Micro-District Coal Heating Case Study

Douglas B. Reynolds
Professor Oil and Energy Economics
303 Tanana Dr. Rm 201
University of Alaska Fairbanks
School of Management
Fairbanks, Alaska 99775-6080
dbreynolds@alaska.edu

Jim Collins
University of Alaska Fairbanks
jmcollins@Alaska.edu

Xiaoqi Han
University of Alaska Fairbanks
Xhan2@Alaska.edu

Abstract

Energy determines economic development. Nowhere is this truer, than in the Fairbanks, Alaska's energy market, where some of the highest energy costs in the world are experienced. However, in a small isolated town, such as Fairbanks, there is currently only one main option for space heating energy, which is expensive fuel oil. Other options have significant barriers to entry or pollution. However, a coal option may work, but it is necessary to conduct a business/engineering analysis. This case is about a proposed creation of a small, coal district-heating utility that would create a local market for space heating needs for Fairbanks, Alaska. Different costs and benefits will be shown. Upfront costs will be assumed by the utility so that residences and businesses have a smooth, easy-to-pay monthly bill. The benefits of coal must be counted against the high costs of bringing in trucked natural gas, or other pollution problems.

I. Introduction

Fairbanks is located in the interior of Alaska about 100 miles south of the Yukon River approximately 350 miles North of Anchorage. North Pole is a smaller community about ten miles east of Fairbanks and is also a part of the pollution area, called the non-attainment area, for wood smoke and particulate pollution. The term "non-attainment" means that the Environmental Protection Agency (EPA) has designated that the area has not attained low pollution. The entire area of the Fairbanks-North Star Borough is 7,338.21 square miles, but the area of the Fairbanks non-attainment area (where most of the population and the pollution problem is located) is 30 square miles.

One of the unique historical aspects of Fairbanks at the turn of the 19th century was that when forests in and around the region were completely cut down for miles around the city, residences started to use coal in great quantities. An old coal bunker that held coal for people to buy was used for people who had coal stoves or coal boilers inside their homes. This is not unlike 1800s Europe or even 1950s America where many people had coal stoves and boilers to keep warm. However, in today's modern world, everyone uses natural gas, except in Fairbanks, where no nearby natural gas resources exist and where significant barriers to entry for a natural gas pipeline makes natural gas expensive. A better modern technology for Fairbanks would be to use coal where a modern coal utility can make the old coal furnaces, coal stoves and coal boilers of yore look old-fashioned. Modern coal heating systems can work much better and be more efficient than old coal systems, and if set up correctly can be as unassuming as natural gas, fuel oil or district heating systems.

The boiler system suggested here will only produce heat, not electricity, in order to keep capital costs down. It will have a tall chimney stack, 50 to 200 feet high, with other pollution reduction devices such as a bag house or scrubbers to keep particulate pollution and other pollution under control per state and federal regulations. The larger than normal boiler system will run hot, which will help keep particulates to a minimum regardless of the call for heat, and the system may use heat storage devices to keep the boiler operating at maximum temperatures, while shutting down for hours at a time to further reduce pollution. The coal will feed automatically into the burner; the ash will automatically be taken away and eventually buried. Maintenance will be on call with telephone type detection devices, which are able to call maintenance personnel the instant a problem arises. The technology for such a boiler system already exists,

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

but such technology has seldom been used for small micro-district heating and never on such a wide scale for residences in an OECD country.

Fairbanks has rail access to a large sub-bituminous coal mine with almost a billion tons of reserves about 100 miles away and where the coal can be delivered to Fairbanks and North Pole for about $50 per ton or $3.20 per mmBtu ($0.37 per gallon of fuel oil equivalent or 2.33 euros (€) per Gigajoule). Assuming capital costs can be controlled and thermal losses reduced, the coal boiler should be able to deliver heat to residences and businesses for as little as half the current price of fuel oil and even be competitive versus an eventual natural gas system. While wood stoves are currently quite competitive with such a system, that will change in the future as more residences heat with wood and nearby forests become increasingly overused, and demand will cause wood prices to rise. In addition, the convenience of having a continuous supply of heat piped in versus having to process wood every day and drive to cut it yourself, will win customers over to a coal system. It is hoped that the micro-district coal utility will reduce Fairbanks particulate pollution as houses switch from the wood-fired heat, which often creates dense smoke clouds, to a single, large scale efficient coal heating system, which would have diluted and controlled emissions. Once pollution advantages are weighed, permitting should be forthcoming. These factors would go a long way to ensuring that the Interior region of Alaska obtains cheap heat.

This case study is about a general business plan. The purpose of explaining the business plan is the idea that if one specific plan can be shown to work, then it forms a basis for a new energy market where none now exists. A coal market would exist if coal heating was used extensively, but the trade-off between a natural gas trucking system and a coal system has to be analysed. That means that either a natural gas system or a coal system will be used in Fairbanks, but probably not both.

II. The Specific Fairbanks Space Heating Energy Market

The community of Fairbanks is a business hub for all of Alaska. Sources of employment include a military base, mining, oil and gas exploration to the North, as well as the main campus of the University of Alaska Fairbanks, local schools, and government offices, and other private enterprises.

Selected demographic and historical data for the community is provided below:

Population	
2010	100,000
Households	
2010	35,000
Economic Data	
Fairbanks unemployment rate 2011	6.7 %
Alaska Unemployment rate 2011	7.6 %
GDP	$5 billion
Fairbanks Median Income	$40,577
Alaska Median Income	$71,395

Fairbanks' winters are some of the coldest in North America. While it can easily get chilly in June or August, it certainly will be cold from September until May. During the dead of winter, temperatures can stay well below minus 40 degrees Fahrenheit (minus 40 Celsius) for a month at a time. Therefore, heating systems have to be able to increase heating output within hours and

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

then sustain that high heating output for months at a time. Heating costs in the interior are now running at $5,000 per year, which is an as much as home mortgage payment. Fairbanks has on average 14,000 heating degree days. One degree day is one full day with the temperature one degree below 70 degrees Fahrenheit. With fuel oil being sold at $4.00 per gallon ($32 per million Btu) and going up, Fairbanks has some of the costliest heating in the entire world.

Since home heating costs in the interior are high, Fairbanks needs a cheaper heating source like coal, which could reduce heating bills significantly. While the state of Alaska has massive natural gas reserves on the North Slope 400 miles north of Fairbanks and very good natural gas reserves around the Kenai Peninsula about 400 miles south of Fairbanks, there are no natural gas reserves near Fairbanks. Consequently residents and businesses in Fairbanks use mostly fuel oil as a heating source. In the 1990s and before, fuel oil was reasonably priced which allowed a typical house to pay $1000 for a season of heating with fuel oil, but today many houses are facing $5000 per year heating fuel oil bills. Plus many houses that are not adequately heated face frozen pipes, mold and mildew problems. Therefore, households have turned to other heating options, particularly wood stoves, which have increased Fairbanks' urban particulate pollution.

One of the problems with wood stoves is that wood that is burned needs to be dry. Typically wood must be cut and dried for an entire year before it can be used in wood stoves or wood boilers. If the wood is not dried, it burns inefficiently and there is considerable smoke and pollution. Lately due to so many people using wood stoves, the use of inadequate dried wood has increased, causing more smoke problems. But in general, since so many people now use wood stoves, there is more smoke even from modern wood stoves and from using well-seasoned wood. Soon the availability of wood will decline and the price of wood will increase, but coal at the Usibelli coal mine near Healy, Alaska, 100 miles away by rail, has almost a billion tons of sub-bituminous coal at less than $0.50 per gallon of fuel oil equivalent ($4.00 per million Btu) when bought in bulk.

There is an intense interest in a natural gas pipeline to Fairbanks, but so far it has been too expensive to build, so the only natural gas in Fairbanks currently is liquid natural gas (LNG) trucked into the Interior from the Cook Inlet near Anchorage. This makes the gas almost as expensive as fuel oil. Also there is a central district heating region in the downtown neighborhoods of Fairbanks, but that central district heat, which is tied to a large coal fired power plant, has not been able to expand significantly due to costs of constructing a large underground pipeline system.

There does exist in downtown Fairbanks a coal-fired power plant which sells district heating for downtown areas, both steam and hot water. One option has been to expand that district, but because of significant costs of underground utilidors, that heating district has not been expanded, so a set of micro-district heating utilities can complement the main downtown heating district. Micro-districts would be more cost effective as they would not necessarily need large underground utilidors but could use above-ground, backyard utilidors that are well insulated. A small micro-district system can attain the economies of scale of using multiple customers, while avoiding the dis-economies of scale of having too large of a system.

Douglas B. Reynolds, **University of Alaska Fairbanks**, **dbreynolds@alaska.edu**

II.1 Pollution Issues

Currently, Fairbanks faces a pollution crisis because many residences are heating with wood stoves, much of which emits particulates and other noxious fumes. Even modern wood stoves are not totally clean. The biggest problem is that Fairbanks has a winter temperature inversion which is where temperatures are colder on the ground than 100 feet above in the air. This inversion causes pollution to stick low to the ground and causes everyone to breathe the dirty air. The inversion creates an ice fog as cars and other burning devices release small amounts of water vapor, then the ice fog also captures other noxious fumes. Nothing can be done to stop the winter temperature inversion, but it is possible to release fumes high in the air so that those fumes release above the inversion phenomenon.

Due to all this pollution, the U.S. federal government is imposing restrictions on smoke in the city. These restrictions are intended to clean the air and create a healthy environment for those with existing health concerns, the young, and the elderly and to prevent the healthy from acquiring health problems in the future. However, the effect of those restrictions is to force everyone to use expensive fuel oil and people are starting to be challenged financially. This is hurting the Fairbanks economy.

Here are facts about current pollution concerns:

- Wood smoke is the source of more than 60 percent of the $PM_{2.5}$ particles
- Small particles less than10 micrometers in diameter pose the greatest problems
- Smoke causes increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing
- The pollution can cause the development of chronic bronchitis
- The federal government has designated that Fairbanks is a non-attainment area and has threatened to withdraw funding for roads and other services if Fairbanks does not reduce particulates.
- Coal's contributions to $PM_{2.5}$ particles is negligible—less than 1%, in spite of coal contributing more to Fairbanks' heat load than wood, due to the downtown district heating.

II.2 Energy Characteristics for Space Heating

Not all energy is created equal. Clearly gasoline has energy characteristics that are much different from electricity. Therefore, while energy is often defined and measured in terms of its thermal equivalent British thermal units (Btu) or Joules or kilowatt-hours, not all Btus have the same value. Different energy resources have different non-thermal energy characteristics which can be considered a quality of each energy resource. High quality energy is more useful for determining economic growth than low quality energy. Therefore, by defining characteristics of energy, we can gain another valuable index or indicator of potential usefulness and value of a given energy resource no matter what the technological or market environment the energy resource is in.

Georgescu-Roegen (1971) and Reynolds (1994) use an engineering definition, based on physics, called the state grade, in order to differentiate energy characteristics and determine energy value outside of Btu content. The energy-state-grade includes the following: liquid, gas, solid and field. Since technological and economic substitutions change over time, it is not always possible to correctly index the economic value of each type of energy such that you can get a universal ordinal value of energy, but in general, energy can be assigned a cardinal rank of importance based on its energy-state-grade characteristics as table 1 shows.

Cardinal Rank	Physical Energy-State-Grade Characteristic	Examples of existing natural resources	2010 price, value per thermal equivalent unit wholesale
1	Liquid	Crude Oil, natural gas liquids	$20 per mmBtu
2	Gas	Natural gas (methane)	$4 per MMBtu
3	Solid	Coal, oil sands*, oil shale*	$2 per MMBtu (coal)
4	Field	Nuclear (uranium), solar, wind, hydropower	Free (solar, wind)

* Oil sand and oil shale (i.e. not the shale oil that occurs in shale gas formations) are hard solids in their natural in-situ state and must therefore be transformed into a liquid before they are sold as a liquid energy resource to refiners. Therefore, they are considered, like coal, a solid state-grade energy resource in-situ.

Some may be surprised that oil sand and oil shale are considered solid energy resources like coal; yet at room temperature and pressure, they are not liquids but solids. They must be transformed into a liquid. Just so, alcohol fuels are not liquid energy resources, they start as a solid state grade grain or sugar and are then converted into a liquid which is why there are not included as energy (natural) resources. Another surprising aspect of the definition of a state-grade is what is called a field. The first three energy-state-grades are energy resources that combust in a hydrocarbon process with oxygen whereas the last energy-state-grade is an energy resource that exists in a constant state of irradiative or pressurized power. These field state-grade energy resources must be captured as they irradiate energy—in an energy field as it were. While nuclear uranium fuel is not exactly free, it is close to it as there are trillions of Btus of available energy in every pound of pure uranium and the biggest cost occurs when paying for the capital to convert the uranium into electricity, not the cost of the uranium fuel itself. This is similar for solar, wind and hydropower. It is the capital cost not the raw energy input cost that makes these energy systems so costly.

Regardless of such a ranking system, it is still possible for low rank energy resource to replace a high rank energy resource such as when cars use electric batteries as a fuel source. However, electricity is not an energy (natural) resource, it is a technology. The actual energy resource that is used to produce electricity is coal, oil, natural gas, uranium (nuclear) or hydro-power. Furthermore, electricity and electrical technological development for the use of electric vehicles has existed for over one hundred years, and yet there has rarely been an independent electric only vehicle in mass production for a sustained number of years. Moreover, whenever there is an energy source that is a low rank energy, such as hydro-power used to produce electricity, and it is used for a technology that normally uses a high rank energy, such as for automobiles, the Energy Return on (Energy) Investment (EROI) of the alternative process is usually much lower. See Hall (2008), Hall et. al (2009) and Hall et. al (1986). Thus if you look at the energy chain from the energy source in-situ to the final energy service—the so called "well to wheel" analysis—then the total EROI of the process is much less for electric technologies than for oil technologies. This means high rank oil is an integral ingredient of our modern economy, and we cannot continue to produce as much GDP without it.

Therefore, the biggest concern in energy is not running out of energy, but the cost of liquid energy resources. In the case of Fairbanks, it is not necessary to have an oil fuel, but a natural gas or a coal fuel will do. Peak oil can therefore cause fuel oil to become more expensive, even with the increase of liquid fuel alternatives.

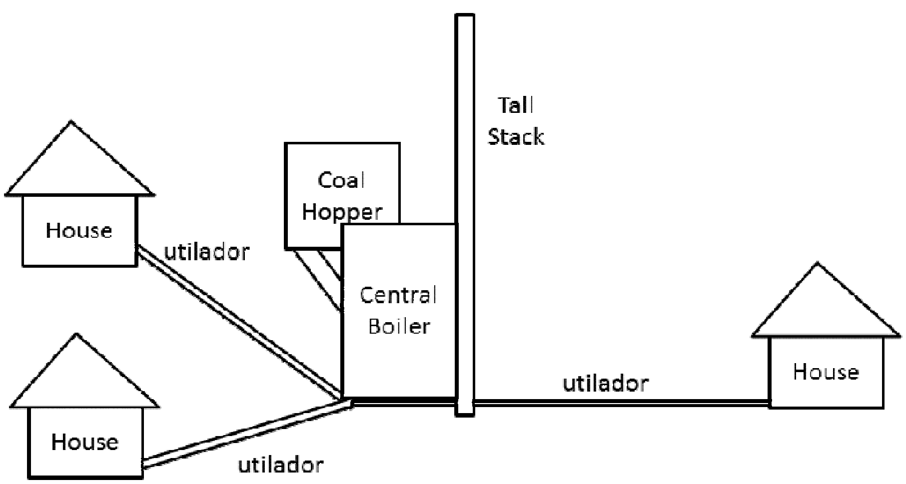
III. Coal Business Specifications

The proposed business will be a residential and commercial heating utility. It will be composed of small districts, or micro-districts, similar to a large district heating system. The utility will burn coal at a central location and heat water in a boiler. The boiler water will be piped in utiladors to residential or commercial buildings. The coal boiler will emit the smoke through a tall smoke stack some 50 to 200 feet high (20 to 70 meters) in order to dissipate particulates and other noxious emissions above the Fairbanks winter temperature inversion.

Residences will have a smooth monthly payment and all coal handling will be automated and done by the coal utility. The utility will incur all the upfront costs and provide residences with a smooth affordable heating bill.

It is clear that coal can replace oil. However, oil heating is amenable to micro-economies of scale where smaller boilers are more efficient than larger boilers due to their proximity to the consumer. Additionally when extra fuel is needed, these small, oil boilers are scalable and can respond to the changing needs of the household or weather and climate conditions.

However, even though a coal micro-district heating system is small, it can nevertheless use macro economies of scale. The key is to make these large, capital projects, with larger boilers and large coal storage units to reduce the cost of using coal in time and money. However, if coal projects are too large, such as most conventional district heating projects, then they can result in dis-economies of scale, by not being able to scale quickly to larger or smaller heating needs of the customers nor can they add on new customers quickly.



Schematic of the Micro-District Heating Utility Project

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

By using a medium scale, micro-district heating system, with a 10 to 20 million Btu boiler (3000 to 6000 kw), the project can attain the economies of scale cost reductions of a large district heating operation but also have the flexibility of achieving the micro-economies of scale of a small oil boiler by saving energy when heat is not needed. A back-up oil boiler can also be used for extreme cold top-up heat or for breakdowns. Once coal heating capital costs are reduced, by limiting the area and number of customers served, micro-district economies of scale can be maintained more efficiently. As more micro-districts are added, there will be economies of scale for maintenance, finance and replacement costs. This could be the wave of the future for home heating. Even though natural gas is cheaper now in the lower 48, it may not be cheap in some areas. Certainly many places around the world without access to cheap natural gas, may need just such coal heating systems.

Competitors for a coal utility would be wood stoves, natural gas and fuel oil. The cheapest of these today are wood stoves; however, because small stoves are polluting, many of these wood stoves users may rather use coal micro-district heat once they realize how low-polluting it will be. Plus the wood stove users engage in a lot of physical labor to fuel their stoves. This could be obviated if they instead used micro-district heat. Wood prices have risen by 100% over the last five years as more and more people have used wood as a fuel. Many wood providers advertise seasoned wood that is not fully seasoned causing harmful pollution by even the best-intentioned. Often the wood has to be bought a year ahead of time, split and stacked by the wood user in order to properly season the wood. The user often needs a shed built just for wood at some expense. Buying new wood stoves to meet EPA regulations often means changing the floor, wall, stove pipe, hearth or other aspects around the wood stove. This increases the costs of using wood. Those who cut their own wood drive an average of 20 to 50 miles away from town to obtain their wood fuel source.

The natural gas is still some years away from being a reality due to the significant barriers to entry of transportation costs. Even if natural gas supplies do make it to the interior, it may not be enough for everyone.

IV. Operations

The coal will come from Usibelli coal mine from Healy, Alaska, by train where there is 100 years' worth of reserves. Coal cars can deliver coal in 2010 dollars for as low as $50 per ton in bulk. The coal is burned in the boiler. Smoke can be scrubbed and emitted through a very high smoke stack to rise above the temperature inversion experienced in the region in the winter.

One of the advantages of having central boilers running the entire system is that in the summer much maintenance work can be accomplished with the same personnel while the need for the boilers is small. One option is to have back-up boilers such as an oil boiler which can help in shoulder seasons and as a top-up for extreme cold. Then, different boilers can be run on different summer seasons to allow all the boilers to be properly maintained.

Insurance will be purchased to cover the boiler system, the smoke stack and scrubber system, personnel including accidents. Insurance will also cover the possibility of a smoke stack falling or being hit by an airplane, or other coal related liabilities. OSHA guidelines must be met.

IV.1 Revenue

The revenue required to support a micro-district heating system will come from commercial, residential, and other users. The revenue requirement will be estimated based on the projected annual costs for the preferred system. Based on these projections, the annual revenue requirement for one micro-district heating system is projected to be approximately $300,000 per year. Here are two examples of micro-districts.

Type	Per unit charge	Hook up Fee (one time)	Expected yearly use	Expected Yearly Revenue
Residential Micro-District:				
Residential yearly Fee	$20/mmBtu	$4,000	150 mmBtu	$3,000
Small Commercial user	$20/mmBtu	$5,000	150 mmBtu	$3,000
100 small users				$300,000
Commercial Micro-District:				
Large Commercial users	$20/mmBtu	$15,000	1500 mmBtu	$30,000
10 large users				$300,000

IV.2 Capital Costs

These are capital costs per micro-district. There are three cost categories that will be incurred in the ongoing operation and upkeep of the micro-district heating utility–Operations and Maintenance (O&M), personnel and Repairs and Replacements (R&R).

For Single Micro-District:	
Coal Boiler Units (1)	$200,000
Oil Back up Boiler	$50,000
Piping	$200,000
Smoke Stack	$80,000
Truck	$100,000

Equipment Depreciation Schedule

Description of Equipment	Number	X	Cost	÷	useful life	=	Depreciation
Coal Boiler	1	X	$200,000	÷	20	=	$10,000
Oil Backup Boiler	1	X	$50,000	÷	20	=	$5,000
Piping (utilidor)	1 mile	X	$200,000	÷	30	=	$6,667
Smoke Stack (200 feet)	1	X	$80,000	÷	20	=	$4,000
Truck for 5 micro-districts	1/5	X	$100,000	÷	10	=	$2,000
Total							**$27,667**

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

IV.3 Administration Costs

This is Administration and other fixed expenses which will cover 10 micro-districts. The following costs will include benefits, insurance, social security and taxes.

ADMINISTRATION:	yearly total	Per Micro-District
Manager	$60,000	$6,000
Engineer/operator	$60,000	$6,000
Finance/accounts clerk	$30,000	$3,000
Labor $50,000 x 4	$200,000	$20,000
Office Space (phone, internet)	$30,000	$3,000
Administration Total	$350,000	$35,000
SITE LAND		
Lease or buy land x 10	$100,000	$10,000
Total	$450,000	$45,000

IV.4 Repairs and Replacement

The organization will incur expenses relating to the repairs and replacement of the system. Repairs and replacement (R&R) costs are those expenses defined, as items costing more than $1,000 and that are not replaced on an annual basis.

An estimate has been made of the expected annual R&R costs for major equipment, i.e. pumps, heat exchanges, boilers, and system controls. The details of these calculations are depicted on the spreadsheet below. The total amount that should be annually set aside for major equipment R&R is $17,166.

Description of Equipment	Number	X	Cost	÷ useful life	=	Depreciation
System Controls	200	X	$400	÷ 20	=	$4,000
Heat Exchangers	100	X	$1000	÷ 20	=	$5,000
Pumps	10	X	$16,000	÷ 20	=	$8,000
Augers	10	X	$4,000	÷ 20	=	$2,000
Other misc. equipment, hammers, saws and other basic tools						$1000
Total (R & R)						**$20,000**

IV.5 Energy Costs

The Micro-district coal heating utility's energy costs will include the purchase of coal by rail from the Healy coal mine. A 20 year contract is possible. Because of normal losses in any heating system, there will need to be more coal energy than the final energy that is purchased by the customers. Electricity to run the boilers is based on a typical boiler operation.

Typical Coal Boiler operation:	per unit	Cost	Per Micro-District
Coal	20 tons/house	$1,000	$100,000
Electricity ($0.20/Kw-hr)	20,000 Kw-hr	$4,000	$4,000
Total			$104,000

Douglas B. Reynolds, **University of Alaska Fairbanks**, **dbreynolds@alaska.edu**

IV.6 Operations and Maintenance Costs

The Micro-district coal heating utility will incur a number of expenses relating to the operations and maintenance of the system. Operations and maintenance items are defined as expenses that are incurred on a regular basis to sustain the operation of utility assets and the cost of utility administration.

Projections per district based on ten micro-districts

Expense Category	Annual Estimate cost
Administration	$45,000
Repairs and Replacement	$20,000
Energy	$104,000
Capital Replacement cost	$27,667
Insurance	$40,000
Total	$236,667

IV.7 Annual Profit

	Revenue per micro-district	
Residential users 100		$300,000
	Expenses per micro-district	
Total Operations and Maintenance		$236,667
	Net Operating Income	
Profit per micro-discrict		$63,333
	Net Operating Income for 10 micro-districts	
Profit		$633,333

Annual estimated operating cash flow depicts the annual flow of money in and out of the business over the course of an operating year; regardless of whether or not the expenditure is fully tax deductible, such as capital expenditures (annual R&R) or loan principal payments. The value of the fixed capital will go up in value during inflation. This investment will gain in equity value and in profit over the years even if the initial profit is low.

V. Start Up Issues

$20 million is required to start up the business. This will allow an initial $2 million project and money to slowly build up the system, run it and test it. It is the case with coal boilers and heating systems that the best research is done on the ground not in the laboratory. Therefore, to wait and do heavy research will not help to lower costs as much as an actual model would serve to reduce costs.

North Pole, Alaska which is a part of the Fairbanks urban area and pollution non-attainment area (the area that the Environmental Protection Agency (EPA) says is having too much pollution) is a good place to start such a project. North Pole has one of the highest rates of using old wood stoves, the kind that pollute enormously and its residents are amenable to using coal even though there are global climate change issues with it. The demographics of North Pole are comprised of poorer residences (vis-a-vis Fairbanks) who struggle with heating costs. The positive view that alternative heating has in North Pole will be beneficial to this project.

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

One option for a location is near an existing coal system of which several already exist. Then the existing system can be added on to as a startup model. A new improved module next to an existing module and leasing land near the existing module could be built. This will give a good idea about costs.

For a second project, two possible locations include the Wal-Mart and surrounding retail corridor in North East Fairbanks or the North Pole Downtown district. This will allow a high heating volume in a small area and will allow enough revenue to possibly pay for other, subsequent utility projects around the community should the investor decide to expand operations.

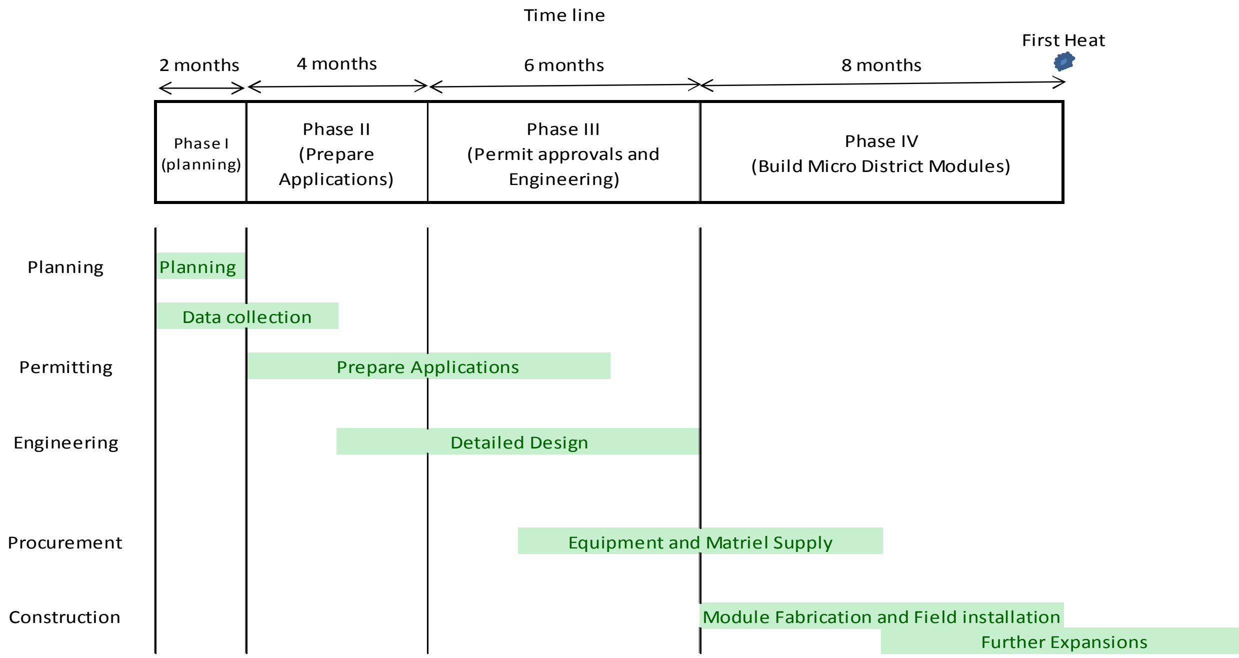
The primary technology behind a micro-district coal heating utility is not just the boiler, but the configuration of the boiler. One idea is to just use one boiler, but that reduces the flexibility of the wide range of heating needs from low heat in the middle summer, say for summer time water heating needs, to very high calls on heat in the mid-winter when temperatures reach minus 50 degrees Fahrenheit. To counter act that high range, two boilers can be used in series both of which can be switched on and off. This will add flexibility to the system and add backup capacity for cheap costs. The second boiler may be an oil boiler which would be needed for extremely cold days and for summer back up while any maintenance to the main coal boiler is performed.

The primary regulatory agency for the utility will be the state of Alaska's Regulatory Commission of Alaska. The primary regulatory for the environment will be the State Department of Environmental Conservation (DEC). DEC regulates a wide array of environmental areas. Of concern to this utility project is the agencies regulatory authority over water air quality and ash disposal standards, operator training standards and engineering plan approval.

The Regulatory Commission of Alaska (RCA) is another regulatory agency that may be involved in the project. The agency is the utility regulator for the state. They issue a "certificate of public convenience and necessity" to utilities after finding them "fit willing and able" to provide the public service.

The Coal micro-district utility will be constructed over a two year period in four phases. Phase one is time to plan and cost an initial micro-district heating system in North Pole. This phase will take two months and be complete in early 2012. Phase two is the preparation of applications for a utility and environmental review. Phase three is the permit approvals which will be done in late 2012. Phase four is the construction of the system and first heat. This phase will be take 8 months. Phase five is the possible expansion of the micro-district to other residential areas.

Douglas B. Reynolds, **University of Alaska Fairbanks**, **dbreynolds@alaska.edu**



VI. Marketing

Based on the previous discussion of revenues and expenses, and a review of the resulting cash flow and operating income statement, the impact on the community could be quite positive. Below is the average current cost of living for most households and the effect of fuel savings they can gain from such a micro-district coal heating utility.

Cost of Living/ Resident Ability to Pay

Description	Average Rate	Times	Amount
Median Household Income			$40,577
Expenses:			
Rent/Mortgage	$1,300	12	$15,600
Food	255	52	$13,260
Electricity	150	12	$1,800
Fuel (Fuel Oil)	1200 gallons ($4.50 per gl)	Per season	$5,400
Micro-District Heat	150 MMBtu	Per season	$3,000
Water and Sewer	100	12	$1,200
Airfares			$2,000
Clothing	150	12	$1,800
Gifts/Holiday			$1000
Other	50	12	$600
Total Expenses if Household Pays for Fuel Oil			$42,660
Total Expenses if Household Pays for Micro-District Coal Heating			$40,260
	Net Fuel oil		($2083)
	Net Micro-District Heating		$317

Douglas B. Reynolds, University of Alaska Fairbanks, dbreynolds@alaska.edu

The target market of the coal utility is the households and businesses in the Fairbanks areas. To reach this target client, local newspaper, radio, and event sponsorship will be used as potential channels of communication. Through these potential channels, messages should be delivered that coal-based energy supply is cheaper, safer, and cleaner than the wood stove. Further, because consumers may worry about the hassle involved in installation and switching to a new type of utility, marketing communication should also emphasize the convenience of the service delivery. Consumers need to be told that all the upfront costs will be assumed by the utility so that residences and businesses will have a smooth, easy-to-pay monthly bill, reducing unwelcome volatility in their payments.

However, one important obstacle in marketing the coal utility service is the potential antagonism from the local environmentalists. Without considering the cost of using wood stove, local environmentalists will likely think that coal utility will exacerbate global warming and will produce pollutants that put local people's heath at threat. These beliefs will prohibit the wide-spread adoption of the coal utility despite its economic and environmental and environmental advantage over its substitute-wood stove. To combat the false beliefs and possible negative word-of-mouth about the coal facility, some public relation work needs to be done prior to the formal launch of the coal utility.

To promote the coal utility, a group of clients who are willing to experiment with the coal utility can be set up to enjoy the service for a winter or two for a minimum charge. Through the experimentation, we can obtain some first-hand consumer experiences with the service, which can be used to improve the service when it is formally launched. Second, data can be obtained regarding the discharge of pollutants, which can serve as solid evidence that the utility is safer and cleaner. Third, if the experimental clients are satisfied with the service, some good word of mouth can spread about the coal utility and we can also use these positive messages in a larger-scale marketing campaign about the coal utility

In terms of public relations, one way to gain community support for such a district heating plan is to include a small building for indoor play space for toddler and young children. Winters are cold in Alaska and children need large, indoor spaces for play. Nothing exists currently for these young children. The Early Childhood Development Commission of the Fairbanks North Star Borough has documented evidence of the need for such a heated play space. The problem has been the heating costs for such a facility. This utility could offer just such a service at a low cost that would bring a huge amount of goodwill to the investor from the local community.

A natural gas trucking system is estimated to cost nearly a billion dollars for the Fairbanks area. No cost estimate is given per million Btu, but costs could be from $15 to $25 per million Btu, see Northern Economics (2012), as opposed to a coal system which could offer costs as low as $20 per million Btu, but may be lower if competition induces lower capital costs. The only problem with the trucking natural gas option is that natural gas prices can increase if North Slope natural gas becomes more valuable for processing heavy oil, and it will take longer to build out a natural gas distribution system than a coal system.

Douglas B. Reynolds, **University of Alaska Fairbanks**, **dbreynolds@alaska.edu**

VII. Summary

This case study has shown the costs and benefits of a coal system. While the state of Alaska has massive natural gas reserves on the North Slope 400 miles north of Fairbanks and very good natural gas reserves around the Kenai Peninsula about 400 miles south of Fairbanks, there are no natural gas reserves near Fairbanks. Consequently residents and businesses in Fairbanks use mostly fuel oil as a heating source. In the 1990s and before, fuel oil was reasonably priced which allowed a typical house to pay $1000 for a season of heating with fuel oil, but today many houses are facing $5000 per year heating fuel oil bills. Plus many houses that are not adequately heated face frozen pipes, mold and mildew problems. Therefore, households have turned to other heating options, particularly wood stoves, which have increased Fairbanks' urban particulate pollution.

One of the problems with wood stoves is that wood that is burned needs to be dry. Typically wood must be cut and dried for an entire year before it can be used in wood stoves or wood boilers. If the wood is not dried, it burns inefficiently and there is considerable smoke and pollution. Lately due to so many people using wood stoves, the use of inadequate dried wood has increased, causing more smoke problems. But in general, since so many people now use wood stoves, there is more smoke even from modern wood stoves and from using well-seasoned wood. Soon the availability of wood will decline and the price of wood will increase, but coal at the Usibelli coal mine near Healy, Alaska, 100 miles away by rail, has almost a billion tons of sub-bituminous coal at less than $0.50 per gallon of fuel oil equivalent ($4.00 per million Btu or €3.00 per GJ) when bought in bulk.

There is an intense interest in a natural gas pipeline to Fairbanks, but so far it has been too expensive to build, so the only natural gas in Fairbanks currently is liquid natural gas (LNG) trucked into the Interior from the Cook Inlet near Anchorage. This makes the gas almost as expensive as fuel oil. Also there is a central district heating region in the downtown neighborhoods of Fairbanks, but that central district heat, which is tied to a large coal fired power plant, has not been able to expand significantly due to costs of constructing a large underground pipeline system.

This case study also shows some of the benefits that could be had with coal heating if done properly. Currently, Fairbanks faces a pollution crisis because many residences are heating with wood stoves, much of which emits particulates and other noxious fumes. Even modern wood stoves are not totally clean. The biggest problem is that Fairbanks has a winter temperature inversion which is where temperatures are colder on the ground than 100 feet above in the air. This inversion causes pollution to stick low to the ground and causes everyone to breathe the dirty air. The inversion creates an ice fog as cars and other burning devices release small amounts of water vapor, then the ice fog also captures other noxious fumes. Nothing can be done to stop the winter temperature inversion, but it is possible to release fumes high in the air so that those fumes release above the inversion phenomenon.

Due to all this pollution, the U.S. federal government is imposing restrictions on smoke in the city. These restrictions are intended to clean the air and create a healthy environment for those with existing health concerns, the young, and the elderly and to prevent the healthy from acquiring health problems in the future. However, the effect of those restrictions is to force everyone to use expensive fuel oil and people are starting to be challenged financially. This is hurting the Fairbanks economy.

Here are facts about current pollution concerns:

- Wood smoke is the source of more than 60 percent of the PM2.5 particles
- Small particles less than 10 micrometers in diameter pose the greatest problems
- Smoke causes increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing
- The pollution can cause the development of chronic bronchitis
- The federal government has designated that Fairbanks is a non-attainment area and has threatened to withdraw funding for roads and other services if Fairbanks does not reduce particulates.

The proposed business will be a residential and commercial heating cooperative utility. It will be composed of small districts or micro-districts similar to a large district heating system. The utility will burn coal at a central location and heat water in a boiler. The boiler water or steam will be piped in utiladors to residential or commercial buildings. The coal boiler will emit the smoke through a tall smoke stack some 50 to 200 feet high (20 to 70 meters) in order to dissipate particulates and other noxious emissions above the Fairbanks winter temperature inversion.

Residences will have a smooth monthly payment and all coal handling will be automated and done by the coal utility. The utility will incur all the upfront costs and provide residences with a smooth affordable heating bill. It is clear that coal can replace oil. However, oil heating is amenable to micro-economies of scale where smaller boilers are more efficient than larger boilers due to their proximity to the consumer. Additionally when extra fuel is needed, these small, oil boilers are scalable and can respond to the changing needs of the household or weather and climate conditions.

References

Georgescu-Roegen, Nicholas, (1971). The Entropy Law and the Economic Process, Published by Harvard University Press.

Hall, Charles A. S., Stephen Balogh and David J. R. Murphy, (2009). "What is the Minimum EROI that a Sustainable Society Must Have?" Energies, volume 2, pp. 25-47;

Hall, Charles A.S., (2008). EROI on the Web, Part 1–6, The oil Drum.com, 1) Why EROI matters, http://www.theoildrum.com/node/3786, 2) Natural gas and imported oil, http://www.theoildrum.com/node/3810 3) Tar sands and oil sands, http://www.theoildrum.com/node/3839 4) Nuclear power, http://www.theoildrum.com/node/3877 5) Passive solar, photovoltaic, wind and hydroelectricity, http://www.theoildrum.com/node/3910 6) Wind, geothermal, http://www.theoildrum.com/node/3949.

Hall, Charles A.S., Cleveland, Cutler J., Kaufmann, Robert, (1986). Energy and Resource Quality: The Ecology of the Economic Process, Reprint edition. University Press of Colorado. (February 1992).

Northern Economics (2012). Fairbanks, North-Star Borough Gas System Distribution Analysis, Preliminary Executive Summary Report. Anchorage, Alaska.

Reynolds, Douglas B. (1994) "Energy Grades and Economic Growth," Journal of Energy and Development, Volume 19, Number 2, Spring 1994, pp. 245 – 264.

Douglas B. Reynolds, **University of Alaska Fairbanks**, **dbreynolds@alaska.edu**