis**

0 1.5 3 6 Miles



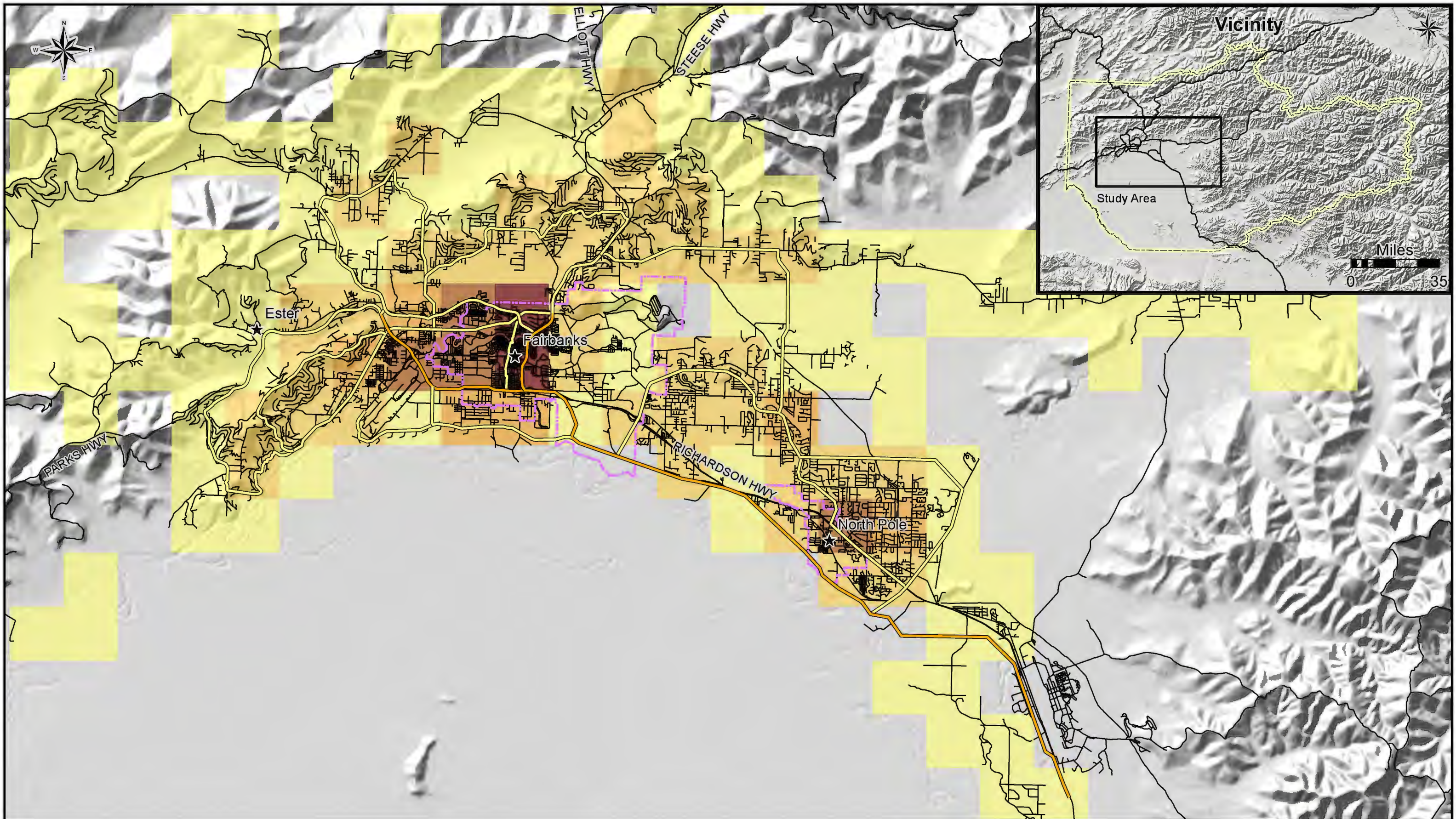


Figure 3 Estimated Combined Residential and Commercial Demand		Legend				Fairbanks North Star Borough Gas Distribution Analysis		
SCALE	1 in = 3 miles	City Boundary Borough Boundary Roads	Network Pipelines Distribution Pipeline Transmission Pipeline	MMBtu/Year 65 - 45,763 45,763 - 164,578	164,578 - 370,219 370,219 - 744,942 744,942 - 1,165,364			
DATE	6/26/2012							

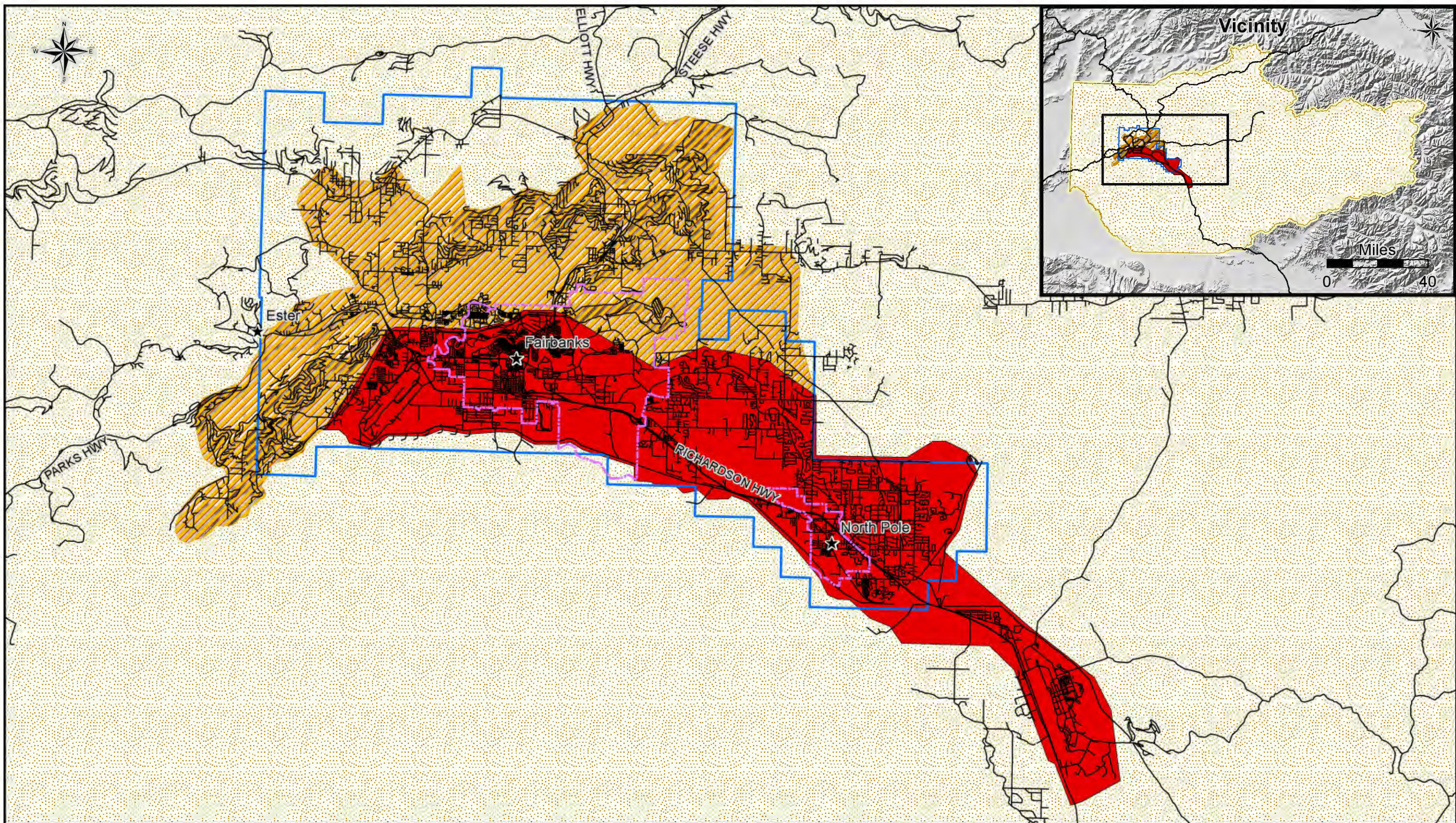


Figure 4
High, Medium, and Low
Demand Areas

SCALE 1 in = 3 miles

DATE 06/26/2012

Baker

Legend

- Roads
- City Boundary
- Borough Boundary
- PM2.5 Non-Attainment Area
- High Demand
- Medium Demand
- Low Demand

**Fairbanks North Star Borough
Gas Distribution Analysis**

0 1.5 3 6 Miles



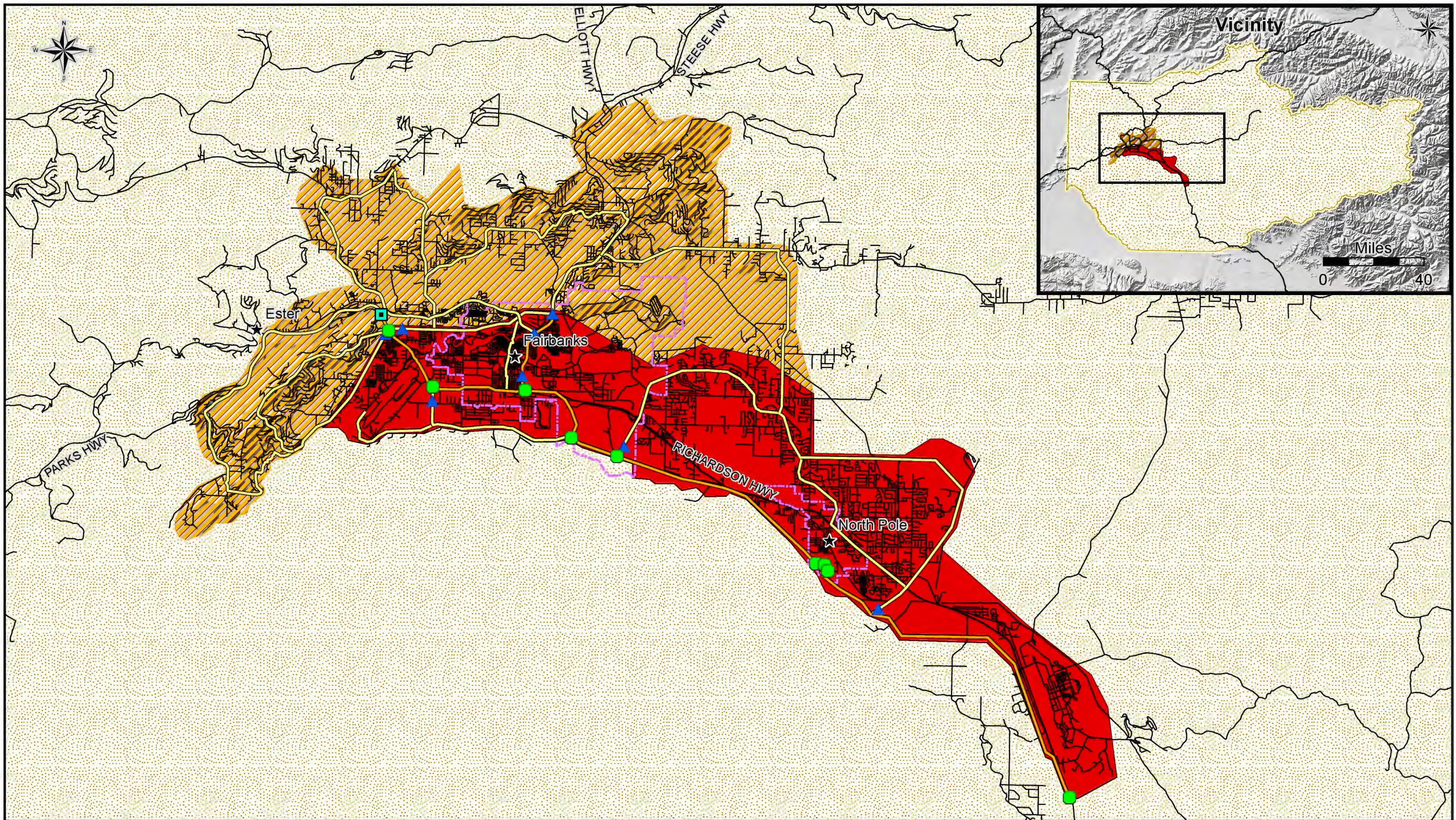


Figure 7
High, Medium, and Low
Demand Areas

SCALE 1 in = 3 miles

DATE 06/26/2012

Baker

Legend

- | | | | |
|--|--|--|---|
| ■ Gas In Point | — Distribution Pipeline | City Boundary | High Demand |
| ▲ Reg Station | — Transmission Pipeline | Borough Boundary | Medium Demand |
| ● Gate Station | — Roads | Low Demand | |

**Fairbanks North Star Borough
Gas Distribution Analysis**

0 1.5 3 6 Miles



Appendix B. Basis of Cost Estimation (Michael Baker, Jr. Inc.)

FINAL COST ESTIMATE SUMMARY: PIPELINE LAYOUT NETWORK

	Length [LF]	Length [Miles]	Construction Cost	Materials	Engineering	Permitting	Total Cost	Cost/Foot	Cost/Mile
HIGH DEMAND AREA									
Pipelines									
<i>Transmission lines</i>	184,644	35	\$ 29,232,000	\$ 11,122,000	\$ 2,018,000	\$ 15,000	\$ 42,387,000	\$ 230	\$ 1,212,000
<i>Distribution feeder lines</i>	275,435	52	\$ 17,852,000	\$ 3,840,000	\$ 1,085,000	\$ 23,000	\$ 22,800,000	\$ 83	\$ 437,000
<i>Distribution lines</i>	2,311,922	438	\$ 57,798,000	\$ 15,783,000	\$ 3,679,000	\$ 191,000	\$ 77,451,000	\$ 34	\$ 177,000
<i>Service lines</i>	852,375	161	\$ 21,309,000	\$ 11,138,000	\$ 1,622,000	\$ 71,000	\$ 34,140,000	\$ 40	\$ 211,000
Pig Launcher and Receiver			\$ -	\$ 600,000	\$ 180,000	\$ -	\$ 780,000		
Unknown Costs (30%)			\$ 37,857,000	\$ 12,745,000	\$ 2,575,000	\$ 90,000	\$ 53,267,000		
Subtotal	3,624,375	686	\$ 164,048,000	\$ 55,228,000	\$ 11,159,000	\$ 390,000	\$ 230,825,000	\$ 64	\$ 336,000
SUBTOTAL COST RANGE (-30% to +50%):							\$161,600,000 to \$346,200,000		

MEDIUM DEMAND AREA

Pipelines									
<i>Transmission lines</i>	-	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<i>Distribution feeder lines</i>	348,820	66	\$ 17,441,000	\$ 4,748,000	\$ 1,109,000	\$ 19,000	\$ 23,317,000	\$ 67	\$ 353,000
<i>Distribution lines</i>	2,607,980	494	\$ 65,200,000	\$ 10,125,000	\$ 3,766,000	\$ 139,000	\$ 79,230,000	\$ 30	\$ 160,000
<i>Service lines</i>	808,500	153	\$ 20,213,000	\$ 8,975,000	\$ 1,459,000	\$ 43,000	\$ 30,690,000	\$ 38	\$ 200,000
Pig Launcher and Receiver			\$ -	\$ -	\$ -	\$ -	\$ -		
Unknown Costs (30%)			\$ 30,856,000	\$ 7,154,000	\$ 1,900,000	\$ 60,000	\$ 39,971,000		
Subtotal	3,765,300	713	\$ 133,710,000	\$ 31,002,000	\$ 8,234,000	\$ 261,000	\$ 173,208,000	\$ 46	\$ 243,000
SUBTOTAL COST RANGE (-30% to +50%):							\$121,200,000 to \$259,800,000		

COMBINED HIGH AND MEDIUM DEMAND AREAS

Total	7,389,675	1,400	\$ 297,758,000	\$ 86,230,000	\$ 19,393,000	\$ 651,000	\$ 404,033,000	\$ 55	\$ 289,000
TOTAL COST RANGE (-30% to +50%):							\$282,800,000 to \$606,000,000		

DETAILS: FINAL COST ESTIMATE, PIPELINE LAYOUT NETWORK

HIGH POPULATION DENSITY AREA						
Description	Class	Dia [in]	Quantity	Unit	Unit Cost	Total Cost
1. TRANSMISSION LINES: Provides natural gas to distribution feeder lines and industrial users						
Construction						
Installation Fairbanks to Eielson	ANSI 600	10	168,494	LF	\$ 90	\$ 15,164,000
Installation Fairbanks towards Fox	ANSI 300	8	16,149	LF	\$ 90	\$ 1,453,000
Cathodic Protection			35	miles	\$ 15,000	\$ 525,000
HDD Chena river	varies	varies	1,600	LF	\$ 400	\$ 640,000
Gate Station	ANSI 600	10	9	EA	\$ 1,250,000	\$ 11,250,000
Pigging connection	ANSI 600	10	2	EA	\$ 50,000	\$ 100,000
Pigging connection	ANSI 300	8	2	EA	\$ 50,000	\$ 100,000
Subtotal-construction						\$ 29,232,000
Materials						
Materials- Steel pipe, FBE coated	ANSI 600	10	168,494	LF	\$ 53	\$ 8,930,000
Materials- Steel pipe, FBE coated	ANSI 300	8	16,149	LF	\$ 44	\$ 711,000
Materials- Valves	ANSI 600	10	4	EA	\$ 34,000	\$ 136,000
Materials- Valves	ANSI 300	8	2	EA	\$ 20,000	\$ 40,000
Materials- Design allowance	varies	10 & 8	5%	EA	\$ 490,850	\$ 491,000
Materials- Misc. Freight			2%	EA	\$ 196,340	\$ 196,000
Materials- Procurement			4%	EA	\$ 412,320	\$ 412,000
Materials- SQS			2%	EA	\$ 206,160	\$ 206,000
Subtotal-materials						\$ 11,122,000
Launcher/Receiver						
Pig Barrels- mobile	ANSI 600	12	2	EA	\$ 300,000	\$ 600,000
Subtotal- Transmission Lines			184,644	LF		\$ 40,954,000
2. DISTRIBUTION FEEDER LINES: Provides natural gas to local distribution lines						
Construction						
Installation	60psig	6	275,435	LF	\$ 50	\$ 13,772,000
HDD Chena river	60psig	6	1600	LF	\$ 300	\$ 480,000
Regulator stations	60psig	6	9	EA	\$ 400,000	\$ 3,600,000
Subtotal-construction						\$ 17,852,000
Materials						
Materials- Plastic	60psig	6	275,435	LF	\$ 12	\$ 3,305,000
Materials- Valves	60psig	6	7	EA	\$ 13,300	\$ 93,000
Materials- Design allowance	varies	varies	5%	EA	\$ 169,900	\$ 170,000
Materials- Misc. Freight			2%	EA	\$ 67,960	\$ 68,000
Materials- Procurement			4%	EA	\$ 135,920	\$ 136,000
Materials- SQS			2%	EA	\$ 67,960	\$ 68,000
Subtotal-materials						\$ 3,840,000
Subtotal- Distribution Feeder Lines			275,435	LF		\$ 21,692,000
3. DISTRIBUTION LINES: Provides natural gas to service lines						
Construction						
Residential lines	60 psig	2	2,311,922	LF	\$ 25	\$ 57,798,000
Subtotal-construction						\$ 57,798,000
Materials						
Materials- Pipe HDPE	60 psig	2	2,311,922	LF	\$ 6	\$ 13,872,000
Materials- Valves	60 psig	2	55	EA	\$ 6,200	\$ 341,000
Materials- Design allowance	varies	varies	5%	EA	\$ 710,650	\$ 711,000
Materials- Misc. Freight			2%		\$ 284,260	\$ 284,000
Materials- Procurement			4%		\$ 568,520	\$ 569,000
Materials- SQS			2%	EA	\$ 284,260	\$ 6,000
Subtotal-materials						\$ 15,783,000
Subtotal- Distribution Lines			2,311,922	LF		\$ 73,581,000
4. SERVICE LINES: Provides natural gas to individual users						
Construction						
Residential lines- high density	60 psig	0.625	11,160	837,000 LF	\$ 25	\$ 20,925,000
Commercial lines- high density	60 psig	1	205	15,375 LF	\$ 25	\$ 384,000
Subtotal-construction						\$ 21,309,000
Materials						
Materials- Pipe HDPE	60 psig	0.625	11,160	837,000 LF	\$ 5	\$ 4,185,000
Materials- Pipe HDPE	60 psig	1	205	15,375 LF	\$ 5	\$ 1,000
Materials- Valves	60 psig	0.625	11,160	EA	\$ 500	\$ 5,580,000
Materials- Valves	60 psig	1	205		\$ 500	\$ 103,000
Materials- Design allowance			5%	LF	\$ 488,300	\$ 488,000
Materials- Misc. Freight			2%	LF	\$ 195,320	\$ 195,000
Materials- Procurement			4%	LF	\$ 390,640	\$ 391,000
Materials- SQS			2%	LF	\$ 195,320	\$ 195,000
Subtotal-materials						\$ 11,138,000
Subtotal- Service Lines			852,375	LF		\$ 32,447,000

DETAILS: FINAL COST ESTIMATE, PIPELINE LAYOUT NETWORK

MEDIUM POPULATION DENSITY AREA							
Description	Class	Dia [in]	Quantity	Unit	Unit Cost	Total Cost	
1. TRANSMISSION LINES: Provides natural gas to distribution feeder lines and industrial users							
Construction							
Installation	ANSI 600	10	-	LF	\$ 90	\$ -	
Cathodic Protection			-	miles	\$ 15,000	\$ -	
HDD Chena river	varies	varies	-	LF	\$ 400	\$ -	
Gate Station	ANSI 600	10	-	EA	\$ 1,250,000	\$ -	
Pigging connection	ANSI 600	10	-	EA	\$ 50,000	\$ -	
Pigging connection	ANSI 300	8	-	EA	\$ 50,000	\$ -	
Subtotal-construction						\$ -	
Materials							
Materials- Steel pipe, FBE coated	ANSI 600	10	-	LF	\$ 53	\$ -	
Materials- Steel pipe, FBE coated	ANSI 300	8	-	LF	\$ 44	\$ -	
Materials- Valves	ANSI 600	10	-	EA	\$ 34,000	\$ -	
Materials- Valves	ANSI 300	8	-	EA	\$ 20,000	\$ -	
Materials- Design allowance	varies	10 & 8	5%	EA	\$ -	\$ -	
Materials- Misc. Freight			2%	EA	\$ -	\$ -	
Materials- Procurement			4%	EA	\$ -	\$ -	
Materials- SQS			2%	EA	\$ -	\$ -	
Subtotal-materials						\$ -	
Launcher/Receiver							
Pig Barrels- mobile	ANSI 600	12	-	EA	\$ 300,000	\$ -	
Subtotal- Transmission Lines			-	LF		\$ -	
2. DISTRIBUTION FEEDER LINES: Provides natural gas to local distribution lines							
Construction							
Installation	60psig	6	348,820	LF	\$ 50	\$ 17,441,000	
HDD Chena River	60psig	6	0	LF	\$ 300	\$ -	
Regulator stations	60psig	6	-	EA	\$ 400,000	\$ -	
Subtotal-construction						\$ 17,441,000	
Materials							
Materials- Plastic	60psig	6	348,820	LF	\$ 12	\$ 4,186,000	
Materials- Valves	60psig	6	9	EA	\$ 13,300	\$ 120,000	
Materials- Design allowance	varies	varies	5%	EA	\$ 169,900	\$ 170,000	
Materials- Misc. Freight			2%	EA	\$ 67,960	\$ 68,000	
Materials- Procurement			4%	EA	\$ 135,920	\$ 136,000	
Materials- SQS			2%	EA	\$ 67,960	\$ 68,000	
Subtotal-materials						\$ 4,748,000	
Subtotal- Distribution Feeder Lines			348,820	LF		\$ 22,189,000	
3. DISTRIBUTION LINES: Provides natural gas to service lines							
Construction							
Residential lines	60 psig	2	2,607,980	LF	\$ 25	\$ 65,200,000	
Subtotal-construction						\$ 65,200,000	
Materials							
Materials- Pipe HDPE	60 psig	2	2,607,980	LF	\$ 6	\$ 8,734,000	
Materials- Valves	60 psig	2	62	EA	\$ 6,200	\$ 384,000	
Materials- Design allowance	varies	varies	5%	EA	\$ 455,900	\$ 456,000	
Materials- Misc. Freight			2%		\$ 182,360	\$ 182,000	
Materials- Procurement			4%		\$ 364,720	\$ 365,000	
Materials- SQS			2%	EA	\$ 182,360	\$ 4,000	
Subtotal-materials						\$ 10,125,000	
Subtotal- Distribution Lines			2,607,980	LF		\$ 75,325,000	
4. SERVICE LINES: Provides natural gas to individual users							
Construction							
Residential lines- medium density	60 psig	0.625	7,825	782,500	LF	\$ 25	\$ 19,563,000
Commercial lines- medium density	60 psig	1	260	26,000	LF	\$ 25	\$ 650,000
Subtotal-construction							\$ 20,213,000
Materials							
Materials- Pipe HDPE	60 psig	0.625	7,825	782,500	LF	\$ 5	\$ 3,913,000
Materials- Pipe HDPE	60 psig	1	260	26,000	LF	\$ 5	\$ 1,000
Materials- Valves	60 psig	0.625	7,825		EA	\$ 500	\$ 3,913,000
Materials- Valves	60 psig	1	260			\$ 500	\$ 130,000
Materials- Design allowance			5%		LF	\$ 391,350	\$ 391,000
Materials- Misc. Freight			2%		LF	\$ 156,540	\$ 157,000
Materials- Procurement			4%		LF	\$ 313,080	\$ 313,000
Materials- SQS			2%		LF	\$ 156,540	\$ 157,000
Subtotal-materials							\$ 8,975,000
Subtotal- Service Lines			808.500	LF			\$ 29,188,000

BASIS OF ESTIMATE

Fairbanks North Star Borough Natural Gas Distribution System Preliminary Cost Estimate

March 30, 2012



Michael Baker Jr., Inc.
1400 W. Benson Blvd., Suite 200
Anchorage, AK 99503
907.273.1600

BASIS OF ESTIMATE

Rev.	Date	Comments	Prepared by:	Checked by:	Approved by:
0	1/24/12	Draft	KMJ	WJO	DMC
1	2/6/12	FNSB Review	KMJ	WJO	DMC
2	3/30/12	FNSB Review	REH	WJO	DMC

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INTRODUCTION

Total Installed Cost (TIC) estimates are developed for a number of reasons including: assessment of commercial opportunities, concept evaluation, and negotiations with third parties. Estimates are a key input to economic analysis to aid decision making at Capital stage gates and are developed throughout the project lifecycle. Estimates are prepared in Today's Money (present costs) and later, if required, escalated to Money-of-the-Day (future costs). Estimates encompass the complete scope of work for a project. The Association for the Advancement of Cost Engineering (AACE) classifies estimates by their accuracy and level of detail. For a project where design is 1-15% complete, for example a concept study or to evaluate feasibility, an expected accuracy range of +50/-30% is assumed, this is defined as a Class 4 estimate.

The project team members that contributed to the estimate development are shown below.

PROJECT ESTIMATE TEAM LOG			
Name	Position/Role	Affiliation	Contact Info
Derek Christianson, P.E.	PM	MBJ	273-1629
Bill Olzack, P.E.	Estimator QA	MBJ	273-1625
Vin Robinson, P.E.	Estimator	Enstar	230-4464
RaeAnne Hebnes, P.E.	CE/Design	MBJ	273-1618
Katie Johnson	EIT	MBJ	273-1621

PROJECT SCOPE

The purpose of this project is to define a supply-neutral optimized plan for the rapid build-out of the Fairbanks North Star Borough (FNSB) energy distribution infrastructure; one that delivers propane or natural gas by Liquefied Natural Gas (LNG) or pipeline, as affordably as possible, to the largest number of Borough residents and business properties. This cost estimate reports on the estimated cost of the construction of distribution and transmission lines to residential and commercial users within the vicinity of Fairbanks, Fort Wainwright, North Pole, and Eielson.

METHODOLOGY

At the time of estimate detailed design was not available. The pipeline construction estimate uses a factored approach for all aspects. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location and constructability (e.g. presence of permafrost). Costs were split by construction phases, phase I areas of high (over 500 people/sq mile) and phase II in medium (100-500 people/sq mile) population densities.

Transmission line pipe, 10 and 8-inch steel pipe, estimation is based on lengths of pipe measured using GIS.

BASIS OF ESTIMATE

Distribution feeder line pipe, 6-inch plastic pipe, estimation is based on lengths of pipe measured using GIS.

Distribution line pipe, 2-inch plastic pipe, estimation is based on length of pipe in miles per square mile. The length of pipe per square mile is calculated based on the following

1. Independent concept pipe networks that are based on FNG expansion areas for high and medium density areas
2. Compare independent pipe network with FNG's identified expansion areas
3. Calculate average and standard deviation values to verify results, which indicate that using this approach could generate realistic estimate of pipe length.

HIGH Population Density			
FNG Expansion Area	Length of Pipe (mi)	Area (sq mi)	Miles of Pipe per sq mi
6	9.0	0.6	15.0
19	3.8	0.25	15.2
20	6.9	0.5	13.8
Average:			14.7
Std Dev:			0.8
Use for Estimating:			15.0

MEDIUM Population Density			
FNG Expansion Area	Length of Pipe (mi)	Area (sq mi)	Miles of Pipe per sq mi
33	18.9	3.1	6.1
25	24.0	3.2	7.5
24	17.8	2.3	7.7
Average:			7.1
Std Dev:			0.9
Use for Estimating:			7.0

Service line piping, 1-inch and 0.625-inch plastic pipe, estimation is based on the number of identified service connections within high and medium density areas and classified as residential or commercial multiplied by an assumed tie-in pipe length for high and medium areas.

Horizontal Directional Drill (HDD) is estimated for two river crossings with each crossing being 800 feet in length.

Pressure Regulating Stations, including Gate Stations and Regulator Stations, are estimated by connection points between transmission line and distribution feeder lines or industrial users.

Cathodic Protection is required for all steel pipe, estimation is based on length of steel pipe.

COST BASIS

The Project Estimator uses the project work breakdown structure, material take-offs, labor productivity rates, price data, other unit rates, and factors to build spreadsheets to calculate the TIC estimate.

The following summarizes the various rates this estimate uses to calculate costs for the estimate.

Construction costs:

Pipe diameter [in]	Installed Cost	Unit	Quantity High density	Quantity Medium density
10	\$ 90	LF	168,494	0
8	\$ 90	LF	16,149	0
6	\$ 50	LF	277,035	348,820
2	\$ 25	LF	2,311,922	2,607,980
1	\$ 25	LF	15,375	26,000
0.625	\$ 25	LF	837,000	782,500
HDD	\$ 400	LF	1,600	0
Cathodic protection	\$ 15,000	mile	35	0
Gate station	\$ 1,250,000	each	9	0
Regulator station	\$ 400,000	each	9	0
Pigging connection	\$ 50,000	each	4	0

1. Bare steel pipe material priced at \$2000/ton. High Frequency Induction (HFI) Welded material. Freight is included to Fairbanks.
2. FBE coating of steel pipe is estimated at \$1.69/inch diameter, adjusted from Flowline Alaska quotation.
3. HDD costs assume 130 foot bank to bank length with 800 total length at each crossing, pilot hole with 1 reaming pass, four total crossings. Mobilization/demobilization is included in unit cost of \$400/LF.
4. Cathodic protection is included for all steel pipe.
5. Gate stations are needed to house purchase meters for gas measurement and to reduce line pressures between the transmission line and a delivery line. Their cost is assumed to be \$1,250,000 each.
6. Regulator stations are needed to reduce transmission line pressures to local distribution pressures (60psig). Their cost is estimated at \$400,000 each.

Material costs:

Direct material costs		
Pipe diameter [in]	Pipe [\$/LF]	Valves [\$/Each]
10- steel	\$ 53	\$ 34,000
8- steel	\$ 44	\$ 20,000
6-plastic	\$ 12	\$ 13,300
2-plastic	\$ 6	\$ 6,200
1-plastic	\$ 5	\$ 500
0.625-plastic	\$ 5	\$ 500

1. Freight for pipe is included in the material cost
2. Pigging barrels are mobile 12-inch diameter, skid mounted and can be connected to 10 and 8-inch pipe. Unit cost of \$300,000 for both a launcher and receiver.
3. Supplier Quality Surveillance (SQS) are tests to ensure quality materials are provided and used for the project. They are assessed at 2% of the material (valve and pipe) costs.
4. Procurement costs are assumed to be 4% of material costs.

Other costs:

1. Engineering is assumed to be 5% of pipeline construction cost.
2. Engineering for launcher/receive is assumed to be 30% of launcher/receiver construction cost.
3. Permitting based on current scope and region as compared to recent projects, estimated cost is \$300,000 for phase I and \$200,000 for phase II.

ALLOWANCES

A material allowance is included to account for items not identified by current level of design. These account for design modifications from the date of estimation to construction. Miscellaneous freight is applied to the material allowance. The costs below are part of the estimate allowances, and are included at the percentages shown.

Material allowances	
	Cost (relative to total cost of pipe & valves)
Materials- Design allowance	5%
Materials- Misc. Freight	2%

ASSUMPTIONS & DESCRIPTION OF WORK

The following are the assumptions that were applied to the pipeline, Launcher/Receiver, Gate and regulator stations, engineering and procurement estimates:

1. Adequate labor supply and life support (e.g., camp space, beds, transportation, etc.).
2. Contractor per diem is not included in the estimate.
3. Adequate funding available for this project.
4. All costs are based on 2012 dollars.
5. All materials and equipment will be on construction site as scheduled.
6. Estimated costs are based on factored costs from prior construction activities
7. Contractor markup and profit is included in factored price per linear foot for installation.
8. Weather delay costs are not included.
9. Engineering, procurement, and SQS based on percentages provided above.
10. Owner/operator will be responsible for procuring the major materials (valves, pipe).
11. Isolation valves required at each residence/commercial building and every 8 miles of transmission or distribution pipe.
12. Transmission lines shall be steel, distribution and service lines shall be plastic (PEX or HDPE).
13. Only 8 & 10 inch transmission lines shall be piggable.
14. 75 linear feet is assumed to be needed to tie houses/businesses to street level mainlines in areas of high population density. 100 linear feet is assumed to be needed in areas of medium population density. Areas of low population density have not been included.
15. For HDD it is assumed only for transmission and major distribution pipes crossing the Chena River

The following are the assumptions that were applied to the permitting and regulatory estimates:

1. NEPA report may not be required but is included in the anticipated permitting costs.
2. Field data is believed to exist in the project area. Therefore field study costs are not included in the estimate.

DESCRIPTION OF WORK

The following is the description of work tasks for the FNSB Natural gas study. Installation is planned for summer construction starting May 1 and ending September 30. Installation has been broken out into two phases of construction; phase I within 0-4 years centered in the high population density areas (over 500 people/sq mile), and phase II within 4-8 years centered in the medium population density areas (100-500 people/sq mile). Activities have been identified as being part of phase I, phase II construction, or both. Details on quantity can be found in estimate document.

- Transmission lines- installation of 10-inch steel transmission line from supply tie-in to Eielson and 8-inch line along Steese Highway terminating at the Johansen expressway all activities will occur in phase I and include:
 - Trenching and installation of 10" pipe
 - Trenching and installation of 8" pipe
 - Installation of isolation valves
 - Installation of gate stations for supply to industrial users (9)
 - HDD crossings of Chena River (2)
 - Connection to existing FNG lines as appropriate
 - Installation of connections for pigging (2)
 - Fabrication of mobile pig launcher and receiver (1 each)
 - Surface rehabilitation after construction (paving, seeding, etc)
- Installation of the primary feeder distribution lines (4 to 8-inch diameter) including:
 - Trenching and installation of linear feet of 6-inch pipe (phase I & II)
 - Installation of isolation valves (phase I & II)
 - Connection to existing FNG lines as appropriate (phase I)
 - Regulation stations for supply to domestic users (phase I)
 - HDD crossings of Chena River (phase I)
 - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of 2-inch diameter distribution lines along residential roads including:
 - Trenching and installation of 2-inch pipe (phase I & II)
 - Installation of isolation valves (phase I & II)
 - Connection to existing FNG lines as appropriate (phase I)
 - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of service lines to residential and commercial users including:
 - Trenching and installation of 1-inch pipe for commercial users (phase I & II)
 - Trenching and installation of 5/8-inch pipe for residential users (phase I & II)
 - Installation of isolation valves (phase I & II)
 - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)

UNKNOWN COSTS

The Unknown Costs (UC) calculation is used to cover the uncertainty and variability associated with a cost estimate, as well as unforeseeable elements of cost within the defined project scope. The unknown costs cover field uncertainties, inadequacies in complete project scope definition, estimating methods, and estimating data. Unknown costs specifically excludes changes in project scope, and unforeseen major events such as earthquakes, prolonged labor strikes, failed HDD, weather delays, etc. The amount of UC is based on the AACE estimate class 4.

The UC level used for these estimates is +30%.

QUALITY ASSURANCE

The Baker estimate Quality Assurance lead, in consultation with the Baker Project Estimating Team members, will review the estimate to verify that it employs the appropriate, methodologies, assumptions and exclusions, appropriate rates and factors and addresses the entire project scope and nothing beyond the approved scope.

If the estimate is reasonable and adequately addresses the project scope and requirements, the Baker QA lead communicates acceptance of the estimate to the Baker Cost Estimating Function Lead/Project Manager. If the estimate is insufficient or the exclusions are not acceptable, the Baker Chief Engineer communicates the need to correct or improve the estimates to the Baker Cost Estimating Function Lead/Project Manager.

All reviews of the estimate, as well as all the review participants are documented below in the "Project Estimate Review Log".

PROJECT ESTIMATE REVIEW LOG			
Estimate Reviewed by	Position/Role	Affiliation	Date
Bill Olzack	QA	MBJ	3/30/12

REFERENCES & ATTACHMENTS

Many documents will be collected and referenced during the development of the estimate. Since these documents ultimately form the basis for the resulting estimated cost, the basis of estimate should contain a record of each of these documents. All project plans, technical documents, and drawings should be itemized and accurately described in the appropriate section of the basis of estimate.

The "Project References and Attachments Log" below includes all major documents associated with the estimate including, but not limited to: any design drawings or technical documents (e.g. P&IDs, Isometrics, etc.), project review meeting minutes, copies of important correspondences, etc.

PROJECT REFERENCES & ATTACHMENTS LOG	
Document Title or Description	Date Issued
Figure 7 Proposed Pipeline Layout	1/24/2012
Figure 5 High, Medium, and Low Demand Areas	2/27/2012

Financial Model

Variable	Low Case	Middle Case	High Case	Interim Calculations	
Price of fuel oil (Nominal \$/Gal) in 2012	\$2.16	\$3.92	\$4.95		
Cost of distillates to industrial users (75% of fuel oil assumed)	\$1.62	\$2.94	\$3.72	75%	
Gas cost (2012 \$/MMBtu) in 2012 at Fairbanks city gate	\$9.59	\$10.00	\$10.15		
Inflation rate	4.00%	5.00%	6.00%		
CAPEX for distribution system (Millions of 2012 \$)	\$282.80	\$404.03	\$606.00		
State of Alaska grant (% of CAPEX)	0%	30%	70%		
	Govt.	Co-op	Private		
Distribution cost	\$2.50	\$3.00	\$3.50		
Wood cost (2012 \$/MMBtu)	\$10.00	\$15.00	\$20.00		
Propane cost (2012 \$/MMBtu) wholesale	\$10.38	\$10.38	\$12.64		
Residential propane cost	\$23.93	\$23.94	\$29.14	2.306270096	
General inflation rate	2.50%	2.50%	2.50%		
Business Type (Private = 0, Other = 1):		0			
	Private	Other			
Interest Rate	6.00%	4.50%			
Refinery utilization (BCF/year)	2.7	4.5	9		
FNSB population in 2015	102,425	105,298	110,386		
Number of residential structures in 2012 in pipe distribution area	20,294	20,863	21,871		
Growth rate	0.4%	1.0%	1.6%		
Average square footage of residential structures built in 2012	1,950	2,143	2,500		
Number of commercial structures in 2012 in pipe distribution area	1,658	1,705	1,787		
Growth rate	0.0041	0.0100	0.0160	3,952	
Number of residential structures in 2012 in low density area		2602		926	
Number of commercial structures in 2012 in low density area		89			
Energy efficiency of existing oil boilers/furnaces	65%	75%	85%		
Energy efficiency of new gas boilers/furnaces	85%	90%	95%		
Energy efficiency of wood stoves	68%	68%	68%		
Energy efficiency of coal burners		55%			
Cost of conversion	\$2,000	\$8,000	\$20,000		
Weighting for number of structures by size	4.40%	61.00%	34.60%		
	Year 1	Year 2	Year 3	Year 4	Year 5

Residential Conversion rate	10%	25%	25%	25%	10%
Conservation (e.g., rebate program, etc.)	Narrative only				
Discount rate for net present value calculations using nominal \$					
Public or cooperative		7.00%			
Private		7.00%			
Business structure (0=private; 1= others)		1			
Return on equity		12%			
Percent equity for private sector		30%			
Percent of total energy savings needed for fuel oil users to switch to gas		10%			
Convenience factor in terms of additional cost that wood burners are willing to pay for gas		10%			
Estimated 2012 wellhead price of ANS crude by DOR		99.61			

Comments

Price increases at same rate as EIA nominal crude oil price annual changes

Price increases at 75% of EIA nominal crude oil price changes

3/30 cost estimate from Baker
Only to Govt. and Co-op

NEI Estimate based on calls to local forester
ANS propane at 5% of ANS crude per ISER, 2009. Adjusted for average 2015
ANS wellhead price of \$99.61 per DOR Fall Revenue Sources Book. Price
increases at 75% of EIA nominal crude oil prices.
Residential cost (escalator based on EIA data on average wholesale price and
average residential cost).

ADOLWD forecast to 2035 and extrapolated to 2065

Adjusted to remove Aurora and FNG and low density area; increased at
ADOLWD rate of population growth:

Regression equation from Assessor's database for 1961-2010 time period.

Adjusted to remove Aurora and FNG and low density area; increased at
ADOLWD rate of population growth:

adjusted for dry cabins

Representative estimates based on discussions with FNSB and ANC
plumbers/HVAC contractors
Representative estimates based on discussions with FNSB and ANC
plumbers/HVAC contractors

Use this information for distribution in @RISK

Variable	Rate or value	2013	2014	2015	2016	2017	2018	2019	2020	2021
PIPE DISTRIBUTION AREA										
RESIDENTIAL (% of residences in pipe area)	89.0%									
Number of residential structures, growth rate	1.004%	21,073	21,284	21,498	21,714	21,932	22,152	22,374	22,599	22,826
Average annual consumption (MMBtu) per structure		250	250	250	250	250	250	250	250	250
Energy required (MMBtu), HIGH and MEDIUM density		5,268,127	5,321,030	5,374,465	5,428,436	5,482,949	5,538,009	5,593,623	5,649,795	5,706,531
Fuel oil percent	80.4%	4,238,015	4,280,574	4,323,560	4,366,978	4,410,831	4,455,125	4,499,864	4,545,053	4,590,695
Wood percent	19.6%	1,030,112	1,040,457	1,050,905	1,061,458	1,072,118	1,082,884	1,093,758	1,104,742	1,115,836
Percent demand in high area	60.418%			3,247,142	3,279,750	3,312,686	3,345,953	3,379,553	3,413,491	
Conversion rates in high area (97% max)	0.97			10%	25%	25%	25%	12%		
Potential natural gas sales in high area (MMBtu)				324,714	1,147,913	1,987,612	2,844,060	3,278,166	3,311,086	3,344,337
Conversion rates in medium area					10%	25%	25%	25%	12%	
Potential natural gas sales in medium area (MMBtu)				0	214,869	759,592	1,315,234	1,881,959	2,169,215	2,190,998
Potential residential natural gas sales in piped area (MMBtu)				324,714	1,362,781	2,747,204	4,159,294	5,160,126	5,480,301	5,535,335
COMMERCIAL (% of structures in pipe area)	95.0%									
Number of commercial structures, growth rate	1.004%	1,722	1,739	1,757	1,775	1,792	1,810	1,829	1,847	1,865
Average annual consumption (MMBtu) per structure		2533	2533	2533	2533	2533	2533	2533	2533	2533
Energy required (millions of Btus), HIGH and MEDIUM density		4,362,146	4,405,962	4,450,218	4,494,919	4,540,069	4,585,673	4,631,734	4,678,258	4,725,250
Fuel oil percent	100%									
Percent demand in high area	84.964%			3,781,080	3,819,059	3,857,420	3,896,167	3,935,303	3,974,831	
Conversion rates in high area (100%)				15%	35%	35%	15%			
Potential natural gas sales in high area (MMBtu)				567,162	1,909,530	3,278,807	3,896,167	3,935,303	3,974,831	4,014,757
Conversion rates in medium area					15%	35%	35%	15%		
Potential natural gas sales in medium area (MMBtu)				0	101,379	341,324	586,080	696,432	703,427	710,493
Potential commercial natural gas sales in piped area (MMBtu)				567,162	2,010,909	3,620,132	4,482,247	4,631,734	4,678,258	4,725,250
INDUSTRIAL (MMBtu)	7,900,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Potential Demand Pipe Distribution Area (MMBtu)		9,930,273	10,026,992	10,124,683	10,223,355	10,323,018	10,423,682	10,525,357	10,628,053	10,731,780
LOW DENSITY AREA (Propane)										
RESIDENTIAL(% of residences in low density area)	11.0%									
Number of residential structures net of dry cabins, growth rate	1.004%	2,628	2,655	2,681	2,708	2,735	2,763	2,791	2,819	2,847
Average annual consumption (MMBtu) per structure		250	250	250	250	250	250	250	250	250
Energy required (MMBtu)		657,032	663,630	670,295	677,026	683,825	690,692	697,628	704,633	711,709
Fuel Oil (MMBtu)		528,558	533,866	539,227	544,642	550,112	555,636	561,216	566,852	572,544
Wood (MMBtu)		128,474	129,764	131,067	132,383	133,713	135,056	136,412	137,782	139,165
Conversion rates in low density area, 95% max				10%	25%	25%	25%	10%		
Potential residential propane sales in low area				67,029	236,959	410,295	587,088	662,746	669,402	676,124
COMMERCIAL	5.0%									
Number of commercial structures, growth rate	1.004%	90	91	92	93	94	95	95	96	97
Average annual consumption (MMBtu) per structure		2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533
Energy required (millions of Btus)		227,701	229,989	232,299	234,632	236,989	239,369	241,774	244,202	246,655
Conversion rates in low density area				15%	35%	35%	15%			
Potential commercial propane sales in low area, MMBtu				34,845	117,316	201,441	239,369	241,774	244,202	246,655
Potential Demand Low Density Area, MMBtu		884,734	893,619	902,593	911,658	920,814	930,061	939,401	948,836	958,365
Potential Demand in FNSB, MMBtu		10,815,007	10,920,611	11,027,276	11,135,013	11,243,832	11,353,743	11,464,758	11,576,889	11,690,145
General Inflation Rate	2.500%									

PIPED DISTRIBUTION AREA GAS PRICE, HIGH and MEDIUM

Natural gas price (\$/MMBtu)	3.00	3.21	3.37	3.51	3.52	3.63	3.72	3.82	3.91	4.00
Other costs to city gate (\$/MMBtu)				6.49	6.51	6.72	6.89	7.06	7.23	7.41
Operations & maintenance cost (\$/MMBtu), base amount	\$0.45	\$0.47	\$0.48	\$0.49	\$0.50	\$0.51	\$0.53	\$0.54	\$0.55	\$0.57
Admin & General Overhead, base amount	\$2.32	\$2.38	\$2.44	\$2.50	\$2.55	\$2.60	\$2.66	\$2.72	\$2.78	\$2.85
Depreciation, Distribution System, total and \$/MMBtu	\$8,080,660			\$6.78	\$2.20	\$1.21	\$0.90	\$0.80	\$0.77	\$0.77
Debt Service										
Capex (\$ Millions)	404.03		19,602,985	34,802,985						
CAPEX High	230.83									
CAPEX Medium	173.21		1.78							
Grants %	30.0%		O&M							
Equity contribution (\$ Millions)	121.2		A&GE							
Amount to be amortized (\$ Millions)	282.8									
Interest rate	6.0%									
Return on equity	12%									
Percent equity	30%									
Term, years	20									
Annual Payment (millions of \$)	\$24.66			\$6.16	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66
Required Return on Equity (millions of \$)	\$10.18			\$2.55	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18
Debt service and return on equity per MMBtu				\$0.79	\$3.13	\$3.10	\$3.07	\$3.04	\$3.01	\$2.98
Total cost per MMBtu				\$20.56	\$18.41	\$17.77	\$17.77	\$17.97	\$18.26	\$18.58

LOW DENSITY AREA PROPANE (from ANS) PRICE

Wholesale propane price at city gate (MMBtu)				\$10.38	\$10.41	\$10.74	\$11.02	\$11.30	\$11.57	\$11.85
Delivered price (MMBtu)				\$23.94	\$24.00	\$24.78	\$25.42	\$26.05	\$26.68	\$27.33
Price per gallon				\$2.19	\$2.20	\$2.27	\$2.33	\$2.39	\$2.44	\$2.50

WOOD FUEL PRICE (MMBtu)

	2.50%	\$14.26	\$14.63	\$15.00	\$15.38	\$15.76	\$16.15	\$16.56	\$16.97	\$17.40
Cost of useable energy (MMBtu)	22%	\$17.40	\$17.84	\$18.30	\$18.76	\$19.23	\$19.71	\$20.20	\$20.70	\$21.22
Percent of FNSB that use wood for primary heat	19.6%									

HEATING FUEL PRICE (MMBtu)

		\$31.56	\$33.61	\$35.45	\$35.57	\$37.10	\$38.38	\$39.65	\$40.93	\$42.25
Cost of useable energy (MMBtu)	15%	\$36.29	\$38.66	\$40.76	\$40.91	\$42.67	\$44.14	\$45.60	\$47.07	\$48.59
Conversion: MMBtu to gallons of heating fuel equivalent	7.353									
Percent of FNSB that use fuel oil for primary heat	80.4%									
Conversion cost per residential structure (annual payment)	\$8,000			\$1,086.94	\$1,086.94	\$1,086.94	\$1,086.94	\$1,086.94	\$1,086.94	\$1,086.94
Cost per MMBtu used per year				\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35
Same estimate used for commercial structures										

PIPED DISTRIBUTION AREA

Amount of residential fuel oil that switches to gas (MMBtu)				261,221	1,096,308	2,210,025	3,345,999	4,151,132	4,408,701	4,452,974
Amount of residential wood that switches to gas (MMBtu)				0	0	0	0	0	1,071,600	1,082,361
Amount of residential energy that switches to gas (MMBtu)				261,221	1,096,308	2,210,025	3,345,999	4,151,132	5,480,301	5,535,335
			High Res	157,824	662,367	1,335,252	2,021,585	2,508,029	3,311,086	
Amount of commercial fuel oil that switches to gas (MMBtu)				567,162	2,010,909	3,620,132	4,482,247	4,631,734	4,678,258	4,725,250
Amount of commercial energy that switches to gas (MMBtu)				567,162	2,010,909	3,620,132	4,482,247	4,631,734	4,678,258	4,725,250
Amount of industrial energy that switches to gas (MMBtu)				150,000	300,000	300,000	300,000	300,000	300,000	300,000
Total piped distribution area that switches to gas, MMBtu				978,383	3,407,216	6,130,156	8,128,246	9,082,866	10,458,559	10,560,584
			High Comm	481,883	1,708,547	3,075,806	3,808,292	3,935,303	3,974,831	
			Med Res	0	433,941	874,773	1,324,415	1,643,102	2,169,215	
			Med Comm	0	302,362	544,326	673,954	696,432	703,427	

LOW DENSITY AREA PROPANE (from ANS)

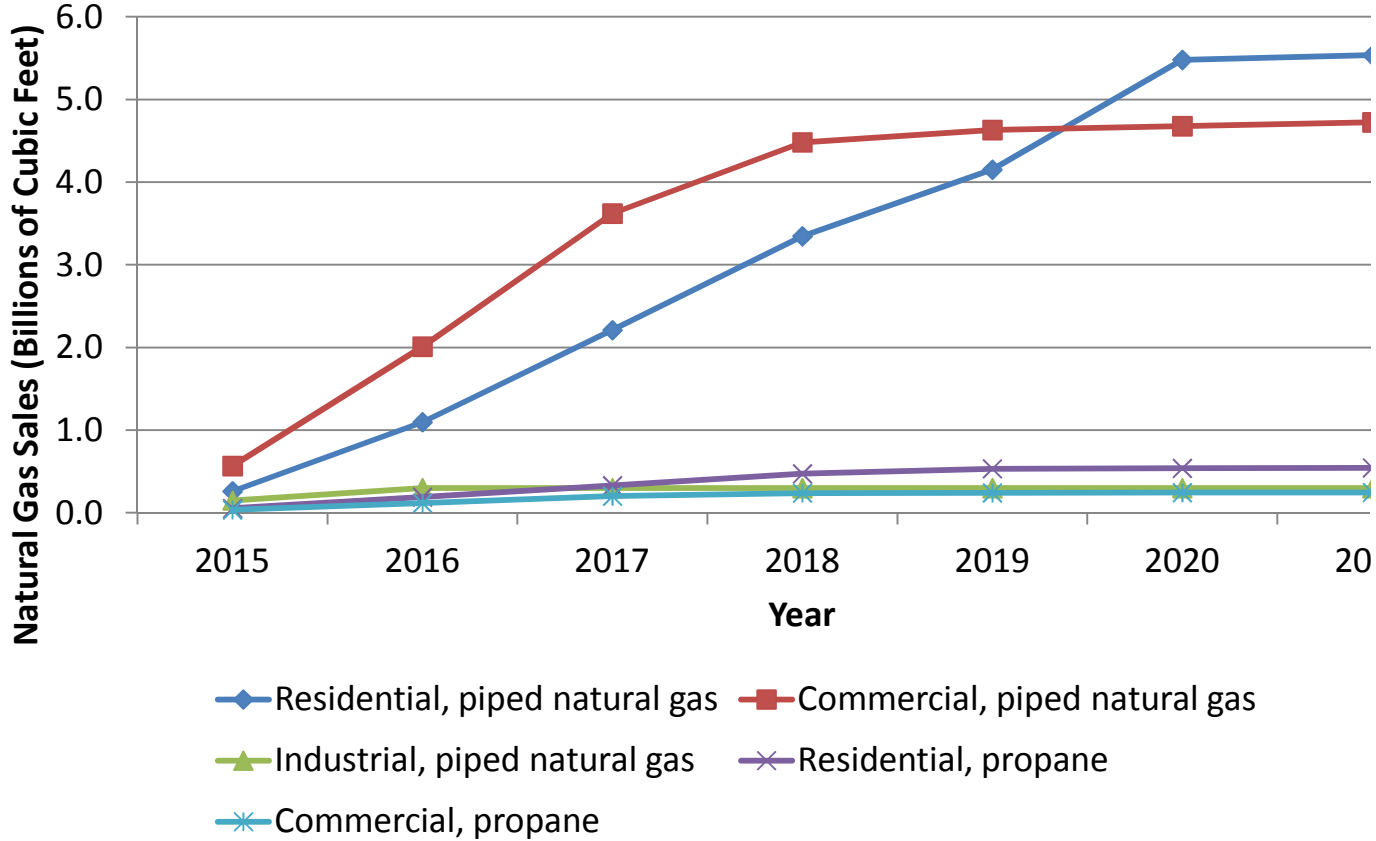
FROM FUEL OIL

Amount of residential energy that switches to propane (MMBtu)				53,923	190,625	330,067	472,291	533,155	538,509	543,917
Amount of commercial energy that switches to propane (MMBtu)				34,845	117,316	201,441	239,369	241,774	244,202	246,655

FROM WOOD

Amount of residential energy that switches to propane (MMBtu)			0	0	0	0	0	0	0
Total energy that switches to gas in Low Density Area (MMBtu)			88,768	307,941	531,508	711,660	774,929	782,711	790,572
Total energy that switches to gas in FNSB (MMBtu)			1,067,150	3,715,157	6,661,664	8,839,906	9,857,795	11,241,270	11,351,157
	2015	2016	2017	2018	2019	2020	2021		
Residential, piped natural gas	0.3	1.1	2.2	3.3	4.2	5.5	5.5	10.6	
Commercial, piped natural gas	0.6	2.0	3.6	4.5	4.6	4.7	4.7		
Industrial, piped natural gas	0.2	0.3	0.3	0.3	0.3	0.3	0.3		
Residential, propane	0.1	0.2	0.3	0.5	0.5	0.5	0.5	0.8	
Commercial, propane	0.0	0.1	0.2	0.2	0.2	0.2	0.2		
						11.2	11.4		

19
17.6
1.4
0.073684211
24
22.23157895



2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
23,055 250	23,287 250	23,521 250	23,757 250	23,995 250	24,236 250	24,480 250	24,726 250	24,974 250	25,225 250	25,478 250	25,734 250	25,992 250	26,253 250	26,517 250
5,763,836	5,821,717	5,880,180	5,939,229	5,998,872	6,059,113	6,119,959	6,181,417	6,243,491	6,306,189	6,369,517	6,433,480	6,498,086	6,563,341	6,629,251
4,636,795	4,683,358	4,730,389	4,777,892	4,825,872	4,874,334	4,923,283	4,972,723	5,022,660	5,073,098	5,124,043	5,175,499	5,227,472	5,279,967	5,332,989
1,127,041	1,138,359	1,149,791	1,161,337	1,172,999	1,184,779	1,196,676	1,208,694	1,220,831	1,233,091	1,245,474	1,257,981	1,270,614	1,283,374	1,296,262
3,377,921	3,411,842	3,446,104	3,480,711	3,515,664	3,550,969	3,586,628	3,622,646	3,659,025	3,695,769	3,732,882	3,770,369	3,808,231	3,846,474	3,885,101
2,213,000	2,235,224	2,257,670	2,280,342	2,303,241	2,326,371	2,349,732	2,373,329	2,397,162	2,421,235	2,445,549	2,470,107	2,494,913	2,519,967	2,545,273
5,590,921	5,647,066	5,703,774	5,761,052	5,818,906	5,877,340	5,936,361	5,995,974	6,056,187	6,117,004	6,178,431	6,240,476	6,303,144	6,366,441	6,430,373
1,884 2533	1,903 2533	1,922 2533	1,942 2533	1,961 2533	1,981 2533	2,001 2533	2,021 2533	2,041 2533	2,062 2533	2,082 2533	2,103 2533	2,124 2533	2,146 2533	2,167 2533
4,772,713	4,820,654	4,869,075	4,917,984	4,967,383	5,017,279	5,067,676	5,118,579	5,169,993	5,221,924	5,274,376	5,327,356	5,380,867	5,434,916	5,489,508
4,055,084	4,095,816	4,136,957	4,178,511	4,220,483	4,262,876	4,305,696	4,348,945	4,392,629	4,436,751	4,481,317	4,526,330	4,571,795	4,617,718	4,664,101
717,629	724,838	732,118	739,472	746,900	754,402	761,980	769,634	777,365	785,173	793,060	801,026	809,072	817,199	825,407
4,772,713	4,820,654	4,869,075	4,917,984	4,967,383	5,017,279	5,067,676	5,118,579	5,169,993	5,221,924	5,274,376	5,327,356	5,380,867	5,434,916	5,489,508
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
10,836,550	10,942,371	11,049,255	11,157,213	11,266,255	11,376,392	11,487,635	11,599,996	11,713,485	11,828,113	11,943,893	12,060,836	12,178,953	12,298,257	12,418,759
2,875 250	2,904 250	2,933 250	2,963 250	2,993 250	3,023 250	3,053 250	3,084 250	3,115 250	3,146 250	3,178 250	3,209 250	3,242 250	3,274 250	3,307 250
718,856	726,075	733,367	740,731	748,170	755,683	763,272	770,936	778,678	786,498	794,396	802,373	810,431	818,569	826,790
578,294	584,101	589,967	595,891	601,875	607,919	614,024	620,190	626,418	632,709	639,062	645,480	651,962	658,509	665,122
140,563	141,974	143,400	144,840	146,295	147,764	149,248	150,746	152,260	153,789	155,334	156,893	158,469	160,060	161,668
682,914	689,772	696,698	703,695	710,761	717,899	725,108	732,390	739,744	747,173	754,676	762,255	769,909	777,641	785,450
98 2,533	99 2,533	100 2,533	101 2,533	102 2,533	103 2,533	104 2,533	105 2,533	107 2,533	108 2,533	109 2,533	110 2,533	111 2,533	112 2,533	113 2,533
249,133	251,635	254,163	256,716	259,294	261,899	264,530	267,187	269,871	272,581	275,319	278,085	280,878	283,699	286,549
249,133	251,635	254,163	256,716	259,294	261,899	264,530	267,187	269,871	272,581	275,319	278,085	280,878	283,699	286,549
967,989	977,711	987,529	997,447	1,007,464	1,017,582	1,027,801	1,038,123	1,048,549	1,059,079	1,069,715	1,080,458	1,091,309	1,102,269	1,113,339
11,804,539	11,920,082	12,036,785	12,154,660	12,273,719	12,393,974	12,515,436	12,638,119	12,762,034	12,887,193	13,013,609	13,141,294	13,270,262	13,400,526	13,532,097

4.11	4.21	4.32	4.44	4.55	4.67	4.78	4.90	5.03	5.16	5.29	5.42	5.57	5.72	5.86
7.60	7.80	8.00	8.21	8.42	8.64	8.85	9.07	9.30	9.55	9.80	10.04	10.31	10.58	10.84
\$0.58	\$0.60	\$0.61	\$0.63	\$0.64	\$0.66	\$0.67	\$0.69	\$0.71	\$0.73	\$0.74	\$0.76	\$0.78	\$0.80	\$0.82
\$2.92	\$2.99	\$3.07	\$3.15	\$3.22	\$3.30	\$3.38	\$3.47	\$3.55	\$3.64	\$3.73	\$3.83	\$3.92	\$4.02	\$4.12
\$0.76	\$0.75	\$0.74	\$0.74	\$0.73	\$0.72	\$0.71	\$0.71	\$0.70	\$0.69	\$0.69	\$0.68	\$0.67	\$0.67	\$0.66

\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$24.66	\$18.49	
\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18
\$2.95	\$2.92	\$2.89	\$2.87	\$2.84	\$2.81	\$2.78	\$2.76	\$2.73	\$2.70	\$2.68	\$2.65	\$2.63	\$2.14	\$0.75
\$18.92	\$19.28	\$19.64	\$20.02	\$20.40	\$20.80	\$21.19	\$21.59	\$22.02	\$22.48	\$22.93	\$23.39	\$23.89	\$23.93	\$23.04

\$12.16	\$12.48	\$12.80	\$13.13	\$13.46	\$13.81	\$14.15	\$14.50	\$14.88	\$15.28	\$15.67	\$16.06	\$16.49	\$16.92	\$17.33
\$28.04	\$28.77	\$29.52	\$30.28	\$31.05	\$31.86	\$32.64	\$33.45	\$34.31	\$35.23	\$36.14	\$37.03	\$38.03	\$39.03	\$39.97
\$2.57	\$2.64	\$2.70	\$2.77	\$2.84	\$2.92	\$2.99	\$3.06	\$3.14	\$3.23	\$3.31	\$3.39	\$3.48	\$3.58	\$3.66
\$17.83	\$18.28	\$18.73	\$19.20	\$19.68	\$20.17	\$20.68	\$21.19	\$21.72	\$22.27	\$22.82	\$23.39	\$23.98	\$24.58	\$25.19
\$21.75	\$22.30	\$22.85	\$23.43	\$24.01	\$24.61	\$25.23	\$25.86	\$26.50	\$27.17	\$27.85	\$28.54	\$29.26	\$29.99	\$30.74

\$43.71	\$45.24	\$46.80	\$48.42	\$50.07	\$51.80	\$53.49	\$55.26	\$57.16	\$59.21	\$61.24	\$63.26	\$65.54	\$67.83	\$70.01
\$50.27	\$52.03	\$53.83	\$55.68	\$57.58	\$59.56	\$61.51	\$63.54	\$65.73	\$68.09	\$70.42	\$72.75	\$75.37	\$78.01	\$80.51

\$1,086.94	\$1,086.94	\$1,086.94												
\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35

4,497,691	4,542,857	4,588,477	4,634,555	4,681,096	4,728,104	4,775,585	4,823,542	4,871,980	4,920,905	4,970,322	5,020,234	5,070,648	5,121,568	5,172,999
1,093,230	1,104,208	1,115,297	1,126,497	1,137,809	1,149,235	1,160,776	1,172,433	1,184,207	1,196,098	1,208,110	1,220,242	1,232,496	1,244,873	1,257,374
5,590,921	5,647,066	5,703,774	5,761,052	5,818,906	5,877,340	5,936,361	5,995,974	6,056,187	6,117,004	6,178,431	6,240,476	6,303,144	6,366,441	6,430,373
4,772,713	4,820,654	4,869,075	4,917,984	4,967,383	5,017,279	5,067,676	5,118,579	5,169,993	5,221,924	5,274,376	5,327,356	5,380,867	5,434,916	5,489,508
4,772,713	4,820,654	4,869,075	4,917,984	4,967,383	5,017,279	5,067,676	5,118,579	5,169,993	5,221,924	5,274,376	5,327,356	5,380,867	5,434,916	5,489,508
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
10,663,634	10,767,719	10,872,850	10,979,036	11,086,289	11,194,619	11,304,036	11,414,553	11,526,180	11,638,928	11,752,808	11,867,832	11,984,011	12,101,357	12,219,881

549,379	554,896	560,468	566,097	571,781	577,523	583,323	589,181	595,097	601,073	607,109	613,206	619,364	625,584	631,866
249,133	251,635	254,163	256,716	259,294	261,899	264,530	267,187	269,871	272,581	275,319	278,085	280,878	283,699	286,549

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
798,512	806,531	814,631	822,812	831,076	839,422	847,852	856,367	864,968	873,655	882,429	891,291	900,242	909,283	918,415
11,462,146	11,574,251	11,687,481	11,801,848	11,917,365	12,034,041	12,151,889	12,270,921	12,391,148	12,512,582	12,635,237	12,759,123	12,884,253	13,010,640	13,138,296



Year														
2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
26,783	27,052	27,324	27,598	27,875	28,155	28,438	28,724	29,012	29,303	29,598	29,895	30,195	30,498	30,805
250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
6,695,822	6,763,063	6,830,978	6,899,576	6,968,862	7,038,844	7,109,529	7,180,924	7,253,036	7,325,872	7,399,439	7,473,745	7,548,797	7,624,603	7,701,170
5,386,544	5,440,636	5,495,271	5,550,456	5,606,194	5,662,492	5,719,356	5,776,790	5,834,801	5,893,395	5,952,577	6,012,354	6,072,731	6,133,714	6,195,309
1,309,279	1,322,427	1,335,707	1,349,120	1,362,668	1,376,352	1,390,174	1,404,134	1,418,234	1,432,476	1,446,862	1,461,391	1,476,067	1,490,889	1,505,861
3,924,115	3,963,522	4,003,324	4,043,526	4,084,131	4,125,145	4,166,570	4,208,411	4,250,672	4,293,358	4,336,473	4,380,020	4,424,005	4,468,431	4,513,304
2,570,832	2,596,649	2,622,725	2,649,063	2,675,665	2,702,534	2,729,673	2,757,085	2,784,772	2,812,737	2,840,983	2,869,513	2,898,329	2,927,434	2,956,832
6,494,948	6,560,171	6,626,049	6,692,588	6,759,796	6,827,679	6,896,243	6,965,496	7,035,445	7,106,095	7,177,456	7,249,533	7,322,333	7,395,865	7,470,135
2,189	2,211	2,233	2,256	2,278	2,301	2,324	2,348	2,371	2,395	2,419	2,443	2,468	2,493	2,518
2533	2533	2533	2533	2533	2533	2533	2533	2533	2533	2533	2533	2533	2533	2533
5,544,648	5,600,343	5,656,596	5,713,415	5,770,804	5,828,770	5,887,318	5,946,454	6,006,184	6,066,514	6,127,450	6,188,998	6,251,165	6,313,956	6,377,377
4,710,950	4,758,270	4,806,065	4,854,341	4,903,101	4,952,351	5,002,096	5,052,340	5,103,089	5,154,348	5,206,122	5,258,415	5,311,234	5,364,584	5,418,469
833,698	842,072	850,531	859,074	867,703	876,419	885,222	894,114	903,095	912,166	921,329	930,583	939,931	949,372	958,908
5,544,648	5,600,343	5,656,596	5,713,415	5,770,804	5,828,770	5,887,318	5,946,454	6,006,184	6,066,514	6,127,450	6,188,998	6,251,165	6,313,956	6,377,377
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
12,540,471	12,663,405	12,787,574	12,912,990	13,039,666	13,167,614	13,296,847	13,427,378	13,559,220	13,692,386	13,826,889	13,962,743	14,099,962	14,238,559	14,378,548
3,340	3,374	3,408	3,442	3,477	3,511	3,547	3,582	3,618	3,655	3,691	3,728	3,766	3,804	3,842
250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
835,092	843,478	851,949	860,504	869,145	877,873	886,689	895,593	904,587	913,671	922,846	932,114	941,474	950,928	960,478
671,801	678,547	685,361	692,244	699,196	706,217	713,309	720,472	727,707	735,015	742,396	749,851	757,381	764,987	772,669
163,291	164,931	166,587	168,260	169,950	171,656	173,380	175,121	176,880	178,656	180,450	182,262	184,093	185,941	187,809
793,338	801,304	809,351	817,479	825,688	833,980	842,355	850,814	859,358	867,987	876,704	885,508	894,400	903,382	912,454
114	115	117	118	119	120	121	123	124	125	126	128	129	130	131
2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533	2,533
289,427	292,335	295,271	298,237	301,233	304,258	307,315	310,401	313,519	316,668	319,849	323,062	326,307	329,585	332,895
289,427	292,335	295,271	298,237	301,233	304,258	307,315	310,401	313,519	316,668	319,849	323,062	326,307	329,585	332,895
1,124,520	1,135,813	1,147,220	1,158,741	1,170,378	1,182,132	1,194,004	1,205,995	1,218,106	1,230,339	1,242,695	1,255,176	1,267,781	1,280,513	1,293,373
13,664,990	13,799,218	13,934,794	14,071,731	14,210,044	14,349,746	14,490,851	14,633,373	14,777,326	14,922,725	15,069,585	15,217,919	15,367,743	15,519,072	15,671,921

6.00	6.16	6.31	6.47	6.63	6.80	6.97	7.14	7.32	7.50	7.69	7.88	8.08	8.28	8.48
11.11	11.39	11.68	11.97	12.28	12.58	12.90	13.22	13.55	13.89	14.23	14.59	14.95	15.32	15.69
\$0.84	\$0.86	\$0.89	\$0.91	\$0.93	\$0.95	\$0.98	\$1.00	\$1.03	\$1.05	\$1.08	\$1.11	\$1.13	\$1.16	\$1.19
\$4.22	\$4.32	\$4.43	\$4.54	\$4.65	\$4.77	\$4.89	\$5.01	\$5.13	\$5.26	\$5.39	\$5.52	\$5.66	\$5.80	\$5.94
\$0.65	\$0.65	\$0.64	\$0.64	\$0.63	\$0.62	\$0.62	\$0.61	\$0.61	\$0.60	\$0.59	\$0.59	\$0.58	\$0.58	\$0.57

\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18
\$0.75	\$0.74	\$0.73	\$0.72	\$0.72	\$0.71	\$0.70	\$0.70	\$0.69	\$0.68	\$0.68	\$0.67	\$0.66	\$0.66	\$0.65
\$23.58	\$24.12	\$24.68	\$25.25	\$25.84	\$26.44	\$27.05	\$27.68	\$28.32	\$28.98	\$29.66	\$30.35	\$31.06	\$31.78	\$32.52

\$17.77	\$18.22	\$18.68	\$19.15	\$19.63	\$20.13	\$20.63	\$21.15	\$21.67	\$22.21	\$22.76	\$23.33	\$23.91	\$24.50	\$25.10
\$40.99	\$42.02	\$43.09	\$44.17	\$45.28	\$46.42	\$47.58	\$48.77	\$49.98	\$51.23	\$52.50	\$53.80	\$55.13	\$56.49	\$57.89
\$3.75	\$3.85	\$3.95	\$4.05	\$4.15	\$4.25	\$4.36	\$4.47	\$4.58	\$4.69	\$4.81	\$4.93	\$5.05	\$5.17	\$5.30
\$25.82	\$26.47	\$27.13	\$27.81	\$28.50	\$29.22	\$29.95	\$30.70	\$31.46	\$32.25	\$33.06	\$33.88	\$34.73	\$35.60	\$36.49
\$31.50	\$32.29	\$33.10	\$33.93	\$34.78	\$35.64	\$36.54	\$37.45	\$38.39	\$39.35	\$40.33	\$41.34	\$42.37	\$43.43	\$44.52

\$72.38	\$74.82	\$77.34	\$79.94	\$82.62	\$85.38	\$88.23	\$91.17	\$94.20	\$97.33	\$100.55	\$103.88	\$107.30	\$110.84	\$114.48
\$83.24	\$86.05	\$88.94	\$91.93	\$95.01	\$98.19	\$101.47	\$104.85	\$108.33	\$111.93	\$115.64	\$119.46	\$123.40	\$127.46	\$131.65

\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35
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5,224,947	5,277,417	5,330,413	5,383,942	5,438,008	5,492,617	5,547,775	5,603,486	5,659,757	5,716,593	5,774,000	5,831,983	5,890,549	5,949,702	6,009,450
1,270,000	1,282,754	1,295,635	1,308,646	1,321,788	1,335,062	1,348,468	1,362,010	1,375,687	1,389,502	1,403,456	1,417,549	1,431,785	1,446,163	1,460,685
6,494,948	6,560,171	6,626,049	6,692,588	6,759,796	6,827,679	6,896,243	6,965,496	7,035,445	7,106,095	7,177,456	7,249,533	7,322,333	7,395,865	7,470,135
5,544,648	5,600,343	5,656,596	5,713,415	5,770,804	5,828,770	5,887,318	5,946,454	6,006,184	6,066,514	6,127,450	6,188,998	6,251,165	6,313,956	6,377,377
5,544,648	5,600,343	5,656,596	5,713,415	5,770,804	5,828,770	5,887,318	5,946,454	6,006,184	6,066,514	6,127,450	6,188,998	6,251,165	6,313,956	6,377,377
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
12,339,596	12,460,513	12,582,645	12,706,003	12,830,600	12,956,449	13,083,561	13,211,950	13,341,629	13,472,610	13,604,906	13,738,531	13,873,498	14,009,821	14,147,512

638,211	644,620	651,093	657,632	664,236	670,906	677,643	684,448	691,322	698,264	705,276	712,359	719,512	726,738	734,036
289,427	292,335	295,271	298,237	301,233	304,258	307,315	310,401	313,519	316,668	319,849	323,062	326,307	329,585	332,895

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
927,638	936,955	946,364	955,869	965,468	975,164	984,958	994,850	1,004,841	1,014,933	1,025,125	1,035,421	1,045,819	1,056,322	1,066,931
13,267,235	13,397,468	13,529,009	13,661,872	13,796,069	13,931,613	14,068,519	14,206,800	14,346,470	14,487,542	14,630,031	14,773,952	14,919,317	15,066,143	15,214,443

2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
31,114 250 7,778,506 6,257,523 1,520,983	31,426 250 7,856,619 6,320,362 1,536,257	31,742 250 7,935,516 6,383,832 1,551,684	32,061 250 8,015,206 6,447,939 1,567,267	32,383 250 8,095,695 6,512,690 1,583,005	32,708 250 8,176,993 6,578,091 1,598,902	33,036 250 8,259,108 6,644,149 1,614,958	33,368 250 8,342,047 6,710,871 1,631,176	33,703 250 8,425,819 6,778,262 1,647,556	34,042 250 8,510,432 6,846,330 1,664,101	34,384 250 8,595,895 6,915,082 1,680,813	34,729 250 8,682,216 6,984,524 1,697,691	35,078 250 8,769,403 7,054,664 1,714,740	35,430 250 8,857,467 7,125,507 1,731,960
4,558,627	4,604,405	4,650,643	4,697,345	4,744,517	4,792,162	4,840,285	4,888,892	4,937,987	4,987,575	5,037,661	5,088,249	5,139,346	5,190,956
2,986,524 7,545,151	3,016,515 7,620,921	3,046,808 7,697,451	3,077,404 7,774,750	3,108,308 7,852,825	3,139,522 7,931,684	3,171,049 8,011,335	3,202,893 8,091,785	3,235,057 8,173,044	3,267,544 8,255,119	3,300,357 8,338,018	3,333,500 8,421,749	3,366,975 8,506,321	3,400,787 8,591,743
2,543 2533 6,441,436	2,569 2533 6,506,138	2,594 2533 6,571,490	2,620 2533 6,637,498	2,647 2533 6,704,170	2,673 2533 6,771,511	2,700 2533 6,839,528	2,727 2533 6,908,229	2,755 2533 6,977,620	2,782 2533 7,047,708	2,810 2533 7,118,499	2,839 2533 7,190,002	2,867 2533 7,262,224	2,896 2533 7,335,170
5,472,896	5,527,869	5,583,395	5,639,478	5,696,125	5,753,341	5,811,131	5,869,502	5,928,459	5,988,008	6,048,156	6,108,907	6,170,269	6,232,248
968,540 6,441,436	978,269 6,506,138	988,095 6,571,490	998,020 6,637,498	1,008,045 6,704,170	1,018,170 6,771,511	1,028,397 6,839,528	1,038,727 6,908,229	1,049,161 6,977,620	1,059,699 7,047,708	1,070,344 7,118,499	1,081,095 7,190,002	1,091,954 7,262,224	1,102,923 7,335,170
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
14,519,942	14,662,757	14,807,006	14,952,704	15,099,865	15,248,504	15,398,636	15,550,276	15,703,438	15,858,139	16,014,394	16,172,218	16,331,627	16,492,637
3,880 250 970,123 780,428 189,695	3,919 250 979,865 788,265 191,600	3,959 250 989,705 796,181 193,524	3,999 250 999,644 804,177 195,467	4,039 250 1,009,682 812,252 197,430	4,079 250 1,019,822 820,409 199,413	4,120 250 1,030,063 828,648 201,415	4,162 250 1,040,407 836,969 203,438	4,203 250 1,050,855 845,374 205,481	4,246 250 1,061,407 853,863 207,544	4,288 250 1,072,066 862,438 209,628	4,331 250 1,082,832 871,099 211,733	4,375 250 1,093,706 879,846 213,860	4,419 250 1,104,689 888,682 216,007
921,617	930,872	940,220	949,661	959,198	968,830	978,560	988,386	998,312	1,008,337	1,018,463	1,028,690	1,039,021	1,049,455
133 2,533 336,239	134 2,533 339,617	135 2,533 343,028	137 2,533 346,474	138 2,533 349,954	140 2,533 353,469	141 2,533 357,019	142 2,533 360,606	144 2,533 364,228	145 2,533 367,886	147 2,533 371,581	148 2,533 375,314	150 2,533 379,084	151 2,533 382,892
336,239	339,617	343,028	346,474	349,954	353,469	357,019	360,606	364,228	367,886	371,581	375,314	379,084	382,892
1,306,362 15,826,304	1,319,482 15,982,239	1,332,733 16,139,739	1,346,117 16,298,821	1,359,636 16,459,501	1,373,290 16,621,795	1,387,082 16,785,718	1,401,012 16,951,288	1,415,082 17,118,521	1,429,294 17,287,433	1,443,648 17,458,042	1,458,146 17,630,364	1,472,790 17,804,417	1,487,581 17,980,218

8.69	8.90	9.12	9.34	9.57	9.80	10.04	10.29	10.54	10.79	11.05	11.32	11.59	11.87
16.08	16.47	16.88	17.29	17.71	18.15	18.59	19.04	19.50	19.97	20.46	20.95	21.46	21.97
\$1.22	\$1.25	\$1.28	\$1.31	\$1.35	\$1.38	\$1.42	\$1.45	\$1.49	\$1.52	\$1.56	\$1.60	\$1.64	\$1.68
\$6.09	\$6.24	\$6.39	\$6.55	\$6.71	\$6.88	\$7.05	\$7.22	\$7.40	\$7.58	\$7.77	\$7.96	\$8.16	\$8.36
\$0.57	\$0.56	\$0.55	\$0.55	\$0.54	\$0.54	\$0.53	\$0.53	\$0.52	\$0.52	\$0.51	\$0.51	\$0.50	\$0.50

\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18	\$10.18
\$0.64	\$0.64	\$0.63	\$0.62	\$0.62	\$0.61	\$0.61	\$0.60	\$0.59	\$0.59	\$0.58	\$0.58	\$0.57	\$0.57
\$33.28	\$34.06	\$34.86	\$35.67	\$36.51	\$37.36	\$38.23	\$39.13	\$40.04	\$40.98	\$41.94	\$42.92	\$43.93	\$44.95

\$25.72	\$26.35	\$27.00	\$27.66	\$28.33	\$29.02	\$29.73	\$30.45	\$31.19	\$31.95	\$32.72	\$33.51	\$34.32	\$35.14
\$59.31	\$60.77	\$62.26	\$63.78	\$65.34	\$66.93	\$68.56	\$70.23	\$71.94	\$73.68	\$75.46	\$77.28	\$79.15	\$81.05
\$5.43	\$5.57	\$5.70	\$5.84	\$5.99	\$6.13	\$6.28	\$6.43	\$6.59	\$6.75	\$6.91	\$7.08	\$7.25	\$7.42
\$37.40	\$38.34	\$39.29	\$40.28	\$41.28	\$42.31	\$43.37	\$44.46	\$45.57	\$46.71	\$47.88	\$49.07	\$50.30	\$51.56
\$45.63	\$46.77	\$47.94	\$49.14	\$50.37	\$51.62	\$52.91	\$54.24	\$55.59	\$56.98	\$58.41	\$59.87	\$61.36	\$62.90

\$118.23	\$122.11	\$126.10	\$130.21	\$134.46	\$138.83	\$143.34	\$147.98	\$152.77	\$157.71	\$162.79	\$168.03	\$173.44	\$179.01
\$135.97	\$140.42	\$145.01	\$149.75	\$154.62	\$159.65	\$164.84	\$170.18	\$175.69	\$181.36	\$187.21	\$193.24	\$199.45	\$205.86

\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35	\$4.35
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6,069,798	6,130,751	6,192,317	6,254,501	6,317,309	6,380,749	6,444,825	6,509,545	6,574,914	6,640,940	6,707,630	6,774,988	6,843,024	6,911,742
1,475,354	1,490,169	1,505,134	1,520,249	1,535,515	1,550,935	1,566,510	1,582,241	1,598,130	1,614,178	1,630,388	1,646,761	1,663,298	1,680,001
7,545,151	7,620,921	7,697,451	7,774,750	7,852,825	7,931,684	8,011,335	8,091,785	8,173,044	8,255,119	8,338,018	8,421,749	8,506,321	8,591,743
6,441,436	6,506,138	6,571,490	6,637,498	6,704,170	6,771,511	6,839,528	6,908,229	6,977,620	7,047,708	7,118,499	7,190,002	7,262,224	7,335,170
6,441,436	6,506,138	6,571,490	6,637,498	6,704,170	6,771,511	6,839,528	6,908,229	6,977,620	7,047,708	7,118,499	7,190,002	7,262,224	7,335,170
300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
14,286,587	14,427,058	14,568,941	14,712,248	14,856,994	15,003,194	15,150,863	15,300,014	15,450,664	15,602,826	15,756,517	15,911,752	16,068,545	16,226,913

741,407	748,852	756,372	763,968	771,640	779,389	787,215	795,121	803,105	811,170	819,316	827,544	835,854	844,248
336,239	339,617	343,028	346,474	349,954	353,469	357,019	360,606	364,228	367,886	371,581	375,314	379,084	382,892

0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,077,646	1,088,469	1,099,400	1,110,441	1,121,593	1,132,857	1,144,235	1,155,726	1,167,333	1,179,056	1,190,898	1,202,858	1,214,938	1,227,139
15,364,233	15,515,527	15,668,341	15,822,689	15,978,588	16,136,052	16,295,098	16,455,741	16,617,997	16,781,883	16,947,415	17,114,609	17,283,483	17,454,052

FINANCIAL PRO FORMAS, Rounded**Rate or value 2013 2014****Assets**

Property, plant, equipment (PPE), \$millions, BOY

Depreciation, straight-line, years

50

Net PPE

Other assets

Total Assets, EOY

Liabilities

Long-term debt (LTD), beginning of year

Interest

Principal

Current maturity of LTD, P+I

Long-term debt (LTD), end of year

Retained Earnings, Capital Grants, net income, contributed capital

Total Liabilities, Owners Equity

Income Statement

Natural gas sales, volumes (MMBtu)

Natural gas selling value (\$/MMBtu), cost

Natural gas selling value (\$/MMBtu), margin

20%

Natural gas selling value (\$/MMBtu), with margin

Natural gas revenue, \$millions, rounded

Less (\$/MMBtu):

Natural gas price (\$/MMBtu)

Operations & maintenance cost

Admin & General Overhead

Depreciation, Distribution System

Subtotal

Debt service and return on equity per MMBtu

Total Expenses, \$/MMBtu

Total Expenses, \$millions, rounded

Net income before taxes, \$millions, rounded

Taxes

40.2%

Estimated net income after taxes

Year 1 2015	Year 2 2016	Year 3 2017	Year 4 2018	Year 5 2019	Year 6 2020	Year 7 2021
\$404,033,000	\$395,952,340	\$390,554,272	\$389,783,340	\$394,046,572	\$402,027,602	\$411,701,197
\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660
\$395,952,340	\$387,871,680	\$382,473,612	\$381,702,680	\$385,965,912	\$393,946,942	\$403,620,537
\$0	\$2,682,592	\$7,309,729	\$12,343,892	\$16,061,690	\$17,754,255	\$20,477,384
\$395,952,340	\$390,554,272	\$389,783,340	\$394,046,572	\$402,027,602	\$411,701,197	\$424,097,921
\$282,823,100	\$280,900,995	\$273,097,248	\$264,825,276	\$256,056,986	\$246,762,598	\$236,910,548
\$4,242,347	\$16,854,060	\$16,385,835	\$15,889,517	\$15,363,419	\$14,805,756	\$14,214,633
\$1,922,105	\$7,803,747	\$8,271,972	\$8,768,290	\$9,294,388	\$9,852,051	\$10,443,174
\$6,164,452	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807
\$280,900,995	\$273,097,248	\$264,825,276	\$256,056,986	\$246,762,598	\$236,910,548	\$226,467,374
\$115,051,345	\$117,457,024	\$124,958,064	\$137,989,586	\$155,265,004	\$174,790,650	\$197,630,548
\$395,952,340	\$390,554,272	\$389,783,340	\$394,046,572	\$402,027,602	\$411,701,197	\$424,097,921
978,383	3,407,216	6,130,156	8,128,246	9,082,866	10,458,559	10,560,584
\$20.56	\$18.41	\$17.77	\$17.77	\$17.97	\$18.26	\$18.58
\$4.11	\$3.68	\$3.55	\$3.55	\$3.59	\$3.65	\$3.72
\$24.67	\$22.09	\$21.33	\$21.32	\$21.57	\$21.91	\$22.29
\$24,137,244	\$75,261,274	\$130,751,054	\$173,331,953	\$195,909,489	\$229,162,856	\$235,408,743
\$10.00	\$10.02	\$10.35	\$10.61	\$10.88	\$11.14	\$11.41
\$0.49	\$0.50	\$0.51	\$0.53	\$0.54	\$0.55	\$0.57
\$2.50	\$2.55	\$2.60	\$2.66	\$2.72	\$2.78	\$2.85
\$6.78	\$2.20	\$1.21	\$0.90	\$0.80	\$0.77	\$0.77
\$19.77	\$15.28	\$14.68	\$14.70	\$14.94	\$15.25	\$15.60
\$0.79	\$3.13	\$3.10	\$3.07	\$3.04	\$3.01	\$2.98
\$20.56	\$18.41	\$17.77	\$17.77	\$17.97	\$18.26	\$18.58
\$20,114,370	\$62,717,728	\$108,959,211	\$144,443,294	\$163,257,908	\$190,969,046	\$196,173,952
\$4,022,874	\$12,543,546	\$21,791,842	\$28,888,659	\$32,651,582	\$38,193,809	\$39,234,790
\$1,617,195	\$5,042,505	\$8,760,321	\$11,613,241	\$13,125,936	\$15,353,911	\$15,772,386
\$2,405,679	\$7,501,040	\$13,031,522	\$17,275,418	\$19,525,646	\$22,839,898	\$23,462,405

Year 8 2022	Year 9 2023	Year 10 2024	Year 11 2025	Year 12 2026	Year 13 2027	Year 14 2028
\$424,097,921	\$436,490,562	\$448,887,394	\$461,277,060	\$473,636,779	\$485,946,248	\$498,181,038
\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660
\$416,017,261	\$428,409,902	\$440,806,734	\$453,196,400	\$465,556,119	\$477,865,588	\$490,100,378
\$20,473,300	\$20,477,493	\$20,470,326	\$20,440,379	\$20,390,129	\$20,315,450	\$20,222,178
\$436,490,562	\$448,887,394	\$461,277,060	\$473,636,779	\$485,946,248	\$498,181,038	\$510,322,556
\$226,467,374	\$215,397,610	\$203,663,659	\$191,225,672	\$178,041,406	\$164,066,084	\$149,252,242
\$13,588,042	\$12,923,857	\$12,219,820	\$11,473,540	\$10,682,484	\$9,843,965	\$8,955,135
\$11,069,764	\$11,733,950	\$12,437,987	\$13,184,266	\$13,975,322	\$14,813,842	\$15,702,672
\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807
\$215,397,610	\$203,663,659	\$191,225,672	\$178,041,406	\$164,066,084	\$149,252,242	\$133,549,570
\$221,092,952	\$245,223,735	\$270,051,388	\$295,595,373	\$321,880,165	\$348,928,796	\$376,772,986
\$436,490,562	\$448,887,394	\$461,277,060	\$473,636,779	\$485,946,248	\$498,181,038	\$510,322,556
10,663,634	10,767,719	10,872,850	10,979,036	11,086,289	11,194,619	11,304,036
\$18.92	\$19.28	\$19.64	\$20.02	\$20.40	\$20.80	\$21.19
\$3.78	\$3.86	\$3.93	\$4.00	\$4.08	\$4.16	\$4.24
\$22.70	\$23.13	\$23.57	\$24.02	\$24.48	\$24.96	\$25.42
\$242,114,876	\$249,106,887	\$256,294,166	\$263,727,004	\$271,390,949	\$279,373,146	\$287,400,492
\$11.71	\$12.01	\$12.33	\$12.64	\$12.97	\$13.30	\$13.63
\$0.58	\$0.60	\$0.61	\$0.63	\$0.64	\$0.66	\$0.67
\$2.92	\$2.99	\$3.07	\$3.15	\$3.22	\$3.30	\$3.38
\$0.76	\$0.75	\$0.74	\$0.74	\$0.73	\$0.72	\$0.71
\$15.97	\$16.36	\$16.75	\$17.15	\$17.56	\$17.99	\$18.40
\$2.95	\$2.92	\$2.89	\$2.87	\$2.84	\$2.81	\$2.78
\$18.92	\$19.28	\$19.64	\$20.02	\$20.40	\$20.80	\$21.19
\$201,762,397	\$207,589,073	\$213,578,472	\$219,772,503	\$226,159,124	\$232,810,955	\$239,500,410
\$40,352,479	\$41,517,815	\$42,715,694	\$43,954,501	\$45,231,825	\$46,562,191	\$47,900,082
\$16,221,697	\$16,690,161	\$17,171,709	\$17,669,709	\$18,183,194	\$18,718,001	\$19,255,833
\$24,130,783	\$24,827,653	\$25,543,985	\$26,284,791	\$27,048,631	\$27,844,190	\$28,644,249

Year 15 2029	Year 16 2030	Year 17 2031	Year 18 2032	Year 19 2033	Year 20 2034	Year 21 2035
\$510,322,556	\$522,321,972	\$534,154,835	\$545,810,390	\$557,278,822	\$568,501,068	\$579,419,836
\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660	\$8,080,660
\$502,241,896	\$514,241,312	\$526,074,175	\$537,729,730	\$549,198,162	\$560,420,408	\$571,339,176
\$20,080,077	\$19,913,522	\$19,736,215	\$19,549,092	\$19,302,906	\$18,999,428	\$24,868,307
\$522,321,972	\$534,154,835	\$545,810,390	\$557,278,822	\$568,501,068	\$579,419,836	\$596,207,483
\$133,549,570	\$116,904,737	\$99,261,215	\$80,559,081	\$60,734,819	\$39,721,102	\$17,446,561
\$8,012,974	\$7,014,284	\$5,955,673	\$4,833,545	\$3,644,089	\$2,383,266	\$1,046,794
\$16,644,832	\$17,643,522	\$18,702,134	\$19,824,262	\$21,013,718	\$22,274,541	\$17,446,561
\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$24,657,807	\$18,493,355
\$116,904,737	\$99,261,215	\$80,559,081	\$60,734,819	\$39,721,102	\$17,446,561	\$0
\$405,417,235	\$434,893,620	\$465,251,308	\$496,544,003	\$528,779,966	\$561,973,274	\$596,207,483
\$522,321,972	\$534,154,835	\$545,810,390	\$557,278,822	\$568,501,068	\$579,419,836	\$596,207,483
11,414,553	11,526,180	11,638,928	11,752,808	11,867,832	11,984,011	12,101,357
\$21.59	\$22.02	\$22.48	\$22.93	\$23.39	\$23.89	\$23.93
\$4.32	\$4.40	\$4.50	\$4.59	\$4.68	\$4.78	\$4.79
\$25.91	\$26.43	\$26.98	\$27.52	\$28.06	\$28.66	\$28.71
\$295,749,681	\$304,592,191	\$313,973,521	\$323,437,758	\$333,043,229	\$343,487,041	\$347,446,161
\$13.97	\$14.33	\$14.71	\$15.09	\$15.46	\$15.88	\$16.30
\$0.69	\$0.71	\$0.73	\$0.74	\$0.76	\$0.78	\$0.80
\$3.47	\$3.55	\$3.64	\$3.73	\$3.83	\$3.92	\$4.02
\$0.71	\$0.70	\$0.69	\$0.69	\$0.68	\$0.67	\$0.67
\$18.83	\$19.29	\$19.78	\$20.26	\$20.73	\$21.26	\$21.79
\$2.76	\$2.73	\$2.70	\$2.68	\$2.65	\$2.63	\$2.14
\$21.59	\$22.02	\$22.48	\$22.93	\$23.39	\$23.89	\$23.93
\$246,458,067	\$253,826,826	\$261,644,601	\$269,531,465	\$277,536,024	\$286,239,201	\$289,538,467
\$49,291,613	\$50,765,365	\$52,328,920	\$53,906,293	\$55,507,205	\$57,247,840	\$57,907,693
\$19,815,229	\$20,407,677	\$21,036,226	\$21,670,330	\$22,313,896	\$23,013,632	\$23,278,893
\$29,476,385	\$30,357,688	\$31,292,694	\$32,235,963	\$33,193,308	\$34,234,208	\$34,628,801

Variable	NPV	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
STATUS QUO												
FUEL COST (\$)												
Residential												
Fuel Oil		172,997,044	186,108,015	198,221,005	200,927,247	211,669,439	221,178,667	230,774,332	240,615,769	250,891,420	262,172,781	274,068,763
Wood		20,155,268	20,879,661	21,630,089	22,393,484	23,183,821	24,002,052	24,849,161	25,726,166	26,634,124	27,574,127	28,547,306
Commercial		166,582,962	179,208,277	190,872,672	193,479,076	203,823,578	212,980,867	222,221,436	231,698,714	241,594,164	252,458,106	263,913,953
Industrial		7,100,960	7,563,172	7,975,337	8,003,846	8,347,926	8,636,229	8,921,317	9,209,288	9,507,105	9,835,820	10,179,889
Subtotal		366,836,234	393,759,125	418,699,104	424,803,653	447,024,764	466,797,815	486,766,245	507,249,938	528,626,814	552,040,835	576,709,911
BOILER/FURNACE REPLACEMENT COST (\$)												
Residential		5,084,345	5,135,403	5,186,973	5,239,061	5,291,673	5,344,812	5,398,486	5,452,698	5,507,455	5,562,761	5,618,623
Commercial		4,895,837	4,945,014	4,994,685	5,044,855	5,095,529	5,146,711	5,198,408	5,250,625	5,303,365	5,356,636	5,410,442
Industrial	not modeled because it would be the same under the status quo and the project, so they net out to zero											
Subtotal		9,980,182	10,080,417	10,181,658	10,283,916	10,387,201	10,491,524	10,596,894	10,703,323	10,810,820	10,919,397	11,029,065
Status Quo Total Cost	\$10,617,526,597	376,816,416	403,839,542	428,880,762	435,087,569	457,411,966	477,289,339	497,363,139	517,953,260	539,437,633	562,960,232	587,738,976
High Density	\$7,103,631,156	252,057,522	270,213,793	287,022,648	291,088,120	306,049,528	319,349,849	332,776,850	346,546,668	360,914,596	376,653,656	393,234,742
Medium Density	\$2,654,941,565	94,269,687	100,967,917	107,187,026	108,806,049	114,368,675	119,337,807	124,359,683	129,512,666	134,889,377	140,769,972	146,963,401
Low Density	\$858,953,877	30,489,208	32,657,832	34,671,089	35,193,400	36,993,762	38,601,683	40,226,606	41,893,927	43,633,661	45,536,604	47,540,833
check		376,816,416	403,839,542	428,880,762	435,087,569	457,411,966	477,289,339	497,363,139	517,953,260	539,437,633	562,960,232	587,738,976
HIGH DENSITY AREA												
FUEL COST (\$)												
Residential		172,997,044										
Natural Gas				5,370,383	12,192,398	23,733,162	35,924,645	45,080,004	60,459,091	62,124,565	63,912,298	65,776,339
Fuel Oil		92,931,078	99,974,069	100,047,599	80,838,249	56,733,804	29,579,207	9,607,331	3,877,641	4,043,238	4,225,043	4,416,753
Wood		10,827,068	11,216,200	11,619,317	12,029,400	12,453,956	12,893,495	13,348,548	414,590	429,222	444,371	460,054
Commercial												
Natural Gas				9,906,934	31,449,770	54,670,278	67,675,396	70,734,200	72,578,808	74,578,333	76,724,636	78,962,555
Fuel Oil		134,513,859	144,708,658	131,008,397	78,116,084	24,687,785	0	0	0	0	0	0
Industrial												
Natural Gas				2,965,343	4,583,551	4,402,727	4,410,598	4,480,633	4,575,060	4,678,743	4,790,773	4,906,825
Fuel Oil	0.75	7,100,960	7,563,172	3,987,669	0	0	0	0	0	0	0	0
Subtotal Fuel Cost		245,372,965	263,462,099	264,905,642	219,209,452	176,681,712	150,483,342	143,250,716	141,905,189	145,854,101	150,097,121	154,522,526
BOILER/FURNACE REPLACEMENT OR CONVERSION COST												
Residential		2,734,611	2,762,072	10,390,855	26,238,004	26,501,489	26,767,620	12,977,484	0	0	0	0
Commercial		3,953,333	3,993,043	21,361,047	50,343,094	50,848,774	22,011,228	0	0	0	0	0
Industrial		0	0	2,750,000								
Subtotal Conversion Cost		6,687,944	6,755,115	34,501,903	76,581,098	77,350,263	48,778,849	12,977,484	0	0	0	0
Subtotal Fuel and Conversion Cost		252,060,908	270,217,214	299,407,544	295,790,550	254,031,975	199,262,191	156,228,199	141,905,189	145,854,101	150,097,121	154,522,526
DISTRIBUTION SYSTEM												
Capital Expenditures		1,255,385	10,288,963	109,696,298	109,584,353							
Operating Expenditures	this expenditure is already captured in the cost of energy (gas)											
Subtotal Distribution Costs		1,255,385	10,288,963	109,696,298	109,584,353	0	0	0	0	0	0	0
High Density Area NPV & Annual Cost	\$3,384,770,287	253,316,294	280,506,177	409,103,843	405,374,904	254,031,975	199,262,191	156,228,199	141,905,189	145,854,101	150,097,121	154,522,526

MEDIUM DENSITY AREA

FUEL COST (\$)

Residential												
Natural Gas			0	7,987,689	15,548,469	23,535,559	29,533,572	39,608,978	40,700,092	41,871,302	43,092,504	
Fuel Oil	60,882,574	65,496,697	65,544,869	52,960,116	37,168,406	19,378,429	6,294,117	2,540,386	2,648,875	2,767,981	2,893,577	
Wood	7,093,211	7,348,146	7,612,243	7,880,903	8,159,045	8,447,004	8,745,125	271,613	281,199	291,124	301,398	
Commercial												
Natural Gas	0	0	0	5,565,674	9,675,014	11,976,533	12,517,850	12,844,291	13,198,148	13,577,980	13,974,025	
Fuel Oil	23,804,954	25,609,130	27,275,990	23,501,181	14,563,347	4,565,293	0	0	0	0	0	
Subtotal Fuel Cost	91,780,739	98,453,973	100,433,101	97,895,564	85,114,281	67,902,817	57,090,664	55,265,268	56,828,313	58,508,386	60,261,504	
Total Natural Gas Sales (\$)	0	0	0	13,553,363	25,223,483	35,512,092	42,051,422	52,453,269	53,898,239	55,449,281	57,066,528	
Total Natural Gas Sold (MMBtu)	0	0	0	316,248	1,100,916	1,901,314	2,578,391	2,872,642	2,901,491	2,930,630	2,960,061	

BOILER/FURNACE CONVERSION COST

Residential	1,791,544	1,809,535	1,827,707	6,875,793	17,362,102	17,536,454	17,712,558	8,587,406	0	0	0	
Commercial	699,622	3,993,043	0	21,575,612	50,848,774	51,359,533	22,232,324	0	0	0	0	
Subtotal Conversion Cost	2,491,167	5,802,578	1,827,707	28,451,405	68,210,876	68,895,987	39,944,881	8,587,406	0	0	0	
Subtotal Fuel and Conversion Cost	94,271,905	104,256,551	102,260,808	126,346,969	153,325,156	136,798,804	97,035,546	63,852,674	56,828,313	58,508,386	60,261,504	

DISTRIBUTION SYSTEM

Capital Expenditures	0	0	7,373,594	83,516,426	82,317,980	0	0	0	0	0	0	
Operating Expenditures	0	0	0									
Subtotal Distribution Costs	0	0	7,373,594	83,516,426	82,317,980	0	0	0	0	0	0	
			0.04257	0.48217	0.47526							
Medium Density Area Total Cost	\$1,500,114,595	94,271,905	104,256,551	109,634,402	209,863,395	235,643,136	136,798,804	97,035,546	63,852,674	56,828,313	58,508,386	60,261,504

LOW DENSITY AREA

FUEL COST (\$)

Residential												
Propane			129,092	1,601,544	4,907,115	10,204,857	13,194,017	13,649,138	14,120,576	14,632,226	15,166,910	
Fuel Oil	19,183,393	20,637,249	19,782,397	14,482,346	9,388,688	3,678,927	1,279,512	1,334,077	1,391,049	1,453,598	1,519,554	
Wood	2,234,989	2,315,315	2,398,529	2,483,181	2,570,820	2,661,553	2,755,488	2,852,737	2,953,420	3,057,655	3,165,570	
Commercial												
Propane			125,129	1,408,052	4,242,664	6,084,813	6,298,094	6,515,360	6,740,416	6,984,668	7,239,916	
Fuel Oil	8,264,149	8,890,489	8,048,784	4,799,230	1,516,747	0	0	0	0	0	0	
Subtotal Fuel Cost	29,682,530	31,843,053	30,483,931	24,774,353	22,626,034	22,630,150	23,527,110	24,351,312	25,205,461	26,128,148	27,091,950	
Total Propane Sales (\$)	0	0	254,221	3,009,596	9,149,779	16,289,670	19,492,111	20,164,498	20,860,992	21,616,894	22,406,826	
Total Propane Sold (MMBtu)			88,768	307,941	531,508	711,660	774,929	782,711	790,572	798,512	806,531	
Total Propane Sold (gallons)			958,613	3,325,496	5,739,824	7,685,315	8,368,563	8,452,607	8,537,496	8,623,238	8,709,840	

BOILER/FURNACE CONVERSION COST

Residential	220,943	223,162	2,144,943	5,416,207	5,470,597	5,525,533	2,232,409	0	0	0	0	
Commercial	96,137	97,103	1,115,034	2,627,880	2,654,276	1,148,973	0	0	0	0	0	
Subtotal Conversion Cost	317,081	320,265	3,259,977	8,044,087	8,124,873	6,674,507	2,232,409	0	0	0	0	
Subtotal Fuel and Conversion Cost	29,999,611	32,163,318	33,743,908	32,818,440	30,750,907	29,304,657	25,759,519	24,351,312	25,205,461	26,128,148	27,091,950	

DISTRIBUTION SYSTEM

Capital Expenditures			1,426,966	3,389,724	3,422,358	3,455,320	1,479,445	0	0	0	0	
Operating Expenditures (Included in fuel cost to consumer)												
Subtotal Distribution Costs	0	0	1,426,966	3,389,724	3,422,358	3,455,320	1,479,445	0	0	0	0	

Low Density Area Total Cost	\$527,022,730	29,999,611	32,163,318	35,170,874	36,208,164	34,173,265	32,759,977	27,238,964	24,351,312	25,205,461	26,128,148	27,091,950
Conversion Total Cost	\$5,411,907,612	377,587,810	416,926,046	553,909,119	651,446,463	523,848,377	368,820,972	280,502,709	230,109,176	227,887,875	234,733,655	241,875,979
B/C Ratio	1.962											
High Density	2.099											
Medium Density	1.770											
Low Density	1.630											
Check of total fuel cost by area		366,836,234	393,759,125	418,699,104	424,803,653	447,024,764	466,797,815	486,766,245	507,249,938	528,626,814	552,040,835	576,709,911
		366,836,234	393,759,125	395,822,675	341,879,369	284,422,027	241,016,310	223,868,490	221,521,770	227,887,875	234,733,655	241,875,979
		0	0									
Net Annual Benefits/Costs		-771,394	-13,086,504	-125,028,357	-216,358,894	-66,436,411	108,468,367	216,860,430	287,844,084	311,549,758	328,226,577	345,862,996
Net Annual Benefits/Costs		(1)	(13)	(125)	(216)	(66)	108	217	288	312	328	346
CHECK				-125,028,357	-341,387,251	-407,823,662	-299,355,295	-82,494,864	205,349,220			
Fuel cost												
Residential		172,997,044										
Fuel oil		172,997,044										
		20,155,268										
Wood		20,155,268										
		166,582,962										
Commercial		166,582,962										
Industrial												
Status Quo Annual Conversion		0.38	0.40	0.43	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.59
Natural Gas/Propane		0.38	0.42	0.55	0.65	0.52	0.37	0.28	0.23	0.23	0.23	0.24

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
286,371,424	299,199,653	312,520,922	326,546,536	340,616,605	355,399,492	371,324,878	388,521,739	405,858,848	423,472,261	443,140,872	463,238,146	482,935,938	504,279,895
29,554,831	30,597,915	31,677,812	32,795,823	33,953,292	35,151,611	36,392,223	37,676,621	39,006,348	40,383,006	41,808,251	43,283,797	44,811,419	46,392,957
275,761,467	288,115,140	300,943,648	314,450,477	328,000,182	342,236,371	357,572,819	374,133,732	390,829,784	407,791,992	426,733,390	446,087,674	465,057,363	485,612,374
10,531,099	10,893,454	11,265,336	11,653,883	12,035,161	12,432,641	12,860,598	13,322,414	13,778,538	14,233,562	14,746,568	15,262,089	15,752,871	16,285,547
602,218,821	628,806,162	656,407,718	685,446,719	714,605,240	745,220,115	778,150,518	813,654,506	849,473,518	885,880,821	926,429,081	967,871,705	1,008,557,590	1,052,570,773
5,675,046	5,732,035	5,789,597	5,847,737	5,906,461	5,965,774	6,025,683	6,086,194	6,147,312	6,209,044	6,271,396	6,334,374	6,397,985	6,462,234
5,464,788	5,519,680	5,575,123	5,631,123	5,687,686	5,744,817	5,802,521	5,860,806	5,919,676	5,979,137	6,039,195	6,099,857	6,161,128	6,223,014
11,139,834	11,251,715	11,364,720	11,478,860	11,594,147	11,710,591	11,828,205	11,947,000	12,066,988	12,188,181	12,310,591	12,434,231	12,559,113	12,685,249
613,358,655	640,057,877	667,772,438	696,925,579	726,199,386	756,930,706	789,978,723	825,601,505	861,540,506	898,069,002	938,739,672	980,305,936	1,021,116,703	1,065,256,021
410,376,885	428,241,064	446,783,575	466,290,083	485,869,788	506,425,658	528,537,684	552,379,639	576,425,512	600,859,647	628,080,870	655,896,124	683,190,294	712,720,582
153,368,284	160,043,252	166,972,825	174,260,906	181,584,932	189,272,583	197,534,716	206,434,999	215,420,202	224,557,494	234,718,301	245,106,978	255,318,743	266,355,672
49,613,486	51,773,561	54,016,039	56,374,590	58,744,666	61,232,465	63,906,322	66,786,867	69,694,792	72,651,861	75,940,501	79,302,835	82,607,666	86,179,766
613,358,655	640,057,877	667,772,438	696,925,579	726,199,386	756,930,706	789,978,723	825,601,505	861,540,506	898,069,002	938,739,672	980,305,936	1,021,116,703	1,065,256,021
67,692,805	69,675,013	71,719,182	73,848,384	75,990,462	78,218,590	80,578,183	83,081,368	85,607,567	88,172,222	90,959,949	92,031,178	89,531,591	92,518,735
4,615,016	4,821,749	5,036,428	5,262,458	5,489,204	5,727,437	5,984,083	6,261,219	6,540,615	6,824,463	7,141,433	7,465,310	7,782,750	8,126,718
476,291	493,100	510,504	528,521	547,174	566,485	586,479	607,177	628,606	650,792	673,760	697,540	722,158	747,645
81,263,420	83,643,218	86,097,412	88,653,698	91,225,455	93,900,526	96,733,434	99,738,737	102,771,684	105,850,812	109,197,754	110,484,047	107,483,545	111,069,920
0	0	0	0	0	0	0	0	0	0	0	0	0	0
5,024,661	5,145,337	5,268,407	5,395,706	5,521,032	5,650,461	5,787,551	5,933,014	6,076,864	6,220,329	6,377,915	6,535,883	6,687,736	6,849,563
0	0	0	0	0	0	0	0	0	0	0	0	0	0
159,072,193	163,778,418	168,631,932	173,688,768	178,773,327	184,063,500	189,669,730	195,621,515	201,625,336	207,718,618	214,350,811	217,213,957	212,207,779	219,312,582
153,980,887	158,463,568	163,085,001	167,897,789	172,736,949	177,769,577	183,099,169	188,753,119	194,456,115	200,243,363	206,535,618	209,051,107	203,702,871	210,438,218
7,883,061	7,959,222	8,036,147	8,113,846	8,192,324	8,271,591	8,351,653	8,432,520	8,514,199	8,596,699	8,680,027	8,764,191	8,849,202	8,935,066
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
159,072,193	163,778,418	168,631,932	173,688,768	178,773,327	184,063,500	189,669,730	195,621,515	201,625,336	207,718,618	214,350,811	217,213,957	212,207,779	219,312,582
0	0	0	0	0	0	0	0	0	0	0	0	0	0
159,072,193	163,778,418	168,631,932	173,688,768	178,773,327	184,063,500	189,669,730	195,621,515	201,625,336	207,718,618	214,350,811	217,213,957	212,207,779	219,312,582

44,348,051	45,646,669	46,985,879	48,380,798	49,784,152	51,243,881	52,789,737	54,429,666	56,084,672	57,764,872	59,591,214	60,293,016	58,655,444	60,612,433
3,023,467	3,158,906	3,299,550	3,447,630	3,596,180	3,752,255	3,920,393	4,101,955	4,284,998	4,470,958	4,678,616	4,890,800	5,098,766	5,324,113
312,036	323,048	334,450	346,253	358,474	371,126	384,224	397,784	411,823	426,358	441,405	456,984	473,112	489,810
14,381,209	14,802,363	15,236,682	15,689,069	16,144,193	16,617,601	17,118,942	17,650,791	18,187,532	18,732,447	19,324,756	19,552,391	19,021,392	19,656,074
0	0	0	0	0	0	0	0	0	0	0	0	0	0
62,064,763	63,930,985	65,856,561	67,863,750	69,882,999	71,984,863	74,213,296	76,580,196	78,969,025	81,394,634	84,035,992	85,193,191	83,248,715	86,082,429
58,729,261	60,449,031	62,222,561	64,069,867	65,928,345	67,861,482	69,908,679	72,080,457	74,272,204	76,497,319	78,915,970	79,845,408	77,676,836	80,268,506
2,989,788	3,019,814	3,050,141	3,080,773	3,111,712	3,142,963	3,174,527	3,206,408	3,238,609	3,271,133	3,303,984	3,337,165	3,370,680	3,404,531
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
62,064,763	63,930,985	65,856,561	67,863,750	69,882,999	71,984,863	74,213,296	76,580,196	78,969,025	81,394,634	84,035,992	85,193,191	83,248,715	86,082,429
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
62,064,763	63,930,985	65,856,561	67,863,750	69,882,999	71,984,863	74,213,296	76,580,196	78,969,025	81,394,634	84,035,992	85,193,191	83,248,715	86,082,429
15,715,607	16,283,056	16,867,663	17,477,762	18,086,445	18,720,570	19,396,718	20,119,142	20,842,988	21,573,721	22,379,393	23,196,788	23,994,804	24,850,404
1,587,766	1,658,891	1,732,750	1,810,514	1,888,524	1,970,487	2,058,784	2,154,131	2,250,255	2,347,911	2,456,963	2,568,390	2,677,603	2,795,944
3,277,293	3,392,959	3,512,707	3,636,682	3,765,032	3,897,911	4,035,481	4,177,906	4,325,358	4,478,013	4,636,057	4,799,678	4,969,074	5,144,448
7,501,855	7,772,747	8,051,830	8,343,084	8,633,663	8,936,389	9,259,176	9,604,055	9,949,614	10,298,463	10,683,087	11,073,308	11,454,281	11,862,744
0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,082,520	29,107,652	30,164,950	31,268,041	32,373,664	33,525,358	34,750,159	36,055,234	37,368,215	38,698,109	40,155,499	41,638,165	43,095,762	44,653,540
23,217,462	24,055,803	24,919,493	25,820,846	26,720,108	27,656,959	28,655,894	29,723,197	30,792,602	31,872,184	33,062,480	34,270,096	35,449,085	36,713,148
814,631	822,812	831,076	839,422	847,852	856,367	864,968	873,655	882,429	891,291	900,242	909,283	918,415	927,638
8,797,312	8,885,663	8,974,901	9,065,035	9,156,074	9,248,028	9,340,905	9,434,715	9,529,467	9,625,171	9,721,836	9,819,471	9,918,087	10,017,694
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,082,520	29,107,652	30,164,950	31,268,041	32,373,664	33,525,358	34,750,159	36,055,234	37,368,215	38,698,109	40,155,499	41,638,165	43,095,762	44,653,540
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

28,082,520	29,107,652	30,164,950	31,268,041	32,373,664	33,525,358	34,750,159	36,055,234	37,368,215	38,698,109	40,155,499	41,638,165	43,095,762	44,653,540
249,219,477	256,817,056	264,653,443	272,820,559	281,029,990	289,573,720	298,633,185	308,256,945	317,962,576	327,811,361	338,542,302	344,045,313	338,552,256	350,048,550

602,218,821	628,806,162	656,407,718	685,446,719	714,605,240	745,220,115	778,150,518	813,654,506	849,473,518	885,880,821	926,429,081	967,871,705	1,008,557,590	1,052,570,773
249,219,477	256,817,056	264,653,443	272,820,559	281,029,990	289,573,720	298,633,185	308,256,945	317,962,576	327,811,361	338,542,302	344,045,313	338,552,256	350,048,550

364,139,178	383,240,822	403,118,996	424,105,020	445,169,396	467,356,986	491,345,538	517,344,560	543,577,930	570,257,641	600,197,371	636,260,623	682,564,447	715,207,471
364	383	403	424	445	467	491	517	544	570	600	636	683	715

0.61	0.64	0.67	0.70	0.73	0.76	0.79	0.83	0.86	0.90	0.94	0.98	1.02	1.07
0.25	0.26	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.34	0.34	0.35

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
526,528,895	549,720,235	573,892,720	599,086,715	625,344,217	652,708,913	681,226,250	710,943,501	741,909,844	774,176,431	807,796,469	842,825,303	879,320,496
48,030,312	49,725,454	51,480,423	53,297,331	55,178,363	57,125,782	59,141,933	61,229,240	63,390,214	65,627,456	67,943,657	70,341,605	72,824,183
507,039,031	529,373,257	552,652,426	576,915,419	602,202,684	628,556,300	656,020,039	684,639,436	714,461,857	745,536,570	777,914,824	811,649,927	846,797,323
16,835,012	17,401,771	17,986,346	18,589,275	19,211,108	19,852,414	20,513,779	21,195,804	21,899,109	22,624,333	23,372,130	24,143,178	24,938,170
1,098,433,249	1,146,220,718	1,196,011,915	1,247,888,739	1,301,936,371	1,358,243,410	1,416,902,000	1,478,007,981	1,541,661,024	1,607,964,789	1,677,027,081	1,748,960,012	1,823,880,172
6,527,129	6,592,675	6,658,880	6,725,749	6,793,290	6,861,509	6,930,413	7,000,009	7,070,304	7,141,305	7,213,019	7,285,453	7,358,614
6,285,522	6,348,658	6,412,428	6,476,839	6,541,897	6,607,608	6,673,979	6,741,017	6,808,728	6,877,120	6,946,198	7,015,970	7,086,443
12,812,651	12,941,333	13,071,308	13,202,588	13,335,186	13,469,117	13,604,392	13,741,026	13,879,032	14,018,424	14,159,216	14,301,423	14,445,057
1,111,245,900	1,159,162,051	1,209,083,223	1,261,091,327	1,315,271,558	1,371,712,526	1,430,506,392	1,491,749,007	1,555,540,056	1,621,983,213	1,691,186,298	1,763,261,435	1,838,325,230
743,488,510	775,544,693	808,941,780	843,734,531	879,979,903	917,737,135	957,067,839	998,036,091	1,040,708,534	1,085,154,474	1,131,445,988	1,179,658,032	1,229,868,555
277,855,631	289,837,575	302,321,223	315,327,082	328,876,486	342,991,622	357,695,566	373,012,321	388,966,848	405,585,108	422,894,102	440,921,908	459,697,727
89,901,759	93,779,783	97,820,221	102,029,714	106,415,169	110,983,769	115,742,988	120,700,595	125,864,675	131,243,631	136,846,207	142,681,494	148,758,948
1,111,245,900	1,159,162,051	1,209,083,223	1,261,091,327	1,315,271,558	1,371,712,526	1,430,506,392	1,491,749,007	1,555,540,056	1,621,983,213	1,691,186,298	1,763,261,435	1,838,325,230
95,608,095	98,803,095	102,107,270	105,524,274	109,057,881	112,711,988	116,490,622	120,397,941	124,438,241	128,615,960	132,935,680	137,402,136	142,020,217
8,485,272	8,859,012	9,248,563	9,654,577	10,077,729	10,518,725	10,978,296	11,457,204	11,956,242	12,476,233	13,018,037	13,582,544	14,170,682
774,032	801,350	829,632	858,913	889,226	920,610	953,101	986,739	1,021,564	1,057,619	1,094,945	1,133,590	1,173,597
114,779,025	118,614,970	122,582,003	126,684,509	130,927,021	135,314,218	139,850,936	144,542,168	149,393,073	154,408,979	159,595,390	164,957,990	170,502,650
0	0	0	0	0	0	0	0	0	0	0	0	0
7,015,250	7,184,881	7,358,546	7,536,336	7,718,344	7,904,664	8,095,394	8,290,633	8,490,481	8,695,043	8,904,425	9,118,735	9,338,083
0	0	0	0	0	0	0	0	0	0	0	0	0
226,661,673	234,263,307	242,126,014	250,258,609	258,670,202	267,370,205	276,368,349	285,674,685	295,299,601	305,253,835	315,548,478	326,194,994	337,205,229
217,402,369	224,602,946	232,047,819	239,745,120	247,703,246	255,930,871	264,436,952	273,230,742	282,321,795	291,719,983	301,435,495	311,478,861	321,860,950
9,021,792	9,109,389	9,197,866	9,287,232	9,377,496	9,468,665	9,560,751	9,653,761	9,747,706	9,842,594	9,938,435	10,035,239	10,133,015
0	0	0	0	0	0	0	21,795,521	55,035,986	55,588,664	56,146,893	27,221,149	0
0	0	0	0	0	0	0	44,806,240	105,598,043	106,658,739	46,170,039	0	0
0	0	0	0	0	0	0	66,601,762	160,634,029	162,247,404	102,316,931	27,221,149	0
226,661,673	234,263,307	242,126,014	250,258,609	258,670,202	267,370,205	276,368,349	352,276,446	455,933,630	467,501,238	417,865,409	353,416,143	337,205,229
0	0	0	0	0	0	0	0	0	0	0	0	0
226,661,673	234,263,307	242,126,014	250,258,609	258,670,202	267,370,205	276,368,349	352,276,446	455,933,630	467,501,238	417,865,409	353,416,143	337,205,229

62,636,386	64,729,548	66,894,235	69,132,841	71,447,837	73,841,777	76,317,299	78,877,128	81,524,077	84,261,055	87,091,063	90,017,203	93,042,678
5,559,014	5,803,865	6,059,074	6,325,069	6,602,292	6,891,204	7,192,286	7,506,036	7,832,974	8,173,640	8,528,596	8,898,425	9,283,736
507,097	524,994	543,523	562,705	582,565	603,126	624,412	646,449	669,265	692,885	717,339	742,656	768,867
20,312,475	20,991,323	21,693,370	22,419,392	23,170,190	23,946,594	24,749,458	25,579,666	26,438,132	27,325,799	28,243,639	29,192,660	30,173,900
0	0	0	0	0	0	0	0	0	0	0	0	0
89,014,972	92,049,730	95,190,202	98,440,007	101,802,884	105,282,700	108,883,455	112,609,280	116,464,449	120,453,379	124,580,637	128,850,944	133,269,180
82,948,861	85,720,871	88,587,605	91,552,232	94,618,027	97,788,370	101,066,757	104,456,794	107,962,210	111,586,854	115,334,702	119,209,863	123,216,578
3,438,721	3,473,256	3,508,137	3,543,368	3,578,953	3,614,896	3,651,199	3,687,867	3,724,904	3,762,312	3,800,096	3,838,259	3,876,806
0	0	0	0	0	0	0	3,833,738	14,422,441	36,418,182	36,783,898	37,153,287	18,012,665
0	0	0	0	0	0	0	0	45,256,304	106,658,739	107,730,090	46,633,801	0
0	0	0	0	0	0	0	3,833,738	59,678,745	143,076,922	144,513,989	83,787,088	18,012,665
89,014,972	92,049,730	95,190,202	98,440,007	101,802,884	105,282,700	108,883,455	116,443,018	176,143,194	263,530,301	269,094,625	212,638,032	151,281,845
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
89,014,972	92,049,730	95,190,202	98,440,007	101,802,884	105,282,700	108,883,455	116,443,018	176,143,194	263,530,301	269,094,625	212,638,032	151,281,845
25,735,098	26,649,847	27,595,644	28,573,515	29,584,515	30,629,739	31,710,313	32,827,401	33,982,205	35,175,965	36,409,961	37,685,515	39,003,991
2,919,301	3,047,884	3,181,907	3,321,593	3,467,176	3,618,897	3,777,010	3,941,775	4,113,466	4,292,365	4,478,769	4,672,984	4,875,329
5,326,012	5,513,984	5,708,590	5,910,064	6,118,649	6,334,596	6,558,164	6,789,622	7,029,249	7,277,334	7,534,174	7,800,079	8,075,369
12,285,098	12,721,802	13,173,329	13,640,169	14,122,827	14,621,824	15,137,700	15,671,009	16,222,325	16,792,240	17,381,367	17,990,336	18,619,798
0	0	0	0	0	0	0	0	0	0	0	0	0
46,265,509	47,933,517	49,659,470	51,445,341	53,293,167	55,205,056	57,183,186	59,229,807	61,347,245	63,537,904	65,804,271	68,148,914	70,5

46,265,509	47,933,517	49,659,470	51,445,341	53,293,167	55,205,056	57,183,186	66,067,829	78,220,260	80,580,375	79,804,500	72,831,542	70,574,487
361,942,155	374,246,555	386,975,687	400,143,956	413,766,252	427,857,962	442,434,989	534,787,293	710,297,084	811,611,914	766,764,534	638,885,716	559,061,561

1,098,433,249	1,146,220,718	1,196,011,915	1,247,888,739	1,301,936,371	1,358,243,410	1,416,902,000	1,478,007,981	1,541,661,024	1,607,964,789	1,677,027,081	1,748,960,012	1,823,880,172
361,942,155	374,246,555	386,975,687	400,143,956	413,766,252	427,857,962	442,434,989	457,513,771	473,111,295	489,245,118	505,933,386	523,194,851	541,048,896

749,303,745	784,915,497	822,107,537	860,947,371	901,505,306	943,854,564	988,071,403	956,961,714	845,242,972	810,371,300	924,421,764	1,124,375,719	1,279,263,668
749	785	822	861	902	944	988	957	845	810	924	1,124	1,279

1.11	1.16	1.21	1.26	1.32	1.37	1.43	1.49	1.56	1.62	1.69	1.76	1.84
0.36	0.37	0.39	0.40	0.41	0.43	0.44	0.53	0.71	0.81	0.77	0.64	0.56

2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063
917,341,922	956,951,853	998,215,055	1,041,198,890	1,085,973,411	1,132,611,477	1,181,188,856	1,231,784,345	1,284,479,886	1,339,360,693	1,396,515,376	1,456,036,082	1,518,018,626
75,394,380	78,055,287	80,810,106	83,662,152	86,614,855	89,671,768	92,836,570	96,113,067	99,505,203	103,017,057	106,652,857	110,416,975	114,313,940
883,414,681	921,561,983	961,301,611	1,002,698,447	1,045,819,967	1,090,736,350	1,137,520,576	1,186,248,542	1,236,999,178	1,289,854,561	1,344,900,044	1,402,224,383	1,461,919,870
25,757,822	26,602,870	27,474,072	28,372,207	29,298,078	30,252,510	31,236,352	32,250,479	33,295,789	34,373,208	35,483,688	36,628,209	37,807,778
1,901,908,806	1,983,171,993	2,067,800,845	2,155,931,696	2,247,706,312	2,343,272,105	2,442,782,354	2,546,396,433	2,654,280,055	2,766,605,518	2,883,551,964	3,005,305,647	3,132,060,214
7,432,510	7,507,148	7,582,536	7,658,681	7,735,590	7,813,272	7,891,734	7,970,984	8,051,029	8,131,879	8,213,540	8,296,021	8,379,331
7,157,624	7,229,520	7,302,138	7,375,486	7,449,570	7,524,398	7,599,978	7,676,317	7,753,423	7,831,304	7,909,967	7,989,420	8,069,671
14,590,134	14,736,668	14,884,674	15,034,166	15,185,160	15,337,670	15,491,712	15,647,301	15,804,453	15,963,183	16,123,507	16,285,441	16,449,002
1,916,498,940	1,997,908,661	2,082,685,519	2,170,965,862	2,262,891,472	2,358,609,775	2,458,274,066	2,562,043,734	2,670,084,508	2,782,568,701	2,899,675,471	3,021,591,089	3,148,509,216
1,282,158,614	1,336,612,504	1,393,317,877	1,452,365,877	1,513,851,281	1,577,872,636	1,644,532,412	1,713,937,152	1,786,197,637	1,861,429,046	1,939,751,134	2,021,288,410	2,106,170,320
479,251,925	499,616,081	520,823,034	542,906,930	565,903,279	589,849,004	614,782,496	640,743,676	667,774,053	695,916,785	725,216,744	755,720,586	787,476,818
155,088,400	161,680,076	168,544,609	175,693,055	183,136,912	190,888,136	198,959,158	207,362,905	216,112,818	225,222,870	234,707,593	244,582,093	254,862,078
1,916,498,940	1,997,908,661	2,082,685,519	2,170,965,862	2,262,891,472	2,358,609,775	2,458,274,066	2,562,043,734	2,670,084,508	2,782,568,701	2,899,675,471	3,021,591,089	3,148,509,216
146,794,973	151,731,621	156,835,547	162,112,318	167,567,679	173,207,567	179,038,112	185,065,646	191,296,708	197,738,051	204,396,652	211,279,713	218,394,674
14,783,416	15,421,749	16,086,726	16,779,432	17,500,995	18,252,590	19,035,439	19,850,810	20,700,024	21,584,455	22,505,531	23,464,737	24,463,616
1,215,017	1,257,899	1,302,295	1,348,257	1,395,841	1,445,105	1,496,107	1,548,909	1,603,575	1,660,170	1,718,763	1,779,424	1,842,225
176,235,436	182,162,611	188,290,644	194,626,218	201,176,234	207,947,820	214,948,338	222,185,391	229,666,833	237,400,772	245,395,586	253,659,924	262,202,720
0	0	0	0	0	0	0	0	0	0	0	0	0
9,562,583	9,792,350	10,027,502	10,268,160	10,514,448	10,766,492	11,024,420	11,288,365	11,558,462	11,834,847	12,117,663	12,407,052	12,703,162
0	0	0	0	0	0	0	0	0	0	0	0	0
348,591,425	360,366,229	372,542,714	385,134,384	398,155,197	411,619,573	425,542,415	439,939,121	454,825,601	470,218,297	486,134,195	502,590,849	519,606,397
332,592,992	343,686,581	355,153,693	367,006,696	379,258,361	391,921,879	405,010,870	418,539,402	432,522,002	446,973,671	461,909,900	477,346,689	493,300,556
10,231,773	10,331,523	10,432,274	10,534,038	10,636,824	10,740,642	10,845,502	10,951,416	11,058,394	11,166,446	11,275,583	11,385,816	11,497,157
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
348,591,425	360,366,229	372,542,714	385,134,384	398,155,197	411,619,573	425,542,415	439,939,121	454,825,601	470,218,297	486,134,195	502,590,849	519,606,397
0	0	0	0	0	0	0	0	0	0	0	0	0
348,591,425	360,366,229	372,542,714	385,134,384	398,155,197	411,619,573	425,542,415	439,939,121	454,825,601	470,218,297	486,134,195	502,590,849	519,606,397

96,170,796	99,404,976	102,748,747	106,205,753	109,779,761	113,474,660	117,294,465	121,243,324	125,325,523	129,545,484	133,907,779	138,417,126	143,078,399
9,685,160	10,103,356	10,539,007	10,992,824	11,465,547	11,957,944	12,470,817	13,004,997	13,561,349	14,140,772	14,744,203	15,372,614	16,027,016
796,003	824,096	853,181	883,293	914,467	946,741	980,155	1,014,748	1,050,561	1,087,639	1,126,025	1,165,766	1,206,910
31,188,433	32,237,366	33,321,846	34,443,054	35,602,212	36,800,582	38,039,465	39,320,208	40,644,201	42,012,878	43,427,723	44,890,265	46,402,086
0	0	0	0	0	0	0	0	0	0	0	0	0
137,840,392	142,569,795	147,462,781	152,524,924	157,761,987	163,179,927	168,784,902	174,583,277	180,581,634	186,786,774	193,205,730	199,845,770	206,714,410
127,359,229	131,642,342	136,070,593	140,648,807	145,381,974	150,275,241	155,333,930	160,563,533	165,969,724	171,558,363	177,335,502	183,307,391	189,480,485
3,915,740	3,955,064	3,994,784	4,034,903	4,075,424	4,116,353	4,157,692	4,199,447	4,241,621	4,284,218	4,327,243	4,370,701	4,414,595
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
137,840,392	142,569,795	147,462,781	152,524,924	157,761,987	163,179,927	168,784,902	174,583,277	180,581,634	186,786,774	193,205,730	199,845,770	206,714,410
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
137,840,392	142,569,795	147,462,781	152,524,924	157,761,987	163,179,927	168,784,902	174,583,277	180,581,634	186,786,774	193,205,730	199,845,770	206,714,410
40,366,799	41,775,390	43,231,266	44,735,976	46,291,118	47,898,342	49,559,352	51,275,905	53,049,816	54,882,958	56,777,263	58,734,727	60,757,407
5,086,136	5,305,751	5,534,531	5,772,852	6,021,101	6,279,683	6,549,016	6,829,539	7,121,706	7,425,989	7,742,879	8,072,887	8,416,545
8,360,374	8,655,438	8,960,916	9,277,175	9,604,596	9,943,573	10,294,513	10,657,839	11,033,988	11,423,413	11,826,581	12,243,979	12,676,108
19,270,425	19,942,913	20,637,977	21,356,358	22,098,817	22,866,144	23,659,151	24,478,679	25,325,592	26,200,786	27,105,184	28,039,738	29,005,431
0	0	0	0	0	0	0	0	0	0	0	0	0
73,083,734	75,679,492	78,364,691	81,142,361	84,015,632	86,987,742	90,062,033	93,241,963	96,531,103	99,933,146	103,451,908	107,091,331	110,855,491
59,637,224	61,718,303	63,869,244	66,092,333	68,389,935	70,764,486	73,218,503	75,754,584	78,375,408	81,083,744	83,882,447	86,774,465	89,762,839
1,066,931	1,077,646	1,088,469	1,099,400	1,110,441	1,121,593	1,132,857	1,144,235	1,155,726	1,167,333	1,179,056	1,190,898	1,202,858
11,521,933	11,637,646	11,754,522	11,872,572	11,991,807	12,112,240	12,233,882	12,356,746	12,480,844	12,606,188	12,732,791	12,860,665	12,989,824
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
73,083,734	75,679,492	78,364,691	81,142,361	84,015,632	86,987,742	90,062,033	93,241,963	96,531,103	99,933,146	103,451,908	107,091,331	110,855,491
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

73,083,734 559,515,551	75,679,492 578,615,516	78,364,691 598,370,185	81,142,361 618,801,669	84,015,632 639,932,816	86,987,742 661,787,242	90,062,033 684,389,350	93,241,963 707,764,361	96,531,103 731,938,338	99,933,146 756,938,216	103,451,908 782,791,832	107,091,331 809,527,950	110,855,491 837,176,298
1,901,908,806 559,515,551	1,983,171,993 578,615,516	2,067,800,845 598,370,185	2,155,931,696 618,801,669	2,247,706,312 639,932,816	2,343,272,105 661,787,242	2,442,782,354 684,389,350	2,546,396,433 707,764,361	2,654,280,055 731,938,338	2,766,605,518 756,938,216	2,883,551,964 782,791,832	3,005,305,647 809,527,950	3,132,060,214 837,176,298
1,356,983,389 1,357	1,419,293,145 1,419	1,484,315,334 1,484	1,552,164,193 1,552	1,622,958,655 1,623	1,696,822,533 1,697	1,773,884,716 1,774	1,854,279,373 1,854	1,938,146,170 1,938	2,025,630,484 2,026	2,116,883,639 2,117	2,212,063,139 2,212	2,311,332,918 2,311
1.92 0.56	2.00 0.58	2.08 0.60	2.17 0.62	2.26 0.64	2.36 0.66	2.46 0.68	2.56 0.71	2.67 0.73	2.78 0.76	2.90 0.78	3.02 0.81	3.15 0.84

2064	2065
1,582,562,641	1,649,771,726
118,348,443	122,525,335
1,524,082,475	1,588,811,987
39,023,433	40,276,242
3,264,016,992	3,401,385,290
8,463,477	8,548,469
8,150,728	8,232,599
16,614,205	16,781,068
3,280,631,197	3,418,166,358
2,194,531,447	2,286,511,707
820,535,872	854,950,179
265,563,878	276,704,471
3,280,631,197	3,418,166,358
225,749,217	233,351,278
25,503,774	26,586,882
1,907,243	1,974,556
271,033,202	280,160,896
0	0
13,006,142	13,316,148
0	0
537,199,579	555,389,759
509,788,561	526,828,322
11,609,616	11,723,204
0	0
0	0
0	0
537,199,579	555,389,759
0	0
537,199,579	555,389,759

147,896,631	152,877,021
16,708,462	17,418,046
1,249,505	1,293,604
47,964,819	49,580,149
0	0
213,819,417	221,168,821
195,861,450	202,457,170
4,458,929	4,503,709
0	0
0	0
0	0
213,819,417	221,168,821
0	0
0	0
213,819,417	221,168,821
62,847,430	65,006,988
8,774,404	9,147,040
13,123,488	13,586,658
30,003,278	31,034,326
0	0
114,748,601	118,775,013
92,850,708	96,041,315
1,214,938	1,227,139
13,120,279	13,252,045
0	0
0	0
0	0
114,748,601	118,775,013
0	0
0	0

114,748,601	118,775,013
865,767,597	895,333,593

3,264,016,992	3,401,385,290
865,767,597	895,333,593

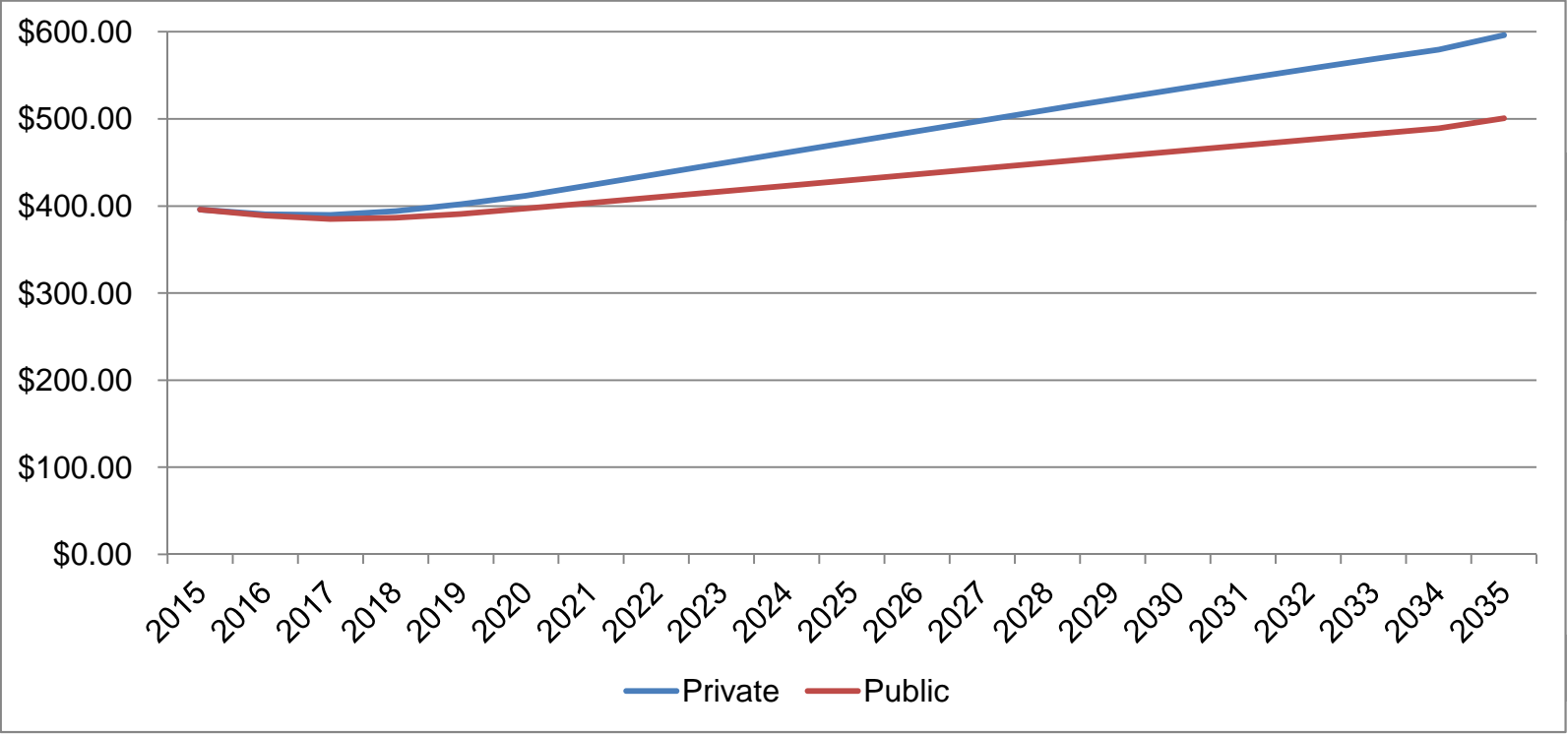
2,414,863,600	2,522,832,765
2,415	2,523

3.28	3.42
0.87	0.90

FUEL COSTS AND SAVINGS
(Millions of Nominal \$)

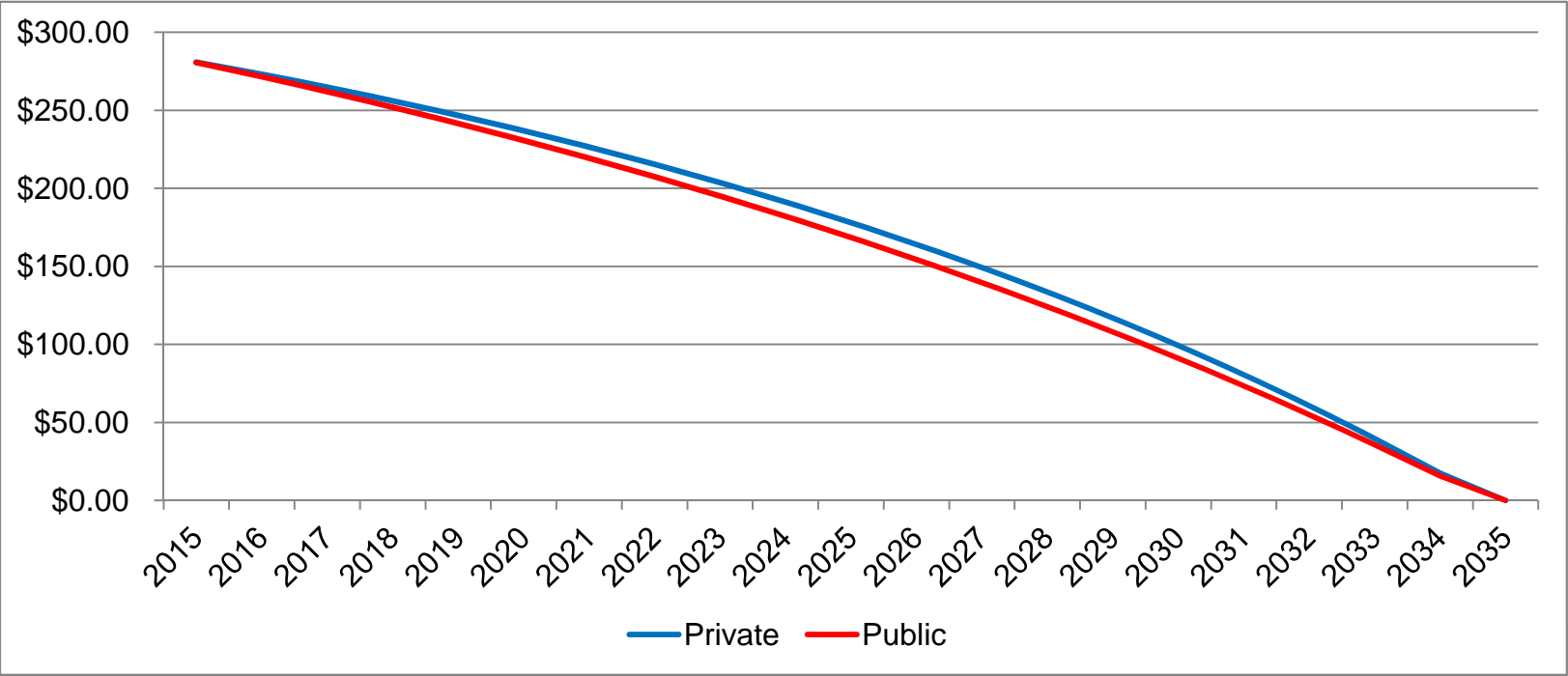
Alternative/Sector	2015	2016	2017	2018	2019	2020	2021	2022	Total 2015-2021	Total 2015-2022
Status Quo	(Millions of Nominal \$)									
Residential	219.9	223.3	234.9	245.2	255.6	266.3	277.5	289.7	1,722.7	2,012.4
Commercial	187.3	189.8	200.0	209.0	218.0	227.3	237.1	247.7	1,468.5	1,716.2
Industrial	8.0	8.0	8.3	8.6	8.9	9.2	9.5	9.8	60.6	70.4
Total	415.1	421.2	443.2	462.8	482.6	502.9	524.1	547.3	3,251.8	3,799.1
Natural Gas/Propane										
Residential	213.6	195.4	173.9	148.1	130.5	125.7	129.4	133.4	1,116.5	1,249.8
Commercial	178.7	145.6	108.7	88.5	87.6	89.9	92.4	95.0	791.3	886.3
Industrial	7.1	5.5	5.3	5.3	5.4	5.5	5.6	5.7	39.7	45.4
Total	399.4	346.5	287.9	241.9	223.5	221.0	227.3	234.1	1,947.5	2,181.5
Savings										
Residential	6.2	27.9	61.0	97.1	125.1	140.7	148.1	156.4	606.2	762.6
Commercial	8.6	44.2	91.3	120.5	130.4	137.5	144.7	152.7	677.2	829.9
Industrial	0.9	2.5	3.0	3.3	3.5	3.7	3.9	4.2	20.9	25.1
Total	15.7	74.7	155.3	220.9	259.1	281.9	296.8	313.2	1,304.4	1,617.6
Savings as a % of Status Quo	4%	18%	35%	48%	54%	56%	57%	57%	40%	43%

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Display	Private	\$395,952,340	\$390,554,272	\$389,783,340	\$394,046,572	\$402,027,602	\$411,701,197	\$424,097,921	\$436,490,562	\$448,887,394	\$461,277,060	\$473,636,779	\$485,946,248
Display	Public	\$395,952,340	\$388,817,994	\$385,162,023	\$386,280,415	\$390,734,856	\$396,849,495	\$403,402,102	\$409,963,982	\$416,550,483	\$423,161,386	\$429,787,839	\$436,424,052
Display	Private	\$395.95	\$390.55	\$389.78	\$394.05	\$402.03	\$411.70	\$424.10	\$436.49	\$448.89	\$461.28	\$473.64	\$485.95
Display	Public	\$395.95	\$388.82	\$385.16	\$386.28	\$390.73	\$396.85	\$403.40	\$409.96	\$416.55	\$423.16	\$429.79	\$436.42



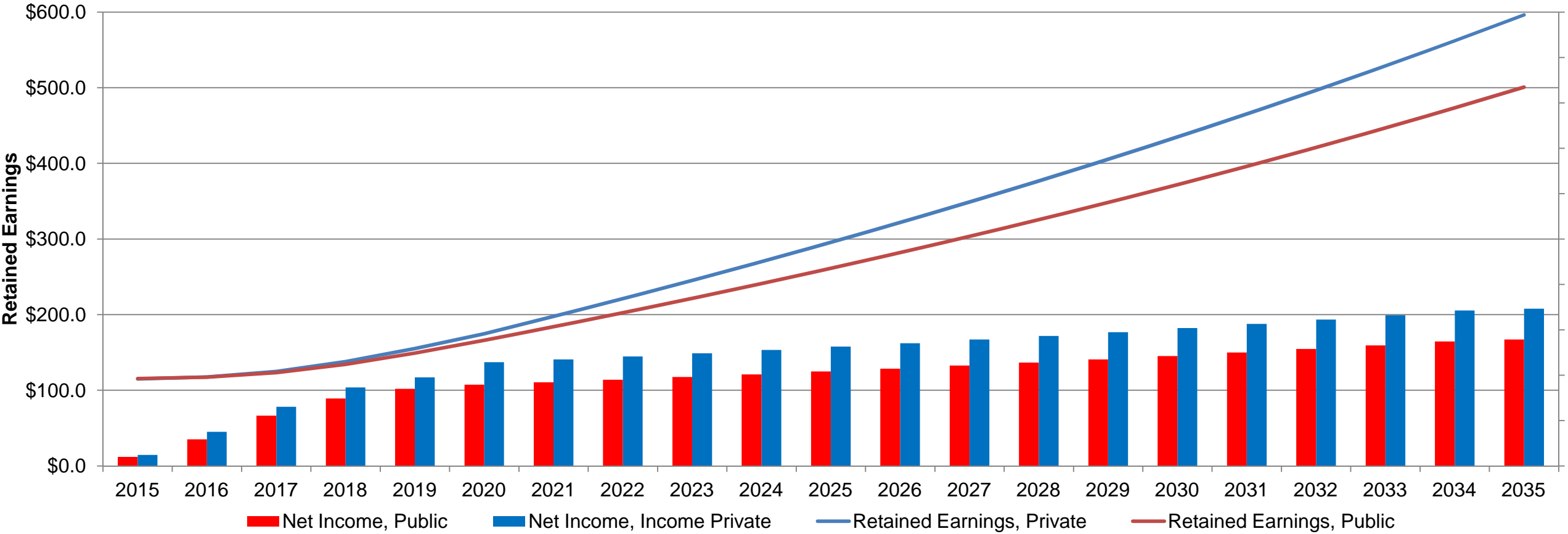
2027	2028	2029	2030	2031	2032	2033	2034	2035
\$498,181,038	\$510,322,556	\$522,321,972	\$534,154,835	\$545,810,390	\$557,278,822	\$568,501,068	\$579,419,836	\$596,207,483
\$443,061,848	\$449,699,077	\$456,309,542	\$462,888,754	\$469,445,106	\$475,989,310	\$482,492,546	\$488,929,248	\$500,765,849
\$498.18	\$510.32	\$522.32	\$534.15	\$545.81	\$557.28	\$568.50	\$579.42	\$596.21
\$443.06	\$449.70	\$456.31	\$462.89	\$469.45	\$475.99	\$482.49	\$488.93	\$500.77

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Display	Private	\$280,900,995	\$273,097,248	\$264,825,276	\$256,056,986	\$246,762,598	\$236,910,548	\$226,467,374	\$215,397,610	\$203,663,659	\$191,225,672	\$178,041,406	\$164,066,084
Display	Public	\$280,569,273	\$271,452,540	\$261,925,555	\$251,969,856	\$241,566,150	\$230,694,277	\$219,333,170	\$207,460,813	\$195,054,200	\$182,089,290	\$168,540,959	\$154,382,952
Display	Private	\$280.90	\$273.10	\$264.83	\$256.06	\$246.76	\$236.91	\$226.47	\$215.40	\$203.66	\$191.23	\$178.04	\$164.07
Display	Public	\$280.57	\$271.45	\$261.93	\$251.97	\$241.57	\$230.69	\$219.33	\$207.46	\$195.05	\$182.09	\$168.54	\$154.38



2027	2028	2029	2030	2031	2032	2033	2034	2035
\$149,252,242	\$133,549,570	\$116,904,737	\$99,261,215	\$80,559,081	\$60,734,819	\$39,721,102	\$17,446,561	(\$0)
\$139,587,836	\$124,126,939	\$107,970,302	\$91,086,616	\$73,443,164	\$55,005,757	\$35,738,666	\$15,604,557	\$0
\$149.25	\$133.55	\$116.90	\$99.26	\$80.56	\$60.73	\$39.72	\$17.45	(\$0.00)
\$139.59	\$124.13	\$107.97	\$91.09	\$73.44	\$55.01	\$35.74	\$15.60	\$0.00

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
RETAINED EARNINGS	Private	\$115,051,345	\$117,457,024	\$124,958,064	\$137,989,586	\$155,265,004	\$174,790,650	\$197,630,548	\$221,092,952	\$245,223,735	\$270,051,388	\$295,595,373	\$321,880,165
	Public	\$115,383,067	\$117,365,454	\$123,236,467	\$134,310,559	\$149,168,706	\$166,155,218	\$184,068,932	\$202,503,169	\$221,496,283	\$241,072,096	\$261,246,881	\$282,041,100
		Retained Earn	\$115.1	\$117.5	\$125.0	\$138.0	\$155.3	\$174.8	\$197.6	\$221.1	\$245.2	\$270.1	\$321.9
		Retained Earn	\$115.4	\$117.4	\$123.2	\$134.3	\$149.2	\$166.2	\$184.1	\$202.5	\$221.5	\$241.1	\$282.0
NET INCOME	Private	\$2,405,679	\$7,501,040	\$13,031,522	\$17,275,418	\$19,525,646	\$22,839,898	\$23,462,405	\$24,130,783	\$24,827,653	\$25,543,985	\$26,284,791	\$27,048,631
	Public	\$1,982,386	\$5,871,013	\$11,074,092	\$14,858,148	\$16,986,512	\$17,913,714	\$18,434,237	\$18,993,114	\$19,575,813	\$20,174,785	\$20,794,219	\$21,432,912
		Net Income, P	\$2.0	\$5.9	\$11.1	\$14.9	\$17.0	\$17.9	\$18.4	\$19.0	\$19.6	\$20.2	\$21.4
		Net Income, Ir	\$2.4	\$7.5	\$13.0	\$17.3	\$19.5	\$22.8	\$23.5	\$24.1	\$24.8	\$25.5	\$27.0



2027	2028	2029	2030	2031	2032	2033	2034	2035
\$348,928,796	\$376,772,986	\$405,417,235	\$434,893,620	\$465,251,308	\$496,544,003	\$528,779,966	\$561,973,274	\$596,207,483
\$303,474,012	\$325,572,138	\$348,339,240	\$371,802,138	\$396,001,942	\$420,983,553	\$446,753,879	\$473,324,691	\$500,765,849
\$348.9	\$376.8	\$405.4	\$434.9	\$465.3	\$496.5	\$528.8	\$562.0	\$596.2
\$303.5	\$325.6	\$348.3	\$371.8	\$396.0	\$421.0	\$446.8	\$473.3	\$500.8
\$27,844,190	\$28,644,249	\$29,476,385	\$30,357,688	\$31,292,694	\$32,235,963	\$33,193,308	\$34,234,208	\$34,628,801
\$22,098,126	\$22,767,102	\$23,462,898	\$24,199,804	\$24,981,611	\$25,770,327	\$26,570,811	\$27,441,158	\$27,836,933
\$22.1	\$22.8	\$23.5	\$24.2	\$25.0	\$25.8	\$26.6	\$27.4	\$27.8
\$27.8	\$28.6	\$29.5	\$30.4	\$31.3	\$32.2	\$33.2	\$34.2	\$34.6

\$100.0

\$90.0

\$80.0

\$70.0

\$60.0

\$50.0

\$40.0

\$30.0

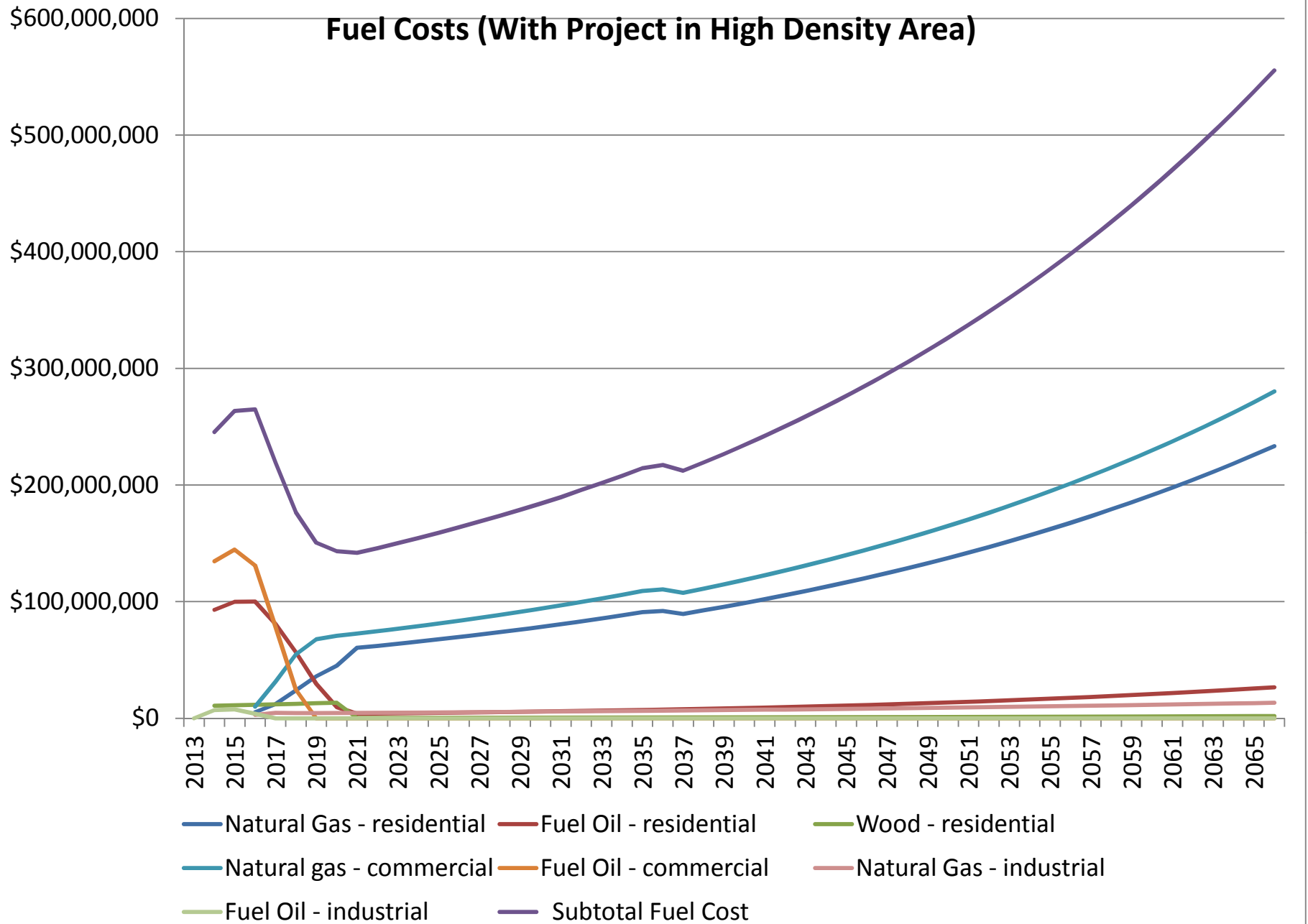
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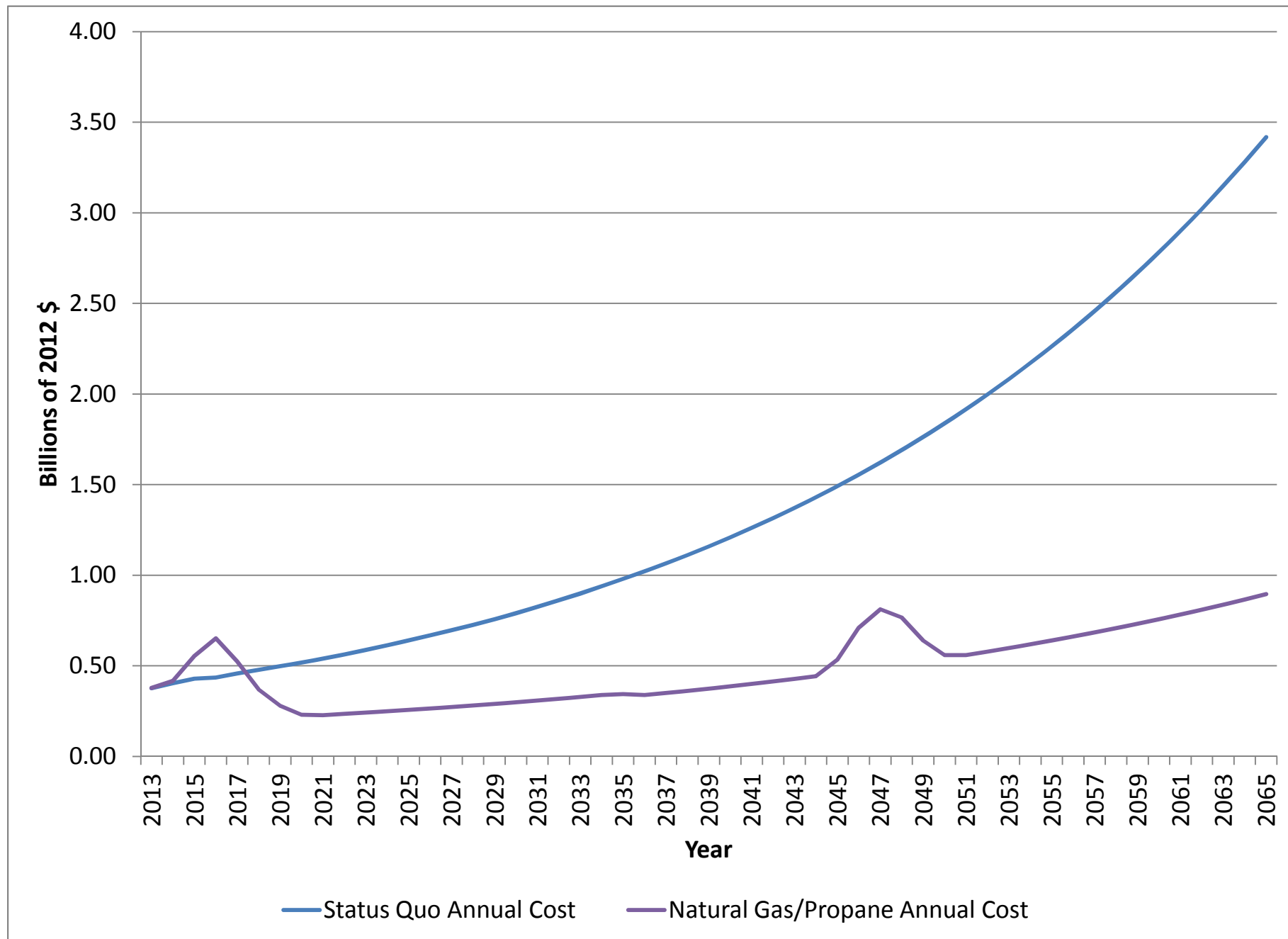
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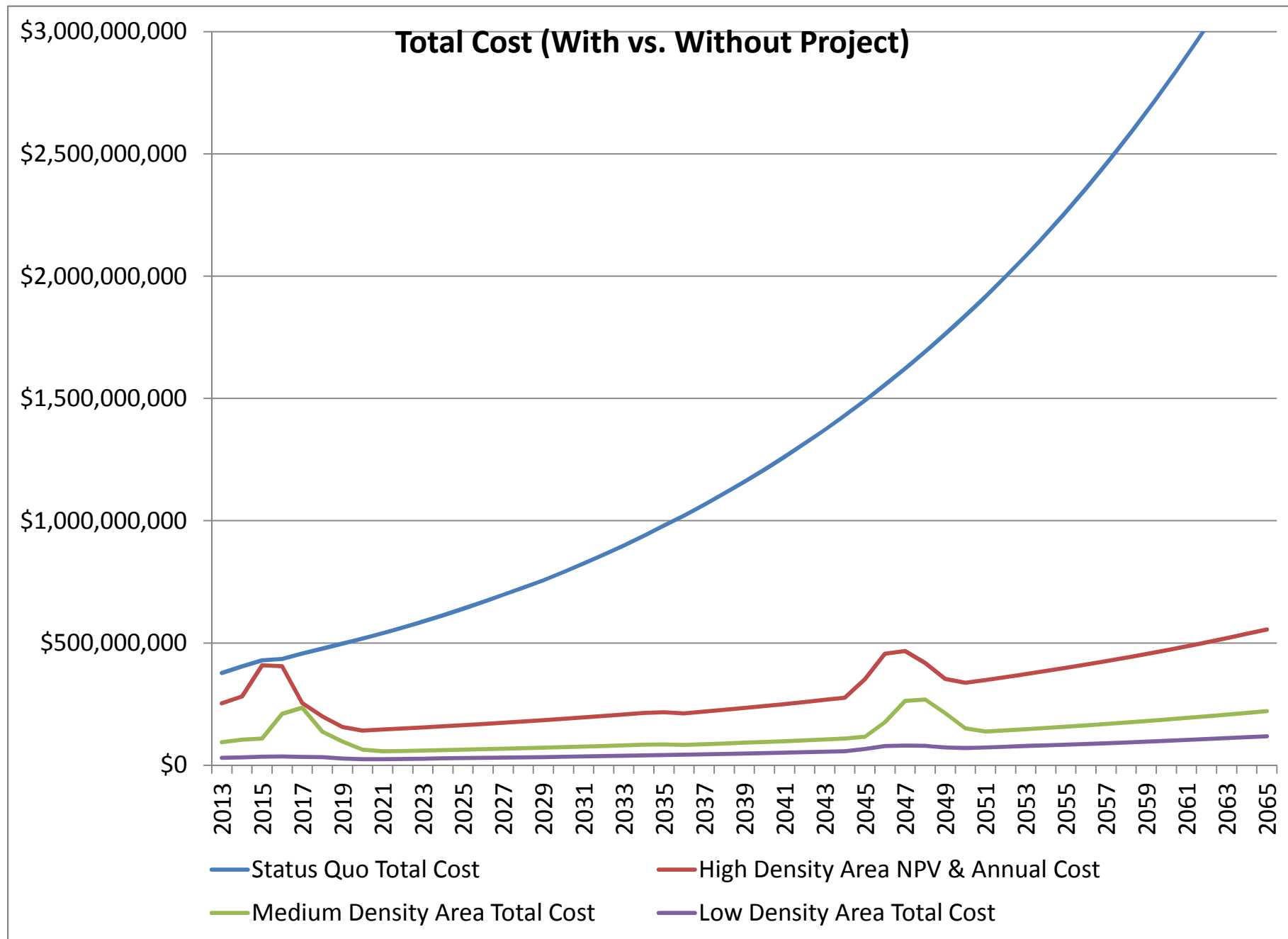
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Net Income

Fuel Costs (With Project in High Density Area)

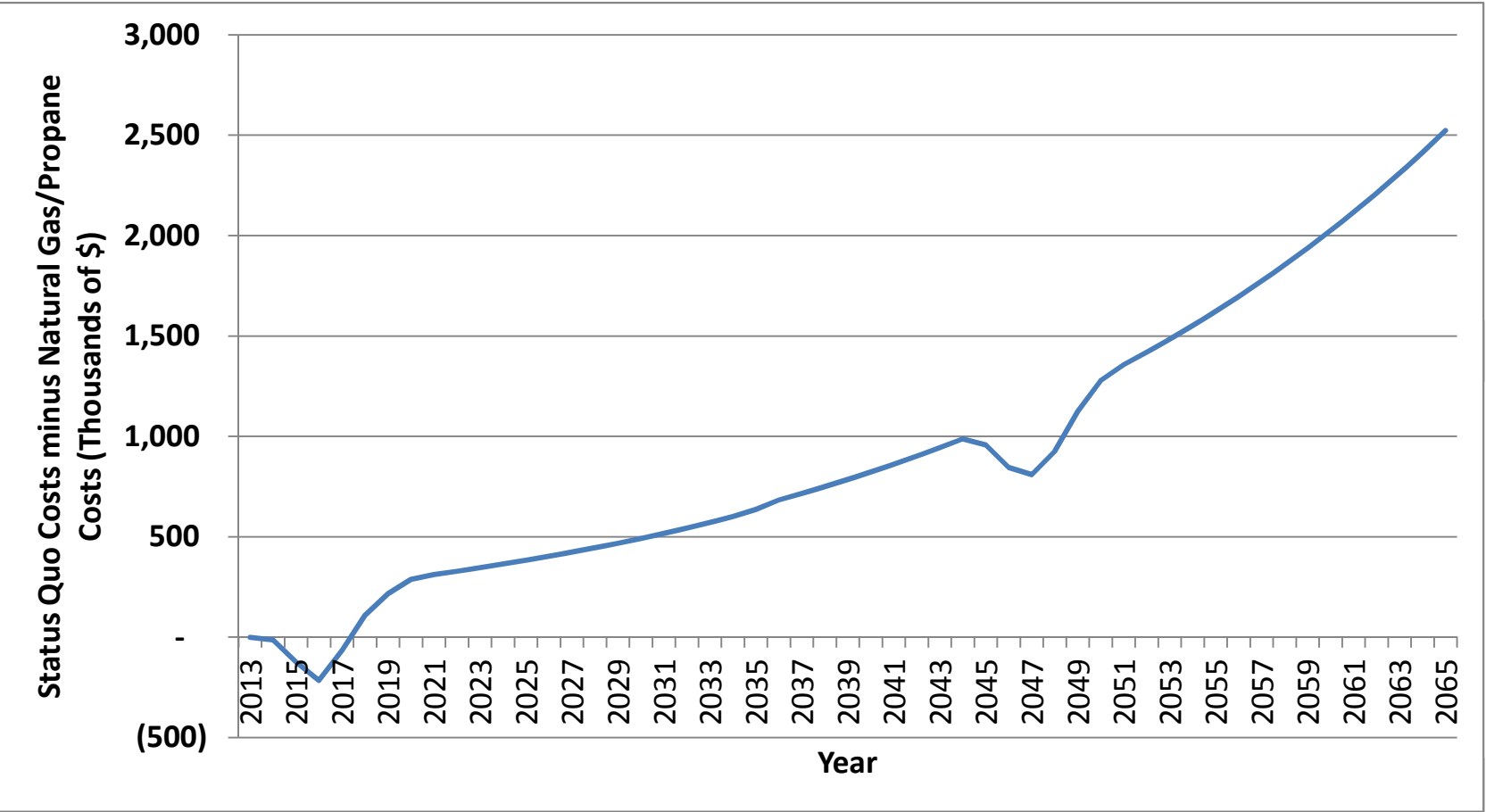






This is now Table ES-6 and Table 19 in the BCA section

Alternative	Net Present Value		
Status Quo	\$10,617,526,597		
High Density Area	\$7,103,631,156		
Medium Density Area	\$2,654,941,565		
Low Density Area	\$858,953,877		
		Cost Savings	Benefit-Cost Ratio
With Natural Gas/Propane Conversion	\$5,411,907,612	\$5,205,618,986	1.96
High Density Area	\$3,384,770,287	\$3,718,860,869	2.10
Medium Density Area	\$1,500,114,595	\$1,154,826,969	1.77
Low Density Area	\$527,022,730	\$331,931,147	1.63
	\$10.62		
	\$7.10		
	\$2.65		
	\$0.86		
	\$5.41	\$5.21	1.96
	\$3.38	\$3.72	2.10
	\$1.50	\$1.15	1.77
	\$0.53	\$0.33	1.63



Total Energy Supply, Disposition, and Price Summary, Reference case
(quadrillion Btu, unless otherwise noted)

Supply, Disposition, and Prices	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production																							
Crude Oil and Lease Condensate	10.51	11.34	11.87	11.76	11.58	12.02	12.4	12.51	12.82	13.07	13.12	13.17	13.07	13.05	13.09	12.97	12.78	12.64	12.5	12.44	12.53	12.48	12.49
Natural Gas Plant Liquids	2.41	2.57	2.64	2.63	2.76	2.81	2.83	2.86	2.86	2.89	2.94	2.99	3.06	3.15	3.28	3.43	3.52	3.55	3.57	3.61	3.65	3.67	3.71
Dry Natural Gas	20.83	21.5	21.83	21.61	21.83	22.3	22.59	23.01	23.06	23.24	23.51	23.8	24.04	24.15	24.32	24.47	24.48	24.6	24.7	24.92	25.21	25.47	25.75
Coal 1/	23.85	21.58	22.59	21.75	21.39	21.13	20.8	20.94	21.15	21.3	21.42	21.61	22.05	22.21	22.55	22.95	23.5	23.64	23.95	24.05	24.4	24.53	24.77
Nuclear Power	8.43	8.35	8.39	8.4	8.5	8.64	8.7	8.77	8.79	8.9	9.01	9.12	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17
Hydropower	2.53	2.69	2.4	2.58	2.66	2.74	2.84	2.92	2.99	2.99	2.99	3	3	3.01	3.01	3.01	3.01	3.04	3.04	3.05	3.06	3.06	3.07
Biomass 2/	3.94	3.52	3.83	4.23	4.32	4.53	4.56	4.7	4.84	4.99	5.19	5.43	5.77	5.94	6.17	6.48	6.9	7.2	7.45	7.65	7.8	8.03	8.15
Other Renewable Energy 3/	1.12	1.29	1.54	1.72	2.05	2.08	2.09	2.14	2.14	2.16	2.19	2.24	2.3	2.33	2.36	2.4	2.49	2.58	2.68	2.74	2.82	2.92	2.97
Other 4/	0.19	0.34	0.55	0.93	0.65	0.68	0.7	0.78	0.86	0.94	0.96	0.96	0.96	0.97	0.97	0.96	0.94	0.88	0.82	0.78	0.78	0.78	0.81
Total	73.8	73.18	75.64	75.6	75.74	76.92	77.51	78.63	79.51	80.49	81.33	82.31	83.42	83.97	84.92	85.85	86.78	87.29	87.88	88.41	89.41	90.11	90.88
Imports																							
Crude Oil	21.39	19.7	20.19	20.16	19.79	19.71	19.37	19.25	18.97	18.68	18.54	18.44	18.46	18.57	18.31	18.25	18.26	18.35	18.44	18.41	18.32	18.28	18.3
Liquid Fuels 5/	6.32	5.4	4.53	4.72	5.21	5.35	5.34	5.33	5.38	5.36	5.36	5.35	5.34	5.24	5.24	5.19	5.16	5.18	5.2	5.21	5.2	5.2	5.26
Natural Gas	4.08	3.82	3.89	3.92	3.92	4.01	4.04	4.01	4.04	4.06	4.04	3.96	3.8	3.61	3.45	3.34	3.27	3.2	3.15	3.12	3.05	3.06	3.07
Other Imports 6/	0.96	0.61	0.55	0.68	0.82	0.86	0.86	0.82	0.81	0.8	0.9	0.94	0.98	1.27	1.29	1.34	1.3	1.39	1.38	1.51	1.38	1.39	1.3
Total	32.76	29.53	29.16	29.48	29.74	29.93	29.61	29.41	29.2	28.9	28.84	28.69	28.57	28.69	28.3	28.12	27.98	28.13	28.18	28.26	27.95	27.94	27.93
Exports																							
Petroleum 7/	3.78	4.17	4.25	4.24	3.27	3.25	3.23	3.27	3.34	3.4	3.45	3.52	3.54	3.57	3.55	3.57	3.59	3.62	3.64	3.65	3.68	3.7	3.75
Natural Gas	1.01	1.09	1.06	1.08	1.19	1.21	1.25	1.24	1.32	1.43	1.53	1.65	1.82	1.94	2.01	2.05	2.05	2.07	2.11	2.16	2.19	2.24	2.24
Coal	2.07	1.51	1.93	1.88	1.86	1.87	1.78	1.76	1.71	1.75	1.81	1.86	1.92	1.85	1.86	1.87	1.88	1.89	1.89	1.89	1.89	1.89	1.86
Total	6.86	6.77	7.23	7.19	6.33	6.32	6.26	6.27	6.37	6.58	6.79	7.04	7.28	7.36	7.42	7.49	7.52	7.58	7.64	7.7	7.76	7.82	7.85
Discrepancy 8/	-0.44	1.16	-0.2	-0.4	-0.3	-0.25	-0.24	-0.24	-0.25	-0.26	-0.22	-0.21	-0.21	-0.18	-0.17	-0.14	-0.12	-0.12	-0.12	-0.11	-0.11	-0.09	-0.07
Consumption																							
Liquid Fuels 9/	38.46	36.62	36.96	37.41	38.23	38.81	38.92	39.1	39.25	39.32	39.31	39.31	39.38	39.51	39.59	39.67	39.73	39.84	39.94	40.04	40.18	40.31	40.55
Natural Gas	23.85	23.31	24.45	24.49	24.54	25.08	25.37	25.77	25.76	25.86	26.01	26.1	26	25.8	25.75	25.75	25.68	25.73	25.73	25.88	26.07	26.29	26.58
Coal 10/	22.38	19.69	21.05	20.41	20.19	19.96	19.71	19.73	19.97	20.07	20.22	20.41	20.85	21.32	21.61	21.98	22.44	22.61	22.88	23.04	23.2	23.28	23.39
Nuclear Power	8.43	8.35	8.39	8.4	8.5	8.64	8.7	8.77	8.79	8.9	9.01	9.12	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17
Hydropower	2.53	2.69	2.4	2.58	2.66	2.74	2.84	2.92	2.99	2.99	2.99	3	3	3.01	3.01	3.01	3.01	3.04	3.04	3.05	3.06	3.06	3.07
Biomass 11/	3.07	2.52	2.66	2.98	2.98	3.15	3.15	3.27	3.37	3.45	3.58	3.71	3.93	4.05	4.18	4.35	4.55	4.71	4.83	4.89	4.94	5.02	5.05
Other Renewable Energy 3/	1.12	1.29	1.54	1.72	2.05	2.08	2.09	2.14	2.14	2.16	2.19	2.24	2.3	2.33	2.36	2.4	2.49	2.58	2.68	2.74	2.82	2.92	2.97
Other 12/	0.31	0.32	0.32	0.3	0.31	0.31	0.31	0.31	0.31	0.31	0.3	0.3	0.29	0.3	0.3	0.29	0.28	0.27	0.27	0.27	0.27	0.26	0.24
Total	100.14	94.79	97.77	98.29	99.46	100.77	101.1	102.02	102.59	103.08	103.61	104.17	104.92	105.49	105.97	106.62	107.37	107.95	108.53	109.07	109.71	110.31	111.03
Prices (2009 dollars per unit)																							
Low Sulfur Light Price (\$ per barrel) 13/	100.51	61.66	78.03	83.21	85.73	88.03	91.38	94.58	97.62	100.5	103.15	105.71	108.1	110.3	112.36	114.21	115.96	117.54	118.99	120.25	121.34	122.3	123.09
Imported Crude Oil Price (\$ per barrel) 13/	93.44	59.04	74.86	80.32	80.65	82.87	85.07	86.83	88.96	91.56	94.04	96.42	98.65	100.74	102.49	104.25	105.88	107.4	108.8	109.98	110.93	111.74	112.38
Gas Price at Henry Hub (\$ / MMBtu)	8.94	3.95	4.43	4.48	4.5	4.56	4.57	4.66	4.74	4.76	4.81	4.87	5.05	5.24	5.39	5.58	5.8	5.97	6.1	6.24	6.31	6.35	6.4
Gas Wellhead Price (\$ / MMBtu) 14/	7.96	3.62	3.98	3.99	3.98	4.04	4.05	4.13	4.2	4.22	4.26	4.31	4.47	4.64	4.77	4.94	5.13	5.29	5.4	5.52	5.59	5.62	5.66
Gas Wellhead Price (\$ / Mcf) 14/	8.18	3.71	4.08	4.09	4.09	4.15	4.16	4.24	4.31	4.33	4.37	4.43	4.59	4.76	4.9	5.07	5.27	5.43	5.54	5.67	5.73	5.77	5.81
Coal Mine mouth Price (\$ / ton) 15/	31.54	33.26	36.64	35.37	33.72	33.31	32.71	32.36	32.36	32.55	32.42	32.44	32.85	32.6	32.7	32.77	33.13	33.22	33.5	33.32	33.1	33.17	33.25
Coal Delivered Price (\$ / million Btu) 16/	2.18	2.31	2.4	2.37	2.31	2.28	2.25	2.26	2.28	2.29	2.29	2.29	2.3	2.31	2.33	2.34	2.35	2.36	2.37	2.38	2.39	2.41	2.42
Electricity (cents per kilowatt-hour)	9.8	9.8	9.6	9	9	8.9	8.9	8.9	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.9	8.9	8.9	8.9	9	9	9	9

Prices (nominal dollars per unit)																							
Low Sulfur Light Price (\$ per barrel) 13/	99.57	61.66	78.71	85.05	88.61	92.52	97.79	103.24	108.69	114.2	119.68	125.15	130.6	135.82	140.88	145.74	150.68	155.46	160.21	164.96	169.57	174.16	178.45
Imported Crude Oil Price (\$ per barrel) 13/	92.57	59.04	75.52	82.1	83.37	87.1	91.03	94.78	99.05	104.05	109.12	114.16	119.18	124.05	128.51	133.04	137.59	142.05	146.49	150.86	155.02	159.12	162.92
Gas Price at Henry Hub (\$ / MMBtu)	8.86	3.95	4.47	4.58	4.65	4.79	4.89	5.09	5.27	5.41	5.58	5.77	6.1	6.45	6.76	7.12	7.53	7.9	8.21	8.56	8.82	9.04	9.28
Gas Wellhead Price (\$ / MMBtu) 14/	7.89	3.62	4.01	4.08	4.12	4.25	4.33	4.51	4.67	4.79	4.94	5.11	5.4	5.71	5.99	6.3	6.67	6.99	7.27	7.58	7.81	8	8.21
Gas Wellhead Price (\$ / Mcf) 14/	8.1	3.71	4.12	4.19	4.23	4.36	4.45	4.63	4.79	4.92	5.07	5.24	5.55	5.86	6.14	6.46	6.84	7.18	7.46	7.77	8.01	8.21	8.43
Coal Mine mouth Price (\$ / ton) 15/	31.25	33.26	36.96	36.15	34.86	35.01	35	35.32	36.03	36.99	37.61	38.41	39.69	40.14	41.01	41.82	43.06	43.93	45.11	45.7	46.26	47.24	48.21
Coal Delivered Price (\$ / million Btu) 16/	2.16	2.31	2.42	2.42	2.39	2.4	2.41	2.47	2.54	2.6	2.65	2.71	2.78	2.85	2.92	2.98	3.06	3.12	3.19	3.26	3.34	3.43	3.5
Electricity (cents per kilowatt-hour)	9.7	9.8	9.7	9.2	9.3	9.4	9.5	9.7	9.8	10	10.2	10.4	10.7	10.9	11.1	11.3	11.5	11.8	12	12.3	12.5	12.8	13

1/ Includes waste coal.

2/ Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table 17 for details.

3/ Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table 17 for selected nonmarketed residential and commercial renewable energy.

4/ Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.

5/ Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.

6/ Includes coal, coal coke (net), and electricity (net).

7/ Includes crude oil and petroleum products.

8/ Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.

9/ Includes petroleum-derived fuels and non-petroleum-derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are natural gas plant liquids and crude oil consumed as a fuel. Refer to Table 17 for detailed renewable liquid fuels consumption.

10/ Excludes coal converted to coal-based synthetic liquids and natural gas.

11/ Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.

12/ Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.

13/ Weighted average price delivered to U.S. refiners.

14/ Represents lower 48 onshore and offshore supplies.

15/ Includes reported prices for both open market and captive mines.

16/ Prices weighted by consumption; weighted average excludes residential and commercial prices, and export free-alongside-ship (f.a.s.) prices.

Btu = British thermal unit.

Mcf = Thousand cubic feet.

- - = Not applicable.

Note: Totals may not equal sum of components due to independent rounding. Data for 2008 and 2009 are model results and may differ slightly from official EIA data reports.

Sources: 2008 natural gas supply values: U.S. Energy Information Administration (EIA), Natural Gas Annual 2008, DOE/EIA-0131(2008) (Washington, DC, March 2010).

2009 natural gas supply values and natural gas wellhead price: EIA, Natural Gas Monthly, DOE/EIA-0130(2010/07) (Washington, DC, July 2010).

2008 natural gas wellhead price: Bureau of Energy Management, Regulation and Enforcement; and EIA, Natural Gas Annual 2008, DOE/EIA-0131(2008) (Washington, DC, March 2010).

2008 and 2009 coal mine mouth and delivered coal prices: EIA, Annual Coal Report 2009, DOE/EIA-0584(2009) (Washington, DC, October 2010).

2009 petroleum supply values and 2008 crude oil and lease condensate production: EIA, Petroleum Supply Annual 2009, DOE/EIA-0340(2009)/1 (Washington, DC, July 2010).

Other 2008 petroleum supply values: EIA, Petroleum Supply Annual 2008, DOE/EIA-0340(2008)/1 (Washington, DC, June 2009).
2008 and 2009 low sulfur light crude oil price: EIA, Form EIA-856, Monthly Foreign Crude Oil Acquisition"
Report. Other 2008 and 2009 coal values: EIA
Other 2008 and 2009 values: EIA, Annual Energy Review 2009, DOE/EIA-0384(2009) (Washington, DC, August 2010).
Projections: EIA, AEO2011 National Energy Modeling System.

2031	2032	2033	2034	2035	Growth Rate (2009-2035)
12.63	12.91	13.01	13.04	12.8	0.50%
3.75	3.78	3.82	3.86	3.92	1.60%
26.02	26.22	26.42	26.67	27	0.90%
24.96	25.21	25.45	25.72	26.01	0.70%
9.17	9.16	9.16	9.15	9.14	0.30%
3.07	3.08	3.08	3.09	3.09	0.50%
8.39	8.47	8.54	8.61	8.63	3.50%
3.02	3.08	3.11	3.16	3.22	3.60%
0.8	0.79	0.79	0.78	0.78	3.20%
91.8	92.71	93.39	94.09	94.59	1.00%
18.19	18.02	17.99	18.07	18.44	-0.30%
5.28	5.3	5.34	5.34	5.33	-0.10%
3.07	3.06	3.02	2.95	2.87	-1.10%
1.33	1.36	1.31	1.29	1.27	2.90%
27.88	27.73	27.67	27.65	27.92	-0.20%
3.79	3.84	3.87	3.89	3.92	-0.20%
2.3	2.36	2.45	2.53	2.64	3.50%
1.87	1.87	1.82	1.78	1.78	0.60%
7.96	8.07	8.14	8.2	8.34	0.80%
-0.06	-0.05	-0.03	-0.03	-0.02 - -	
40.81	41.02	41.25	41.47	41.7	0.50%
26.79	26.92	27	27.09	27.24	0.60%
23.53	23.72	23.89	24.1	24.3	0.80%
9.17	9.16	9.16	9.15	9.14	0.30%
3.07	3.08	3.08	3.09	3.09	0.50%
5.15	5.19	5.21	5.25	5.25	2.90%
3.02	3.08	3.11	3.16	3.22	3.60%
0.25	0.26	0.25	0.25	0.25	-0.90%
111.78	112.42	112.95	113.56	114.19	0.70%
123.71	124.2	124.53	124.68	124.94	2.80%
112.8	113.02	113.26	113.43	113.7	2.60%
6.49	6.62	6.74	6.87	7.07	2.30%
5.75	5.86	5.96	6.09	6.26	2.10%
5.9	6.01	6.12	6.24	6.42	2.10%
33.39	33.66	33.73	33.81	33.92	0.10%
2.43	2.45	2.45	2.47	2.47	0.30%
9	9	9.1	9.1	9.2	-0.20%

182.68	186.95	191.1	195.08	199.37	4.60%
166.57	170.12	173.8	177.48	181.43	4.40%
9.59	9.96	10.34	10.76	11.28	4.10%
8.49	8.82	9.15	9.52	9.99	4.00%
8.71	9.05	9.39	9.77	10.24	4.00%
49.31	50.67	51.76	52.91	54.13	1.90%
3.59	3.68	3.76	3.86	3.95	2.10%
13.3	13.6	13.9	14.3	14.7	1.60%

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.987567
R Square	0.975289
Adjusted R	0.97117
Standard E	0.114164
Observation	8

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	3.086413	3.086413	236.8057	4.76E-06
Residual	6	0.078201	0.013034		
Total	7	3.164614			

	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.522835	0.157212	3.325661	0.015892	0.13815	0.907519	0.13815	0.907519
Crude per (1.385286	0.090021	15.38849	4.76E-06	1.165013	1.60556	1.165013	1.60556

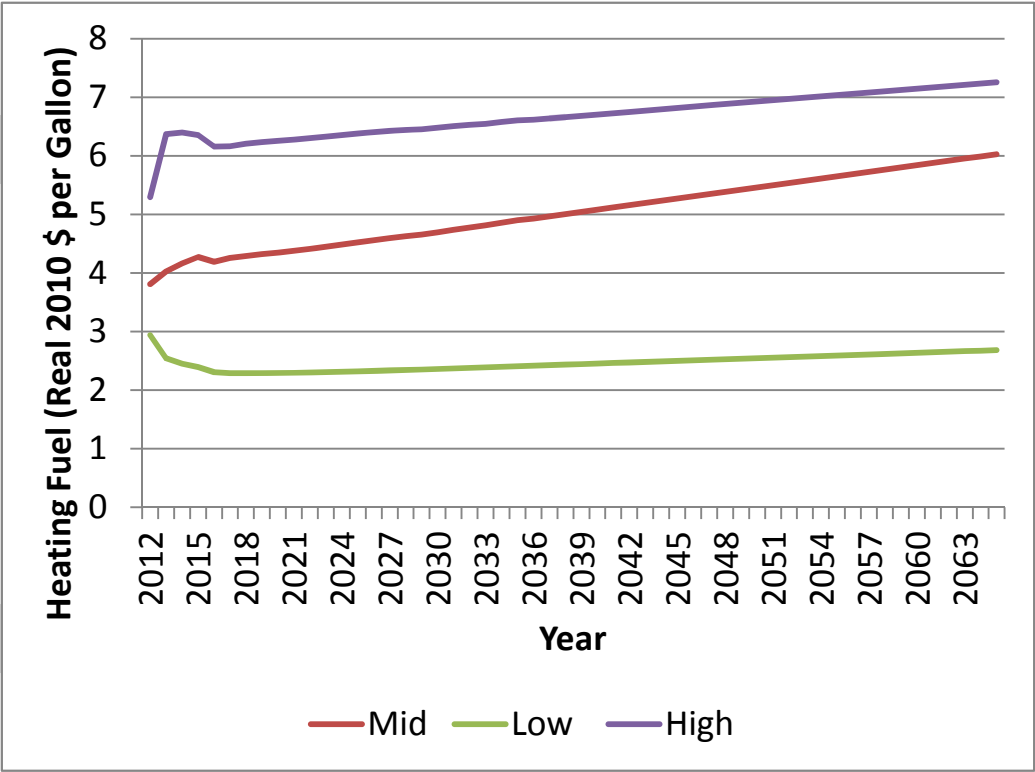
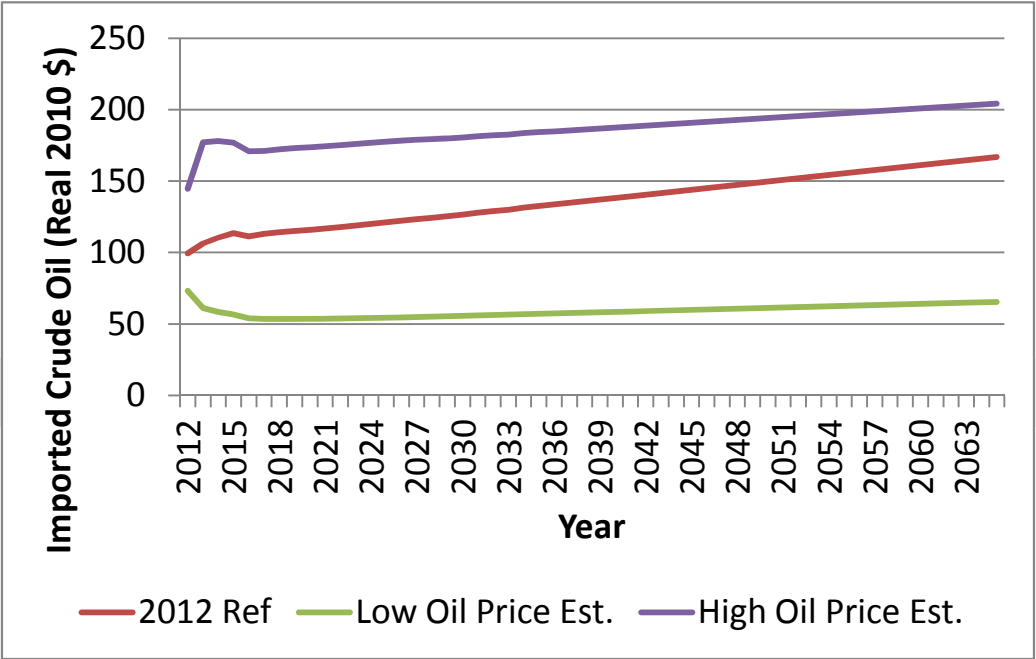
					10.03											
					2011						2010 \$			Nominal \$		
Imported crude oil prices (Sept)					Imported Crude Oil			102.50			2012 Ref			Low Oil Price		
Nominal \$	#1 Fuel Oil	Per Barrel	Per Gallon	42	Year	Reference	Low Oil	High Oil	Year	2012 Ref	Low Oil Price	High Oil Pri	Mid Escala	75% of Esc	Mid	Low
Year																High
																Year
1986	0.778	12.85	0.306		2012	95.18	52.47	120.24	2012	100	73	145			104.58	77
1987	0.918	18.57	0.442		2013	103.34	50.98	128.22	2013	106	61	177	9.4%	7.1%	114.45	66
1988	0.088	13.84	0.330		2014	110.43	49.73	133.73	2014	110	58	178	6.5%	4.9%	121.90	64
1989	0.957	17.62	0.420		2015	116.55	48.46	136.84	2015	114	57	177	5.4%	4.1%	128.55	64
1990	1.179	29.88	0.711		2016	119.58	45.71	143.76	2016	111	54	171	0.4%	0.3%	129.01	63
1991	0.927	19	0.452		2017	122.78	45.07	148.35	2017	113	54	171	4.3%	3.2%	134.55	64
1992	0.975	19.26	0.459		2018	124.03	44.46	152.74	2018	114	54	172	3.5%	2.6%	139.20	65
1993	0.999	15.32	0.365		2019	125.30	43.94	156.77	2019	115	54	173	3.3%	2.5%	143.79	67
1994	0.961	15.91	0.379		2020	126.58	43.35	160.6	2020	116	54	174	3.2%	2.4%	148.43	69
1995	0.955	16.71	0.398		2021	127.74	42.87	164.21	2021	117	54	174	3.2%	2.4%	153.23	70
1996	10.88	22.04	0.525		2022	128.97	42.38	167.46	2022	118	54	175	3.5%	2.6%	158.53	72
1997	1.087	17.85	0.425		2023	130.15	42.01	170.75	2023	119	54	176	3.5%	2.6%	164.08	75
1998	0.964	12.77	0.304		2024	131.33	41.63	172.29	2024	120	54	177	3.5%	2.6%	169.74	77
1999	1.075	21.64	0.515		2025	132.50	41.36	175.09	2025	121	54	178	3.4%	2.6%	175.58	79
2000	1.372	30.56	0.728		2026	133.67	41.17	177.62	2026	122	55	178	3.4%	2.6%	181.57	81
2001	1.343	22.51	0.536		2027	134.85	40.82	180.31	2027	123	55	179	3.4%	2.6%	187.84	84
2002	1.212	27.14	0.646		2028	135.97	40.61	182.31	2028	124	55	179	3.3%	2.5%	193.98	86
2003	1.273	25.66	0.611		2029	137.18	40.43	184.01	2029	125	55	180	3.3%	2.5%	200.39	88
2004	1.824	40.42	0.962		2030	138.51	40.15	185.03	2030	127	56	181	3.4%	2.6%	207.29	91
2005	2.544	58.79	1.400		2031	139.79	40.02	186.33	2031	128	56	182	3.6%	2.7%	214.73	94
2006	2.494	57.29	1.364		2032	141.02	39.82	187.34	2032	129	56	182	3.4%	2.6%	222.08	97
2007	2.683	72.34	1.722		2033	142.13	39.74	187.84	2033	130	56	183	3.3%	2.5%	229.42	100
2008	3.67	96.38	2.295		2034	143.41	39.67	188.17	2034	131	57	184	3.6%	2.7%	237.68	103
2009	2.731	67.65	1.611		2035	144.56	39.66	187.79	2035	133	57	184	3.5%	2.6%	245.99	106
2010	3.02	73.2	1.743		2036				2036	134	57	185	3.2%	2.4%	253.90	108
2011	3.922	101.05	2.406		2037				2037	135	58	185	3.4%	2.5%	262.49	111
					2038				2038	136	58	186	3.4%	2.5%	271.35	114
					2039				2039	137	58	187	3.4%	2.5%	280.48	116
					2040				2040	138	58	187	3.4%	2.5%	289.90	119
					2041				2041	139	59	188	3.4%	2.5%	299.62	122
					2042				2042	141	59	189	3.3%	2.5%	309.64	125
					2043				2043	142	59	189	3.3%	2.5%	319.98	127
					2044				2044	143	60	190	3.3%	2.5%	330.64	130
					2045				2045	144	60	191	3.3%	2.5%	341.63	133
					2046				2046	145	60	191	3.3%	2.5%	352.97	136
					2047				2047	146	60	192	3.3%	2.5%	364.66	138
					2048				2048	147	61	193	3.3%	2.5%	376.71	141
					2049				2049	149	61	193	3.3%	2.5%	389.14	144
					2050				2050	150	61	194	3.3%	2.5%	401.95	147
					2051				2051	151	62	195	3.3%	2.5%	415.16	150
					2052				2052	152	62	195	3.3%	2.5%	428.78	152
					2053				2053	153	62	196	3.3%	2.5%	442.82	155
					2054				2054	154	62	197	3.3%	2.5%	457.30	158
					2055				2055	155	63	198	3.3%	2.4%	472.22	161
					2056				2056	157	63	198	3.3%	2.4%	487.61	163
					2057				2057	158	63	199	3.3%	2.4%	503.46	166
					2058				2058	159	64	200	3.2%	2.4%	519.81	169
					2059				2059	160	64	200	3.2%	2.4%	536.66	172
					2060				2060	161	64	201	3.2%	2.4%	554.02	174
					2061				2061	162	64	202	3.2%	2.4%	571.92	177

*Fuel oil prices are as of September of each year.

2062	2062	163	65	202	3.2%	2.4%	590.37	180	571	2062
2063	2063	165	65	203	3.2%	2.4%	609.38	183	579	2063
2064	2064	166	65	204	3.2%	2.4%	628.98	185	588	2064
2065	2065	167	65	204	3.2%	2.4%	649.17	188	596	2065

2010 Real \$ Uses data for years 2003 - 2011 for regression equation
Regression: 0.522835 +1.385286*(Crude Price/42)
1.385286

Fairbanks Heating Fuel Estimate			
Mid	Low	High	
	3.81	2.94	5.30
	4.03	2.54	6.37
	4.17	2.45	6.40
	4.27	2.39	6.36
	4.19	2.30	6.16
	4.26	2.29	6.16
	4.29	2.29	6.21
	4.32	2.29	6.23
	4.35	2.29	6.25
4.374819132	2.29	6.27	
	4.41	2.30	6.30
	4.45	2.31	6.33
	4.49	2.31	6.36
	4.52	2.32	6.38
	4.56	2.33	6.40
	4.59	2.34	6.43
	4.63	2.34	6.44
	4.66	2.35	6.46
	4.70	2.36	6.48
	4.74	2.37	6.51
	4.78	2.38	6.53
	4.81	2.39	6.55
	4.86	2.40	6.58
	4.90	2.41	6.60
	4.93	2.42	6.62
	4.97	2.42	6.64
	5.01	2.43	6.66
	5.04	2.44	6.68
	5.08	2.45	6.71
	5.12	2.46	6.73
	5.16	2.47	6.75
	5.20	2.48	6.77
	5.23	2.49	6.79
	5.27	2.50	6.82
	5.31	2.51	6.84
	5.35	2.52	6.86
	5.38	2.53	6.88
	5.42	2.53	6.90
	5.46	2.54	6.93
	5.50	2.55	6.95
	5.54	2.56	6.97
	5.57	2.57	6.99
	5.61	2.58	7.01
	5.65	2.59	7.04
	5.69	2.60	7.06
	5.73	2.61	7.08
	5.76	2.62	7.10
	5.80	2.63	7.13
	5.84	2.64	7.15
	5.88	2.65	7.17



Nominal \$
2.50% assumed inflation rate

2011 Year		Fairbanks Heating Fuel Estimate			
		Mid	Low	High	
2012	2012	4.00	3.09	5.56	
2013	2013	4.34	2.73	6.86	
2014	2014	4.60	2.70	7.06	
2015	2015	4.83	2.71	7.19	
2016	2016	4.86	2.67	7.14	
2017	2017	5.06	2.72	7.33	
2018	2018	5.23	2.79	7.56	
2019	2019	5.40	2.86	7.78	
2020	2020	5.57	2.93	8.01	
2021	2021	5.74	3.01	8.23	
2022	2022	5.93	3.09	8.47	
2023	2023	6.13	3.18	8.73	
2024	2024	6.34	3.27	8.98	
2025	2025	6.55	3.36	9.24	
2026	2026	6.76	3.45	9.51	
2027	2027	6.99	3.55	9.78	
2028	2028	7.21	3.65	10.05	
2029	2029	7.45	3.75	10.32	
2030	2030	7.69	3.86	10.62	
2031	2031	7.96	3.98	10.93	
2032	2032	8.23	4.09	11.24	
2033	2033	8.49	4.21	11.55	
2034	2034	8.79	4.34	11.90	
2035	2035	9.08	4.47	12.24	
2036	2036	9.37	4.59	12.58	
2037	2037	9.68	4.72	12.93	
2038	2038	9.99	4.86	13.30	
2039	2039	10.32	5.00	13.68	
2040	2040	10.66	5.14	14.07	
2041	2041	11.01	5.29	14.47	
2042	2042	11.37	5.44	14.88	
2043	2043	11.73	5.60	15.30	
2044	2044	12.12	5.76	15.73	
2045	2045	12.51	5.93	16.18	
2046	2046	12.91	6.10	16.64	
2047	2047	13.33	6.27	17.11	
2048	2048	13.76	6.45	17.59	
2049	2049	14.20	6.64	18.09	
2050	2050	14.66	6.83	18.60	
2051	2051	15.13	7.03	19.12	
2052	2052	15.62	7.23	19.66	
2053	2053	16.12	7.44	20.22	
2054	2054	16.63	7.65	20.79	
2055	2055	17.16	7.87	21.38	
2056	2056	17.71	8.09	21.98	
2057	2057	18.27	8.32	22.60	
2058	2058	18.86	8.56	23.24	
2059	2059	19.45	8.81	23.89	
2060	2060	20.07	9.06	24.57	
2061	2061	20.71	9.32	25.26	

2012 Real \$

Fairbanks Natural Gas Estimates			
Mid	Low	High	
	4.69	3.00	6.37
	4.79	3.03	6.56
	4.87	3.03	6.71
	5.05	3.09	7.00
	5.18	3.13	7.22
	5.27	3.13	7.40
	5.42	3.18	7.65
	5.60	3.22	7.99
	5.89	3.28	8.50
	6.20	3.38	9.03
	6.53	3.46	9.60
	6.88	3.58	10.18
	7.18	3.69	10.68
	7.42	3.79	11.05
	7.60	3.87	11.32
	7.81	3.96	11.66
	8.05	4.06	12.05
	8.32	4.13	12.51
	8.60	4.17	13.04
	8.85	4.21	13.50
	9.13	4.26	14.00
	9.46	4.33	14.60
	9.76	4.39	15.13
	10.05	4.48	15.63
	10.28	4.53	16.03
	10.56	4.59	16.52
	10.83	4.65	17.01
	11.11	4.72	17.50
	11.38	4.78	17.99
	11.66	4.84	18.48
	11.94	4.91	18.97
	12.21	4.97	19.46
	12.49	5.03	19.95
	12.76	5.09	20.43
	13.04	5.16	20.92
	13.32	5.22	21.41
	13.59	5.28	21.90
	13.87	5.34	22.39
	14.14	5.41	22.88
	14.42	5.47	23.37
	14.69	5.53	23.86
	14.97	5.59	24.35
	15.25	5.66	24.84
	15.52	5.72	25.32
	15.80	5.78	25.81
	16.07	5.84	26.30
	16.35	5.91	26.79
	16.63	5.97	27.28
	16.90	6.03	27.77
	17.18	6.10	28.26

5.92	2.65	7.19
5.95	2.66	7.21
5.99	2.67	7.24
6.03	2.68	7.26

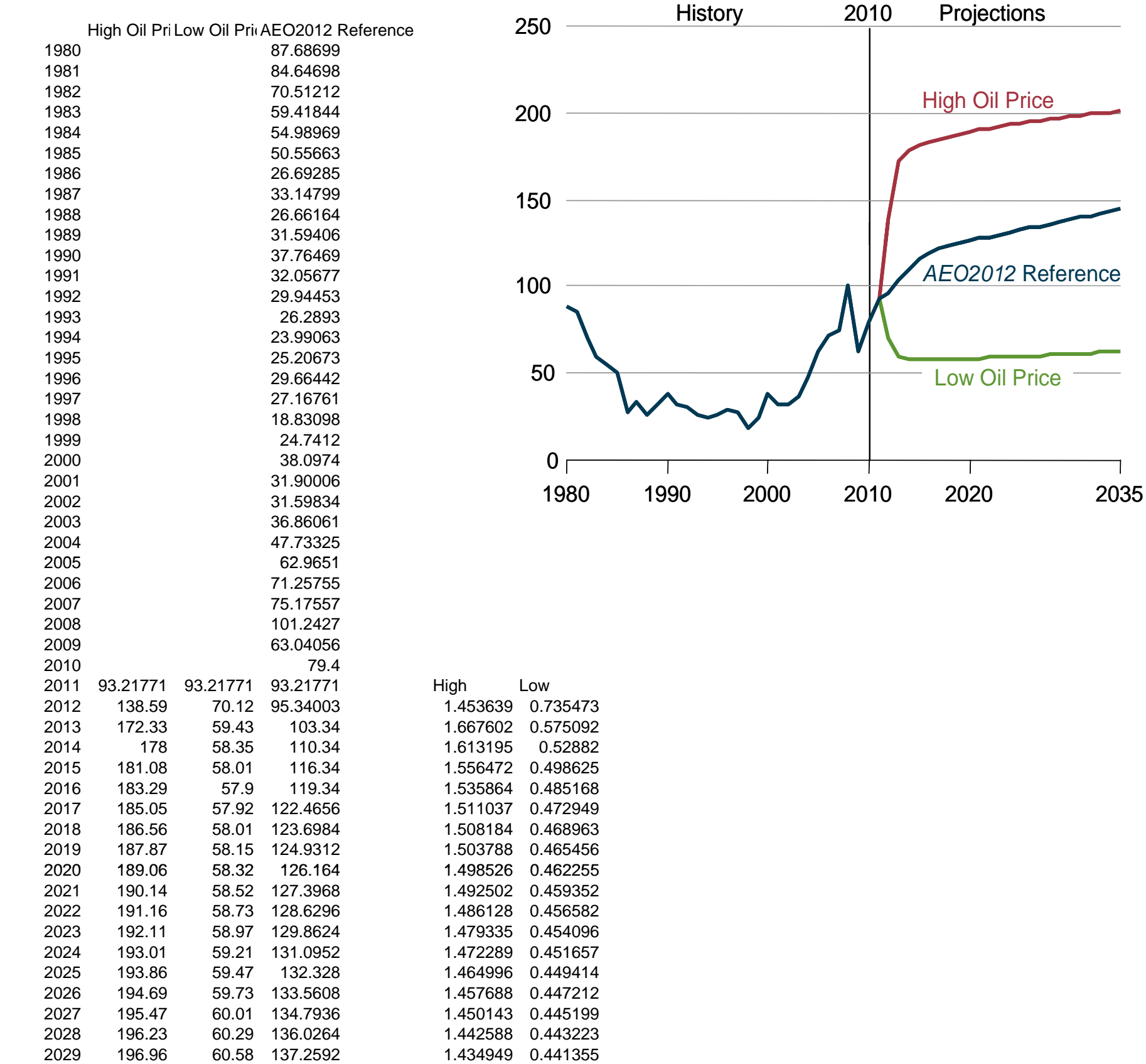
2062	2062	21.36	9.58	25.97	17.45	6.16	28.75
2063	2063	22.03	9.86	26.70	17.73	6.22	29.24
2064	2064	22.73	10.14	27.45	18.00	6.28	29.73
2065	2065	23.44	10.43	28.22	18.28	6.35	30.22

Nominal \$
2.50% assumed inflation rate

Fairbanks Natural Gas Estimates			
Mid	Low	High	
4.92	3.15	6.69	
5.16	3.26	7.06	
5.37	3.34	7.40	
5.71	3.50	7.92	
6.00	3.64	8.37	
6.26	3.73	8.79	
6.60	3.88	9.32	
7.00	4.02	9.98	
7.54	4.20	10.88	
8.14	4.43	11.85	
8.78	4.66	12.90	
9.48	4.93	14.03	
10.15	5.21	15.08	
10.75	5.48	16.01	
11.28	5.74	16.81	
11.88	6.02	17.74	
12.56	6.33	18.80	
13.30	6.60	20.00	
14.10	6.83	21.36	
14.87	7.07	22.67	
15.71	7.33	24.09	
16.70	7.63	25.77	
17.65	7.94	27.36	
18.64	8.31	28.97	
19.54	8.61	30.47	
20.56	8.94	32.18	
21.63	9.29	33.96	
22.73	9.65	35.81	
23.88	10.03	37.73	
25.07	10.41	39.73	
26.30	10.81	41.80	
27.59	11.22	43.95	
28.91	11.65	46.18	
30.29	12.09	48.49	
31.72	12.54	50.90	
33.20	13.01	53.39	
34.73	13.50	55.97	
36.33	14.00	58.65	
37.97	14.52	61.43	
39.68	15.05	64.31	
41.45	15.60	67.30	
43.29	16.18	70.40	
45.19	16.77	73.61	
47.15	17.38	76.93	
49.19	18.01	80.38	
51.30	18.66	83.95	
53.49	19.33	87.65	
55.75	20.02	91.48	
58.09	20.74	95.45	
60.52	21.48	99.56	

63.03	22.24	103.81
65.62	23.03	108.22
68.31	23.84	112.78
71.09	24.68	117.50

Figure 5. Average annual world oil prices in three cases, 1980-2035 (real 2010 dollars per barrel)



2030	197.68	60.87	138.492	1.427375	0.43952
2031	198.37	61.16	139.7248	1.419719	0.437718
2032	199.05	61.46	140.9576	1.412127	0.436018
2033	199.7	61.77	142.1904	1.404455	0.434418
2034	200.36	62.07	143.4232	1.396985	0.432775
2035	200.99	62.38	144.656	1.389434	0.43123

2010\$										2012 \$					6.37	6.94	7.27	6.61	7.1	6.74	6.36
Gas Price at Henry Hub (\$ / MMBtu)										Average 2011 city gate price for Anchorage:					3.00						
Year	2012			2011 AEO						Prevailing value of ANS gas in 2011:											
	Ref Case	High Gas	E Low Gas	E Ref Case	High Gas	Low Gas	High	Low	Mid	High	Low										
2012	3.60	3.65	3.45	4.65	4.72	4.46	1.015054	0.95914	4.69	6.37	3										
2013	4.11	4.17	3.87	4.79	4.86	4.5	1.014614	0.939457	4.79	6.56	3.03										
2014	4.16	4.23	3.83	4.89	4.97	4.5	1.01636	0.920245	4.87	6.71	3.03										
2015	4.27	4.36	3.86	5.09	5.19	4.6	1.019646	0.903733	5.05	7.00	3.09										
2016	4.30	4.36	3.80	5.27	5.35	4.66	1.01518	0.88425	5.18	7.22	3.13										
2017	4.42	4.48	3.81	5.41	5.48	4.66	1.012939	0.861368	5.27	7.40	3.13										
2018	4.59	4.66	3.89	5.58	5.67	4.73	1.016129	0.84767	5.42	7.65	3.18										
2019	4.72	4.85	3.91	5.77	5.92	4.78	1.025997	0.828423	5.60	7.99	3.22										
2020	4.80	4.95	3.84	6.1	6.3	4.88	1.032787	0.8	5.89	8.50	3.28										
2021	5.00	5.19	3.89	6.45	6.69	5.02	1.037209	0.778295	6.20	9.03	3.38										
2022	5.29	5.56	4.03	6.76	7.11	5.15	1.051775	0.761834	6.53	9.60	3.46										
2023	5.49	5.81	4.10	7.12	7.54	5.32	1.058989	0.747191	6.88	10.18	3.58										
2024	5.64	5.92	4.10	7.53	7.91	5.48	1.050465	0.727756	7.18	10.68	3.69										
2025	5.75	5.96	4.10	7.9	8.19	5.63	1.036709	0.712658	7.42	11.05	3.79										
2026	5.98	6.12	4.19	8.21	8.39	5.75	1.021924	0.700365	7.60	11.32	3.87										
2027	6.17	6.23	4.24	8.56	8.64	5.88	1.009346	0.686916	7.81	11.66	3.96										
2028	6.18	6.25	4.22	8.82	8.93	6.03	1.012472	0.683673	8.05	12.05	4.06										
2029	6.13	6.28	4.16	9.04	9.27	6.14	1.025442	0.679204	8.32	12.51	4.13										
2030	6.19	6.45	4.14	9.28	9.66	6.2	1.040948	0.668103	8.60	13.04	4.17										
2031	6.42	6.69	4.19	9.59	10	6.26	1.042753	0.652763	8.85	13.50	4.21										
2032	6.67	6.95	4.24	9.96	10.37	6.33	1.041165	0.635542	9.13	14.00	4.26										
2033	6.83	7.15	4.25	10.34	10.82	6.43	1.046422	0.621857	9.46	14.60	4.33										
2034	6.99	7.28	4.24	10.76	11.21	6.53	1.041822	0.606877	9.76	15.13	4.39										
2035	7.23	7.42	4.27	11.28	11.58	6.66	1.026596	0.590426	10.05	15.63	4.48										
2036									10.28	16.03	4.53										
2037									10.56	16.52	4.59										
2038									10.83	17.01	4.65										
2039									11.11	17.50	4.72										
2040									11.38	17.99	4.78										
2041									11.66	18.48	4.84										
2042									11.94	18.97	4.91										
2043									12.21	19.46	4.97										
2044									12.49	19.95	5.03										
2045									12.76	20.43	5.09										
2046									13.04	20.92	5.16										
2047									13.32	21.41	5.22										
2048									13.59	21.90	5.28										
2049									13.87	22.39	5.34										
2050									14.14	22.88	5.41										
2051									14.42	23.37	5.47										
2052									14.69	23.86	5.53										
2053									14.97	24.35	5.59										
2054									15.25	24.84	5.66										
2055									15.52	25.32	5.72										
2056									15.80	25.81	5.78										
2057									16.07	26.30	5.84										
2058									16.35	26.79	5.91										
2059									16.63	27.28	5.97										
2060									16.90	27.77	6.03										
2061									17.18	28.26	6.10										
2062									17.45	28.75	6.16										

2063	17.73	29.24	6.22
2064	18.00	29.73	6.28
2065	18.28	30.22	6.35

5.46 5.44 5.91 6.09 6.18 6.39

Fuel	Avg Price	Units	Gross Heat	AFUE Efficiency	Mid-point	\$/100,000 BTUs	Useful BTUs/\$1	Rank	Source:
Electricity	\$0.1976	kWh	3,413	95 - 100%	98%	\$5.938	16,840	11	www.energysavers.gov DOE
District Hot Water	\$27.0300	MMBtu	1,000,000	95 - 100%	98%	\$2.772	36,071	7	www.energysavers.gov DOE
District Steam	\$10.5000	MMBtu	1,000,000	95 - 100%	98%	\$1.077	92,857	1	Use hot water AFUE
Fuel oil (#2)	\$4.0500	gallon	135,000	80 - 90%	85%	\$3.529	28,333	8	DOE
Natural gas	\$23.3500	MCF	1,000,000	85 - 95%	90%	\$2.594	38,544	5	Interviews, ALTROL
Propane, small vol	\$4.3500	gallon	91,333	80 - 90%	85%	\$5.603	17,847	10	Small appliance only
Propane, heating	\$3.0500	gallon	91,333	85 - 95%	90%	\$3.710	26,951	9	DOE
Wood, pellets	\$295.000	ton	16,000,000	68%	68%	\$2.711	36,881	6	CCHRC
Wood, birch	\$250.000	cord	20,500,000	68%	68%	\$1.793	55,760	3	CCHRC
Wood, spruce	\$250.000	cord	15,000,000	68%	68%	\$2.451	40,800	4	CCHRC
Coal, stoker	\$110.000	ton	15,200,000	55%	55%	\$1.316	76,000	2	FNSB

1,470,588 MMBtus of wood required to meet 1 MMBtu of gas
22.058824