

DISTRICT HEATING FEASIBILITY STUDY
For
OLD CROW, YUKON

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Submitted to:

VUNTUT GWITCHIN FIRST NATION

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CHAPTER 1. - INTRODUCTION

1 Acknowledgments

Kattner/FVB District Energy Inc. acknowledges the cooperation provided by Andrew Pape-Salmon of the Pembina Institute and Michael Wilson of Enerficiency Consulting.

2 Study Objective

Kattner/FVB District Energy Inc. was asked by the Pembina Institute to examine the feasibility of district heating in Old Crow utilizing waste heat from YECL's Power Plant.

3 Scope of Work

3.1 OBJECTIVE

To develop a district heating service for the community of Old Crow. This system would get its heat energy solely from the YECL power plant located in the community. The heat would be recovered off the engines jacket water and exhaust. The system would utilize as much of the available waste heat as possible. Boilers and furnaces in targeted buildings are to be left intact.

3.2 BUILDING LOAD SURVEY

Prepare an overall map of the occupied area of the town indicating targeted buildings.

Review the targeted buildings' heating and DHW systems based on the survey data provided by the Pembina Institute.

Establish a load diversity factor.

Review existing records and buildings survey data in order to:
Establish heating loads and compile annual heating requirements for each building.
Determine the community heat demands and load duration requirements.
Determine capital costs associated with connecting targeted customers to the system.

3.3 DISTRIBUTION SYSTEM

Develop distribution options (layout and selection of piping type and installation, if recommended), with consideration of local geography and soil conditions.

3.4 HEAT SUPPLY



Prepare central heating plant basic flow schematic.

3.5 INPUTS TO ECONOMIC ANALYSIS

Estimate operation and maintenance costs including staffing.

3.6 DELIVERABLES

Final report that describes our work and the proposed district heating system and includes:

Flow Schematics

- .1 Thermal side of YECL power plant
- .2 Typical building interface schematics

Layouts:

- .3 Distribution pipe routing

4 INTRODUCTION TO DISTRICT ENERGY

4.1 BACKGROUND

A district heating system consists of the production of energy at a central plant and the distribution of this energy through a network of pipes to remote consumers. Customers simply purchase their heating instead of producing it themselves.

The concept of district heating is not new; history points to the Romans as the earliest users. Piped heating systems were first used by the Romans to heat dwellings as well as baths. It was not until 1880, however, that district heating became well established, in the northeastern United States. Within a decade it had spread to a number of cities across the United States with steam being the preferred energy transfer medium.

The arrival of many small electric utility companies in the United States to serve the growing demand for electric power gave birth to district heating. The exhaust steam produced and normally vented to the atmosphere could be sold to district heating consumers. These systems were the earliest successful combined heat and power schemes. The first district heating company was established in Lockport, New York in 1878 by the Holly Steam Combination Company. The company started with fourteen customers and by 1880 the system included several factories. The distribution network consisted of nearly three miles of steam piping. The early distribution lines were iron pipe wrapped with asbestos, felt and paper and buried approximately three feet in the ground in a wooden box filled with sawdust.



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The development of hot water district heating systems was primarily a European concept designed to overcome the limitations of steam systems.

Today the concept of district heating (and cooling) is widely employed in many countries. In Europe, especially the Scandinavian countries, large hot water district heating systems are common. In North America, district heating and cooling development has been mainly limited to university, military, government, and large industrial complexes.

In Canada, the first district heating system was established in 1924 to serve a small section of the City of Winnipeg's commercial core. Hot water heating systems that use the European concept in Canada include Fort McPherson, Ouje Bougoumou, Sudbury, Windsor, Cornwall, and Charlottetown. Other Canadian cities served today by steam district heating systems include Toronto, Montreal, Ottawa and Vancouver.

The district heating system in Ft. McPherson has been in operation since 1996. The system supplies heating to the School, Hamlet Office, Water Treatment Plant, Community Pool, and the Tent & Canvas Shop. The primary source of energy for this system is provided through heat recovery off the diesel generators in the community power plant (i.e., jacket water and exhaust gases). The buildings' own boilers are used to provide peaking and stand-by capacity.

KATTNER/FVB District Energy Inc. provides the services of professionals with actual district energy system operating experience. In addition, KATTNER/FVB has also studied actual operating experiences from several systems in both Europe and North America.

4.2 DISTRICT HEATING SERVICE

The buildings in Old Crow would be provided with hot water for space heating and domestic hot water from a central heating plant through an above ground distribution network. The primary heating source for the district heating system would be the diesel engines in a cogeneration configuration at the YECL Power Plant in Old Crow. The targeted buildings would initially be providing their own peaking and standby capacity by the means of existing boilers and furnaces.

Hot water (e.g. 45 propylene glycol concentration) will be supplied at 70°C (158°F) in the warm weather season and increased to the maximum of 90 °C in the cold weather season (maximum temperature available from the jacket water heat exchangers). Each building's internal heating system (building side of crossover bridge - direct connection or heat exchanger - indirect connection), receives a final supply temperature in the range of 85-90°C and returns the water at 65-70°C during design days

To provide domestic hot water a separate heat exchanger is installed in the energy transfer station to isolate the domestic hot water supply from the district energy system.

CHAPTER 2. - HEATING DEMANDS AND PRODUCTION

1 Description of the System

The proposed district heating system will consist of the production of heating energy from the central plant (i.e., heat recovery off the diesel generators in the YECL Power Plant), an above ground hot water distribution piping network, and the interface to the buildings' heating systems via energy transfer stations (ETSS). The energy is transferred from the district system to the building hydronic heating systems either directly via a by-pass bridge (or decoupler) or indirectly via a heat exchanger. For the purpose of this study, it has been assumed that all buildings are directly connected.

In addition, forced air heating systems or direct fired unit heaters currently heat the YTG Maintenance Garage, 3 Bay Garage, Nursing Station, and the RCMP buildings. Conversion to district heating will require new fan coil units installed in the existing ductworks and new unit heaters for hydronic heating in the garages.

It is also assumed that the district heating system will provide the buildings' domestic hot water requirements (where applicable). This will require a separate DHW heat exchanger in each building. Further interconnection details including typical building ETS flow schematics are provided in Chapter 6 - Appendices.

2 Heating Demands

2.1 GENERAL

Weather conditions for Old Crow have been taken into account and compared with actual performance data from other similar district energy systems. The combination of actual performance data and local climatic conditions is used as input into our estimating procedures.

A first step in the evaluation of heating loads for a building or a complex of buildings is to determine the energy utilization over the year and to develop a load duration curve (see Appendix 3). The load duration curve graphically displays the relationship between the system load and the duration time that the load exists.

Next, the utilization hours are developed. Equivalent utilization hours represent the period of time the system would sustain full load to generate the equivalent amount of energy that is generated over the course of a year. The term is commonly used to compare different heating or cooling alternatives. The utilization hours that have been developed for Old Crow,

from the load duration curve, is one of the critical inputs into determining the actual heating energy consumption. The average building utilization hours in Old Crow is estimated at 2,200 hours. An alternative term commonly used by utilities is load factor. 2,200 equivalent utilization hours translate into a 25% load factor.

2.2 HEATING ENERGY CONSUMPTION

The heating energy consumption for individual buildings in Old Crow has been made available. Information from other district heating systems in both North America and Europe has been used to arrive at some typical full load utilization hours for different building types and usage. Energy is then derived at by multiplying the full load utilization hours by the estimated peak demand for each building.

2.3 HEATING LOAD

The district heating system has to be designed to provide enough capacity to deliver each building's peak heating needs during the coldest design days. The winter design day for Old Crow (i.e., Inuvik, NWT) is -40°C according to ASHRAE 1% design criteria.

To establish an accurate estimate of each building's peak capacity requirements three different methods can be used:

Use a watts per square meter estimate based on climatic conditions and building type.

Determine a building's current installed boiler capacity and how much of it is utilized during peak conditions. This is often difficult to get due to the fact that most boilers instantaneous load is hard to determine.

Work backwards from fuel consumption with some assumptions for boiler efficiency and building usage

All of the above three methods have been used to determine each buildings peak heating load and annual energy requirements. Table 1 summarizes the peak heating loads and annual energy requirements for the buildings being considered for the district heating service. Refer to Appendix 4 for details regarding estimated displaced oil, current oil use and assumed seasonal heating equipment efficiencies.

Table 1 - Heating Loads For Old Crow

Building	Peak Heat Load	Annual Heat Energy
Teachers' Residences	28 kW	67 MWh
3 Bay Garage	38 kW	75 MWh
Nursing Station	83 kW	199 MWh
Air Terminal	67 kW	143 MWh
Foreman's Residence	12 kW	29 MWh
YTG Maintenance Garage	71 kW	171 MWh
RCMP Barracks	28 kW	56 MWh
RCMP Duplex	40 kW	80 MWh
RCMP Old Barracks	36 kW	72 MWh
RCMP Garage & Shed	7 kW	14 MWh
YECL Power Plant	**25 kW	**45 MWh
Total	435 kW	951 MWh

** The peak demand for plant internal heating system is estimated at 50 kW. The radiation from the engine(s) can provide approximately 25 kW and an additional 25 kW provided by the jacket water heat exchangers. It is proposed that the plant heating system will become a priority non-metered customer of the district heating system.

2.4 LOAD DIVERSIFICATION FACTOR

A district heating system will typically have a lower thermal peak than the sum of the individual buildings' thermal peaks that are being served. This is mainly due to the fact that individual buildings reach their respective thermal peaks at different times during the day. However, due to the relatively homogeneous targeted building category (e.g. a majority of the buildings are public buildings i.e. Nursing Station, Air Terminal etc. will likely reach their thermal peak at around 7 AM to 9 AM. For the residences, the domestic hot water peak happens for a very short period of time while the space heating peak constantly builds on itself during the day; therefore, does not have an impact on the building peak.

The term to describe the combination of these phenomenon is called load diversification. However, since the residences make up a fairly small portion of the total thermal load, the system in diversification is expected to be only between 90 and 95%, based on the building categories and experience from other similar systems.

This allows us to design a production plant and distribution system to deliver approximately 90% of the buildings' total peak thermal load. In Old Crow the targeted buildings' peak thermal load is 435 kW, the diversified peaking capacity required should therefore be 400 kW.

3 Production Plant Heating

3.1 GENERAL

Diesel engines are a well-proven technology for electricity generation. In an electrical generation application, they produce approximately 35 - 40 units of electrical energy from 100 units of fuel. With a heat recovery boiler and water jacket cooling, about 80% of the total energy can be recovered. The plant proposed in Old Crow consists of three diesel engines, water jacket cooling, heat exchangers, and distribution pumping. A preliminary schematic of the production plant is included in the Appendices.

3.2 HOT WATER PRODUCTION PLANT OPERATION

It is proposed that the Old Crow district heating system utilize the residual heat from the three existing diesel engines located at Yukon Electric's (YECL) power plant (Caterpillar #3406B & #3412 & #3508). In order to utilize these engines' waste heat rejection, plate & frame heat exchangers would be installed on the jacket water cooling circuits. In addition, the district heating piping configuration inside the plant would allow for a future heat recovery boiler to be installed at either the #3412 or #3508 to accommodate future additional thermal loads.

Based on the current operating records provided by YECL, the 3412 have the longest yearly operating hours and thus would be the best candidate. Based on published heat rejection data from Caterpillar, the following thermal capacity can be delivered from these engines at current peak electrical operating conditions:

Table 2 - Thermal Capabilities Of Existing Power Plant

UNIT	Heat From Water Jacket (kW)	Heat From Exhaust (kW)	Total (kW)
3508	250	N/A	250
3412	200	N/A	200
3406B	120	N/A	120

The 3508 can presently provide the community's peak electrical demand (~430 kW according to data for the 2000/01 season). This means that up to 250 kW will be available for the proposed district heating system from the jacket water alone based on the current electrical load. The capacity is reduced to approximately 200 kW when the 3412 are operating. Finally, the 3406B can provide approximately 120 kW from the jacket water. It should be noted that the jacket water heat rejection capacities indicated in the table above, are based on the 2000 electrical load data provided. A possible future increase in the electrical demand in the community would lead to a corresponding increase in the recoverable heat.

According to the data logs provided by YECL for year 2000, the 3508 runs during mostly daytime winter conditions and the 3412 at night and almost continuously during the shoulder seasons (e.g. spring/fall). The 3406B runs mostly during summer conditions.

According to the engine operational data provided, only one engine is operating at any given time. Thus the maximum thermal heat capacity for the district heating system is 250 kW.

The amount of recovered heat energy (from the jacket water) on an annual basis was derived from the hourly and total electrical data for 2000 provided by YECL, from heat rejection data for the engines, and from the load duration curve established for Old Crow. The result of this analysis shows that approximately 85% of the annual thermal energy requirements of the targeted customers can be supplied from the JW heat recovery alone. The result of this analysis is graphically presented in Appendix 3

With a heat recovery boiler added to the 3508, another (minimum) 250 kW thermal capacity could potentially be recovered of this engine. This again would increase the annual thermal energy supplied from the engines to virtually 100% of the DH systems annual requirements.

3.3 STANDBY AND PEAKING FACILITY

For Old Crow, it has been assumed that the targeted buildings would provide their own peaking and standby requirements. The buildings would use the existing furnaces and boilers when the load exceeds the plant capacity. In the future, additional boiler capacity could be added at the plant (in a form of a heat recovery boiler or an oil fired boiler) and thus eliminate the need to utilize existing building boilers/furnaces for peaking purposes.

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4 Distribution System

4.1 GENERAL

The distribution system proposed for Old Crow would consist of an above ground direct hot water distribution network with supply and return pipelines in a closed circuit. Kattner/FVB recommends that the piping be installed above ground because of the discontinuous permafrost conditions at the site. Each building will be connected to the network via a customer energy transfer station that will regulate and meter the energy taken from the distribution system.

Hot water will be pumped via variable speed/constant pumps through the distribution piping from the hot water production plant. An expansion tank, located in the hot water production plant, connected to the system compensates for thermal expansion caused by temperature changes in the system.

The pipe layout for the heating network is illustrated in Appendix 2.

4.2 HOT WATER DISTRIBUTION NETWORK

Centralized heat production is only an advantage if an efficient system of distribution to the buildings is available. Typically a third to half (or even higher for extreme environments like Old Crow) of the total investment in a district heating system (comprising - production, piping and ETS's) is the pipe network. The choice of materials and correct installation of the pipe network are therefore critical factors in the economic performance and overall reliability of the entire district heating system.

Due to the location and the soil conditions in the case of Old Crow it is recommended that consideration be given to installing the majority of the distribution network above ground on piled supports. It is proposed that the pre-insulated heating pipe be utilized with the piping being encased in a protective galvanized metal jacket. These pipes are a well proven design that have been successfully utilized in systems in countries throughout the world over the last 20 years. A small portion of the pipework will be installed below ground in corrugated steel culvert where it is necessary to cross roads and property accesses.

With the above ground distribution system on piled supports proposed for Old Crow soil conditions should not cause any concerns. Previous soil reports reveal soil conditions in the Townsite contain rich ice inclusions with visible ice logged up to 30% by volume, and averaging 10-15% through most of the material. This indicates that the foundation soils are susceptible to significant thaw-settlements, if not maintained in a permanently frozen condition. In such conditions it is recommended that installation of the

distribution system be kept above ground wherever practicable in order not to disturb the permafrost conditions.

CHAPTER 3. - ECONOMIC ANALYSIS

1 Capital Investment Required

1.1 DISTRIBUTION AND SERVICE PIPING

The capital cost estimation for the Distribution Piping is based on actual installation costs for the distribution and service lines from similar district heating projects, information from material suppliers, local expertise and in house calculations. The total costs are shown in the following table:

Table 3 – Distribution Piping Costs

Service	Mechanica I	Civil (Piling)	Civil (Road Crossings)	Air Freight*	Total
Phase 1	\$490,000	\$60,000	\$50,000	\$90,000	\$690,000
Phase 2	\$395,000	\$55,000	\$50,000	\$90,000	\$590,000
Total	\$885,000	\$115,000	\$100,000	\$180,000	\$1,280,000

Distribution Piping Budget Assumptions

- The costs listed above include thirteen (13) percent to cover project management, and twelve (12) percent to cover engineering and commissioning and ten (10) for contingency.
- All pre-insulated steel piping with medium gauge galvanized outer jacket (e.g. Spiwrap® System).
- All piping will be above ground placed on piled supports with the exception of road crossings.
- *Piping material assumed to be shipped by air by two chartered Hercules. Max. load carrying capacity is 42,000 lbs/plane. Some potential savings may be available by trucking to Dawson City and ship by air on to Old Crow.
- Refer to Distribution Piping description in Appendix 8 .

1.2 ENERGY TRANSFER STATIONS

The capital cost estimation for the Energy Transfer Stations is based on actual installation costs, for similar type buildings as Old Crow, information from material suppliers (prefabricated systems) and in house calculations. The building interface costs (ETS and interconnecting piping) for the targeted buildings are summarized in Table 4 below.

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Table 4 – ETS Costs

Building	ETS Cost (1000\$)
Teachers' Residences	14
3 Bay Garage	27
Nursing Station	36
Air Terminal	0*
Foreman's Residence	8
YTG Maintenance Garage	36
RCMP Barracks	23
RCMP Duplex	32
RCMP Old Barracks	30
RCMP Garage & Shed	5
Total	211

ETS Budget Assumptions

- The costs listed above include twenty (20) percent to cover project management, and engineering as well as a ten (10) percent contingency.
- Primary side components and piping to meet the requirements of the building service piping code B31.9.
- No cost allowance for asbestos abatement.
- All buildings are directly connected to the district heating system via energy transfer stations.
- Domestic hot water included for the residences (excluding the Teacher's Residences) and the Nursing Station only.
- Refer to ETS descriptions in Appendix 9.
- * The cost for the ETS for the ATB to be incorporated into the overall mechanical cost for the new building according to the Pembina Institute
- Energy meters included for individual metering at each building ETS. The potential cost reduction with central metering only (at the plant) is \$12,000.

1.3 PRODUCTION PLANT

The hot water production plant should be installed within YECL's existing power plant. The capital cost estimation for the district heating connection is based on actual installation costs, from similar types of projects, information from material suppliers and in house calculations. The capital cost includes the connections to each of the jacket water heat exchangers

and the heat recovery boiler. The estimated costs, material and labour, for the plant is detailed in Table 6.

Table 6 - Production Plant Costs

	Cost
D-H Jacket Water Heat Exchangers	\$ 18,000
Water Treatment	\$ 12,000
Controls & Electrical	\$ 30,000
Energy Meter	\$ 4,000
Pumps incl. Variable Speed Drives	\$ 22,000
Piping, Fitting & Misc. Equipment	\$ 30,000
Subtotal	\$116,000
Proj. Construction & Management (5%)	\$ 5,500
Engineering & Commissioning (15%)	\$ 17,500
Contingency (10%)	\$ 11,000
Total	\$150,000

Plant Budget Assumptions

- The costs listed above include twenty (20) percent to cover project management, and engineering as well as a ten (10) percent contingency.
- Piping to meet the requirements of the building service piping code B31.9.
- No cost allowance for asbestos abatement.
- No cost allowance for removal of existing equipment and piping.
- All DH equipment installed within the existing building. A preliminary review of the sketch and pictures provided by Pembina indicates that there is sufficient room between the engines for the JW heat exchangers. The pump skid would be installed at the location of an existing workbench.

1.4 INCREMENTAL COST ANALYSIS

It is common to develop district heating projects in phases to optimize the return of investment. Typically the core area with the highest heating density is developed first. The more marginal areas are then developed later based on an incremental analysis. Some potential customers may even be uneconomic to connect since the required invested capital will never be recovered through the experienced energy savings. For Old Crow, the following incremental staging will increase the economic viability of the project:

Table 7 - Incremental Cost Analysis

Incremental Stage	Distribution System	Plant	ETS	Total	Displaced Fuel/year ¹
Total Project-Phase I & II	\$1,280,000 [1,045 m]	\$150,000	\$211,000	\$1,641,000	\$162,335
Phase I only	\$690,000 [585 m]	\$150,000	\$121,000	\$961,000	\$125,995

1). Based on \$1.25/L

2 Operating And Maintenance Costs District Energy System

Experience from other district heating systems point to a strong relationship between capital costs for energy transfer stations, distribution piping and production plant and their respective operating and maintenance costs.

Table 8 – Annual O&M Costs

	Annual Cost
ETS	\$2,000
Piping	\$4,000
Production Plant	\$2,000
Pumping	\$3,000
Administration Overhead	\$0*
Total	\$11,000

Annual variable costs include for plant consumables such as electricity, water, chemicals, and equipment maintenance. * It is assumed that the administration overhead will be incorporated into the existing plant and building operation (including customer billing).

CHAPTER 4. - ENVIRONMENTAL AND SOCIAL BENEFITS

1 General

The development of a district energy service is a response to the need to provide energy into the future in a manner, which is consistent with the need to protect our environment. The production of Combined Heat and Power (CHP) in Old Crow allows for significant improvements in energy conservation. Energy conservation and the smart use of fuel sources are the most cost effective ways available to us to reduce emissions of global

warming and ozone depleting gases into the atmosphere. In addition, quality of life can be maintained without a significant increase in the cost of energy to meet the international protocols for a positive reduction in nitrous oxides (NO_x) and carbon dioxide (CO₂).

The underlying principles adopted for district energy are to provide a cost effective, reliable, efficient and environmentally friendly service which not only benefits the customer but also the public at large through lower emissions of nitrous oxides and carbon dioxide in the production of heating.

2 District Heating

The primary source of energy for the district heating system will be the diesel engines in a cogeneration configuration at the YECL Power Plant in Old Crow. The targeted customers will initially be providing their own peaking and standby capacity. Some 85 % of the district heating system's annual thermal energy requirements can be provided through heat recovery off the engine(s) jacket water. The system design however allows for future installation of a heat recovery boiler (or hot water boiler) in the plant to cover 100 % of the annual thermal requirements.

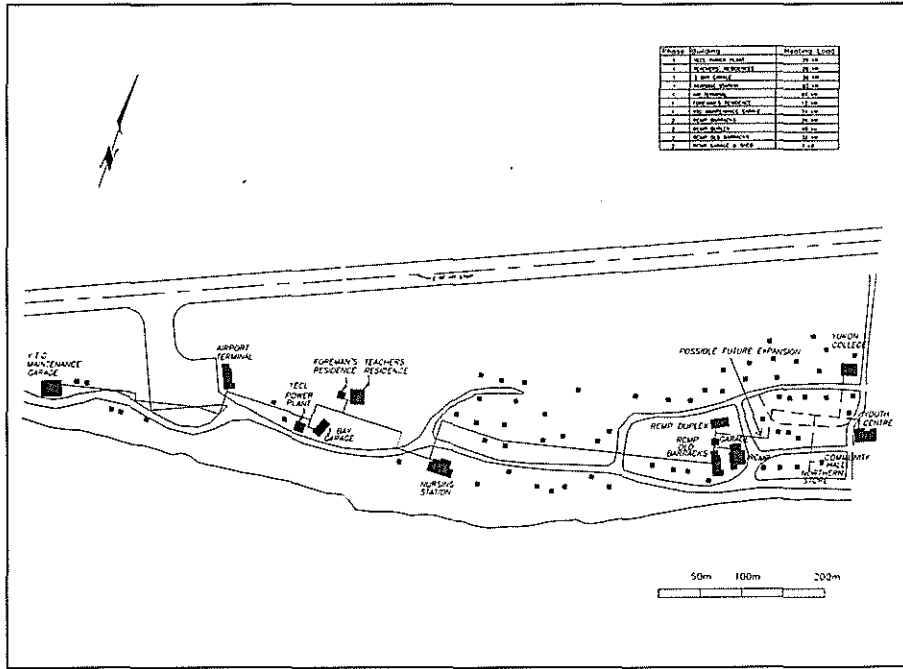
Typically, if a diesel engine is used to generate electricity alone it will produce 35 to 40 units of electricity for every 100 units of fuel it consumes (35%-40% efficiency). By configuring the diesel generator to operate in a cogeneration mode both heating and electricity are generated at the same time with between 60 - 80 units of energy (electrical & heat) being produced for every 100 units of fuel it consumes (over 60% - 80% efficiency).

CHAPTER 5. - APPENDICES

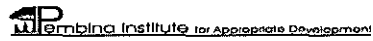
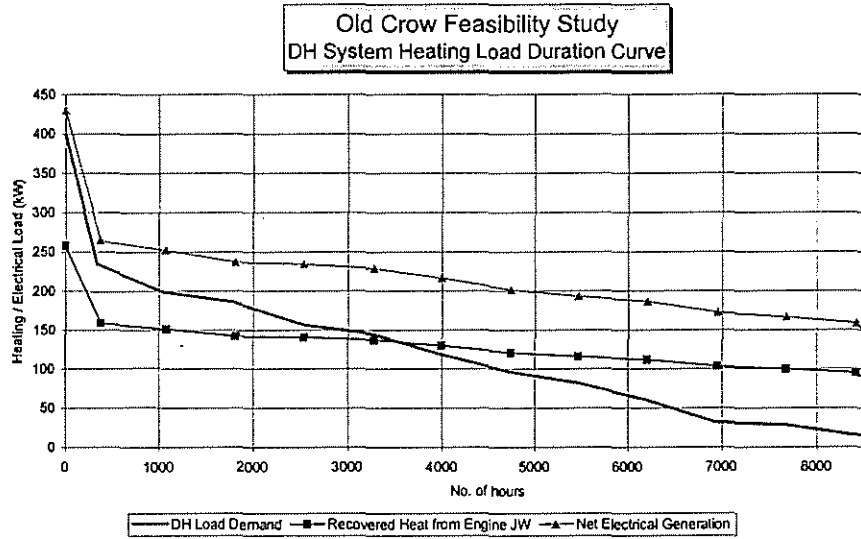
1 Useful Conversion Factors

Length	1 m	=	3.2808	ft
Area	1 m ²	=	10.764	ft ²
Volume	1 m ³	=	35.31	ft ³
	1 m ³	=	220.0 gal	= 1000 l
	1 l	=	0.222	gal
Mass	1 kg	=	2.2046	lb
	1 t	=	0.9842	ton = 1000 kg
	1 unit	=	200 ft ³	= 5.67 m ³
Velocity	1 m/s	=	196.85	ft/min
Flow rate	1 kg/s	=	7937	lb/h
	1 m ³ /s	=	2119	ft ³ /min
	1 l/s	=	15.8	USGPM
Pressure	1 bar	=	14.5	lbf/in ² (psi)
	1 bar	=	100	kPa
	1 bar	=	401.5	in H ₂ O
Energy	1 kWh	=	3.6 MJ	= 0.0036 GJ
	1 GJ	=	9.478	therms
	1 kWh	=	3412.1	Btu
	1 kW	=	1.341	hp
	1 MWh	=	3.6	GJ
	1 MWh	=	3.412	MMBtu
Calorific value		1 kJ/kg	=	0.4299 Btu/lb
		1 MJ/m ³	=	26.84 Btu/ft ³
		1 MJ/kg	=	0.2778 MW/ton

2 District Heating Distribution System Layout



3 District Heating Load Duration Curve

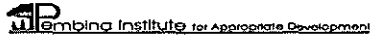
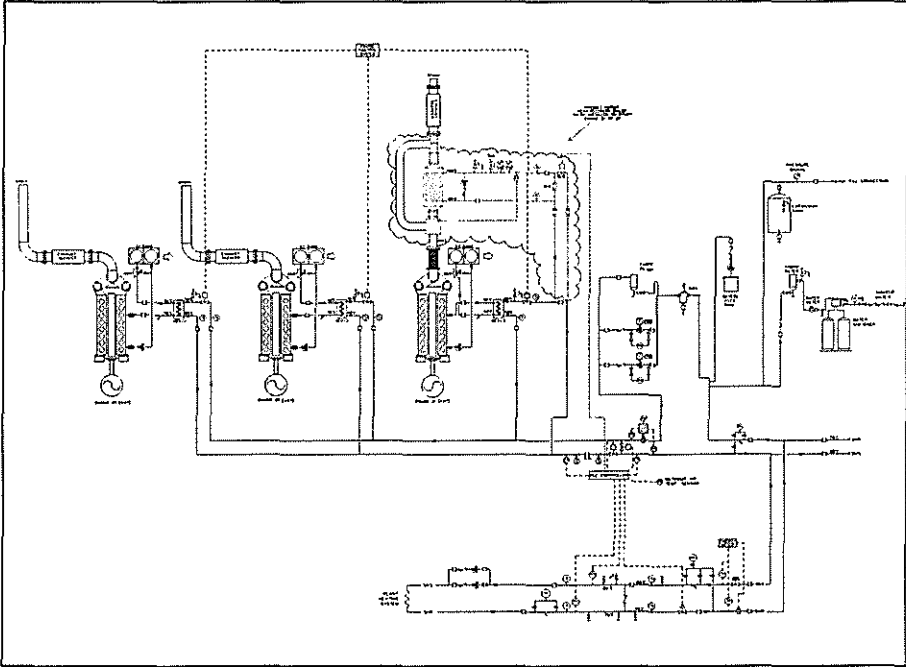


4 Estimated Heating Loads And Energy Requirements

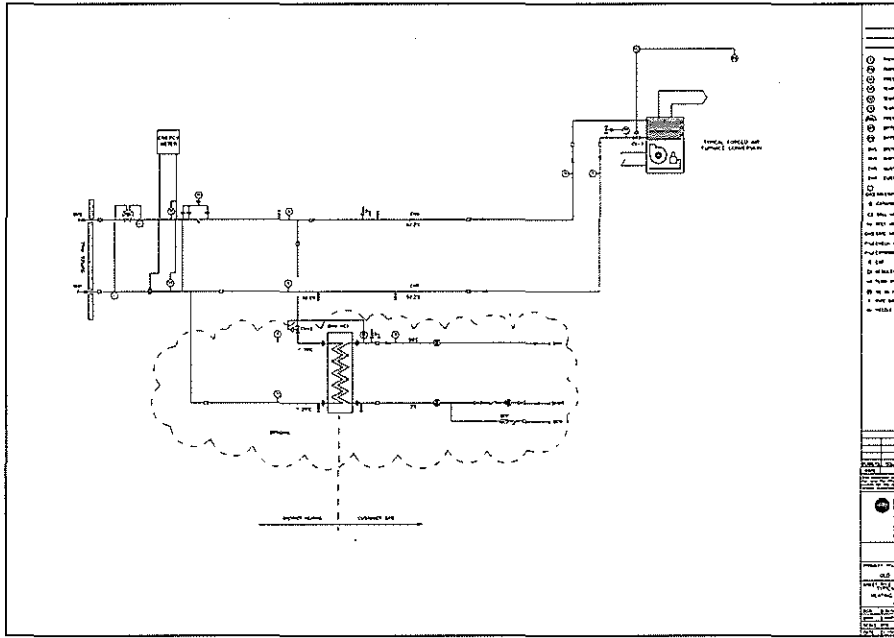
BUILDING NAMES:	Building Area (m ²)	Peak Htg Load (KW)	Htg Energy (MWh)	Heat Rec. (MWh)	Displ. Fuel (L)	Boiler Eff. (H.H.V.)
EXISTING BUILDINGS: PHASE 1						
YECL Power Plant		25	45	45	-	
Teacher Residences	232	28	67	60	10,022	0.60
3 Bay Garage	250	38	75	68	11,250	0.60
Foreman's Residence	99	12	29	26	4,277	0.60
YTG Maintenance Garage	474	71	171	154	25,596	0.60
Nursing Station	691	83	199	179	29,851	0.60
NEW BUILDINGS PHASE I:						
Air Terminal	305	67	143	129	19,800	0.65
SUBTOTAL	2,051	323	728	660	100,796	
EXISTING BUILDINGS: PHASE 2						
RCMP Barracks	232	28	56	47	7,281	0.65
RCMP Duplex	334	40	80	68	10,482	0.65
RCMP Old Barracks	302	36	72	62	9,478	0.65
RCMP Garage & Shed	302	7	14	12	1,831	0.65
SUBTOTAL	1,170	111	222	189	29,073	
TOTAL	3,221	434	950	849	129,869	

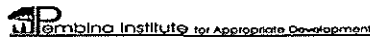
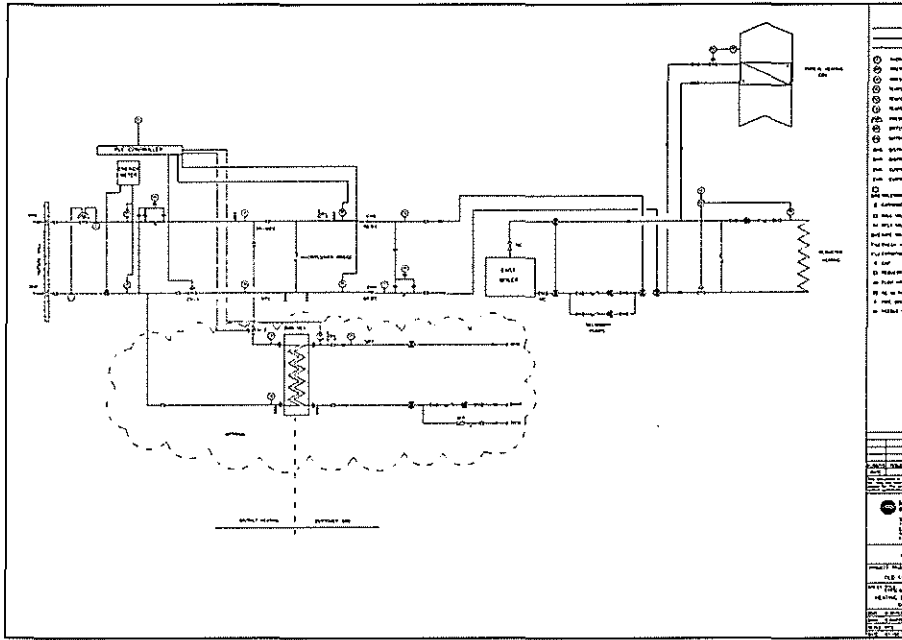


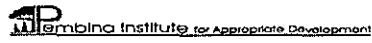
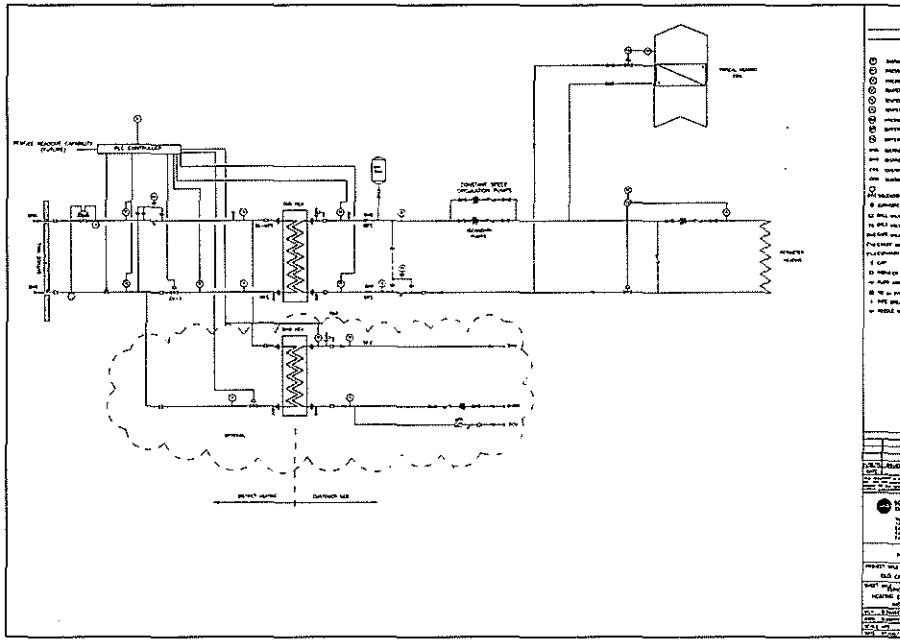
5 Hot Water Production Plant Schematic



6 Typical Building Energy Transfer Station Schematics

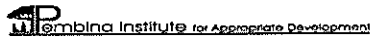






7 Project Schedule

ID	Task Name	Duration	Start	Finish	November		December		January		February		March		April		May		June		July	
					10/14	11/11	12/8	1/5	2/2	3/3	4/21	5/28	6/28	7/23								
1	Engineering Design	84 days	Mon 10/22/00	Mon 12/18/00																		
2	Preliminary Design	22 days	Mon 10/22/00	Tue 11/20/00																		
3	Building Load Survey	4 days	Mon 10/23/00	Thu 10/26/00																		
4	Preliminary Design, ETS, Piping, & Pl	12 days	Fri 10/26/00	Mon 11/13/00																		
5	Detailed Schedule	3 days	Tue 11/13/00	Wed 11/14/00																		
6	Major Equipment List - Long Delivery	4 days	Thu 11/15/00	Tue 11/20/00																		
7	Preliminary Design Review	6 days	Wed 11/21/00	Tue 11/27/00																		
8	Meeting & Material Review	4 days	Wed 11/21/00	Mon 11/26/00																		
9	Owner Review Complete	1 day	Tue 11/27/00	Tue 11/27/00																		
10	Major Equipment Order - Long Delivery	40 days	Tue 11/27/00	Mon 12/18/00																		
11	Pumps	6 wks	Tue 11/27/00	Mon 1/7/01																		
12	VFD's	6 wks	Tue 11/27/00	Mon 1/7/01																		
13	Heat Exchangers	6 wks	Tue 11/27/00	Mon 1/7/01																		
14	Ball Valves	8 wks	Tue 11/27/00	Mon 1/21/01																		
15	Piping	8 wks	Tue 11/27/00	Mon 1/21/01																		
16	80% Design	10 days	Wed 12/6/00	Tue 12/19/00																		
17	ETS, Distribution, Cogen Plant	6 days	Wed 12/6/00	Fri 12/7/00																		
18	80% Design Review	1 day	Mon 12/10/00	Mon 12/10/00																		
19	Meeting & Material Review	4 days	Wed 12/13/00	Mon 12/18/00																		
20	Owner Review Complete	1 day	Tue 12/19/00	Tue 12/19/00																		
21	Detail Design	18 days	Fri 12/14/00	Tue 1/8/01																		
22	ETS, Distribution, Cogen Plant	17 days	Fri 12/14/00	Mon 1/7/01																		
23	Completion of Design	1 day	Tue 1/8/01	Tue 1/8/01																		
24	Tender	22 days	Wed 1/9/01	Thu 2/7/01																		
25	Invite for Construction Tender	15 days	Wed 1/9/01	Tue 1/29/01																		
26	Construction Tender Close	1 day	Wed 1/30/01	Wed 1/30/01																		
27	Review Construction Tenders	5 days	Thu 1/31/01	Wed 2/6/01																		
28	Award Construction Contract	1 day	Thu 2/7/01	Thu 2/7/01																		
29	Construction	71 days	Wed 2/14/01	Wed 4/24/01																		
30	Delivery of Equipment & Piping to Old Crow	2 days	Wed 2/14/01	Thu 2/15/01																		
31	Mobilization	1 wk	Wed 2/14/01	Tue 2/20/01																		
32	Installation	60 days	Wed 2/20/01	Tue 4/10/01																		
33	Construction Complete	1 day	Wed 4/10/01	Wed 4/10/01																		
34	Testing & Commissioning	5 days	Thu 4/12/01	Wed 4/25/01																		



8 Preinsulated Steel Pipe System

8.1 GENERAL

Preinsulated Schedule 40 steel pipes consist of three different elements, carrier pipe (steel), insulation (polyurethane foam PUR) and jacket pipes (spiral 18 gauge galvanized outer jacket). The carrier pipe steel is typically high frequency welded steel pipe. These three components are securely bonded together to form a solid unit. The expansion forces that result from the pipe being heated are transferred via the foam insulation to the outer casing jacket, which in turn expands in line with the steel pipe. This system has been extensively used throughout the N.W. Territories for above ground utility systems (including Fort McPherson).

8.2 STEEL PIPE

Although many different types of carrier pipe are currently available (Plastic, Copper, etc.) steel carrier pipe is preferred in the case of the Fort McPherson system. It has some advantages to the designer, installer and purchaser of the network:

- It has well defined mechanical properties, making it a suitable construction material.
- The welding of steel pipes is widely accepted and ensures a high degree of water tightness and mechanical strength in the joints.
- Several manufactures produce high quality steel pipe.

8.3 FOAM INSULATION

Polyurethane foam is a two component plastic that has many applications. In the case of preinsulated steel pipe it is used because of its ability to maintain excellent insulating and mechanical properties throughout the lifetime of the system (20 years or more) at operating temperatures up to 130°C (266°F).

8.4 GALVANIZED STEEL OUTER JACKET

The medium gauge spiral galvanized steel (Spiwrap®) outer jacket outer casing serves two purposes. First it serves as a form for the polyurethane insulation during the foaming process when the pipe is being fabricated. Afterwards it serves as a watertight protective casing for the insulation that

is able to resist all normally occurring mechanical impacts during transportation, installation and operation of the network.

8.5 RECOMMENDED SYSTEM

The above ground steel pipe system with galvanized steel outer jacket, placed on piled supports is recommended as the preferred method for installation for the following reasons:

- ⇒ Costed out as the least expensive of the various alternatives considered.
- ⇒ Much of the prefabrication work can be done off site and shipped ready made.
- ⇒ The simple twin pipe system, varying in size from 32 mm dia. to 100 mm dia., will be less intrusive into the environment.
- ⇒ Durable proven system of insulated piping

8.6 ALTERNATIVE MATERIALS AND SYSTEMS CONSIDERED

The following alternative materials and systems were considered for the Fort McPherson project:

PEX System - The carrier pipe is made of cross-linked polyethylene (PEX) with an organic oxygen diffusion retainer. The jacket pipe is made of polyethylene (LDPE) with semi-flexible polyurethane (PUR) foam between carrier pipe and jacket. Jointing of the pipes is by copper compression couplers. This system was considered in combination with a corrugated steel pipe (CSP). The PEX system would be placed inside the CSP for protection and support. This system due to the material and fittings is found to be expensive compared with other systems.

Insulated Steel Pipes in Corrugated Steel Pipe ((CSP)) - This system would comprise both supply and return insulated steel pipes installed inside a CSP utilidor type casing as protection and for ease of laying. The system proved to be not only expensive but cumbersome in that large sizes of CSP are required to accommodate branch line take offs.

9 Energy Transfer Stations

9.1 GENERAL

Each heat transfer station generally consists of one heat exchanger unit for domestic hot water heating and direct connection via a by-pass bridge to the space heating. The ETS is equipped with the necessary controls as well as all the internal piping. The ETS is designed for ease of connection to the building's internal hot water system, utilizing as little space as is possible.

Energy meters which can instantaneously measure temperatures and loads, and automatically accumulate energy and flow rates are included in each ETS.

The service lines, pipes that connect the energy transfer stations with the distribution system, are assembled on site and will include isolating valves, strainers, pressure indicators and the energy meters.

For Old Crow all energy transfer stations would be located in each building's existing boiler room. The energy transfer stations are then connected at the boiler headers. In the case of the buildings currently heated by forced air, new hydronic coils will be fitted into the existing ductwork and connected directly to the distribution network. Since the waste heat available from the plant will only cover about 60 % of the peak demand, each building's will have to provide their own peak thermal load. It is estimated that the boilers/furnaces will have to operate less than 1,500 hours per year and cover approximately 15 % of annual thermal energy requirements. Approximately 85 % of the annual energy requirements will in the form of waste heat provided from the plant. Refer to load duration curve in Appendix 2.

The ETS will preheat each building's secondary system to meet its heating requirement, the boiler/furnace will only kick in when the system temperature drops below the boiler low set point. The downside of this approach is that there will be some heat losses through the boiler(s) as it is kept warm during the heating season even when it is not running. However, the losses will not be any larger than what is currently being experienced so it should be acceptable to the customers. It is also very important to set the low thermostat as low as possible to avoid unnecessary operation of the boilers. Also the high thermostat should not be set higher than what is required to meet the building peak load. The control of the firing of the boilers/furnaces would be handled from the programmable controller supplied for each ETS.

9.2 ENERGY TRANSFER STATION CONTROL STRATEGY

The district heating system will initially be supplying baseload energy to the buildings (50% of peak load). The differential pressure (DP) in the distribution system will vary throughout the network which means that the buildings close to the plant will have more available DP than the one located further away from the plant (See Appendix 2). The flow to each building will therefore have to be restricted in order to make sure that all customers will receive some waste energy during all operating conditions.

To achieve this, all ETS's will be fitted with a pressure differential control valve (PDCV), which will be set at 1.0 bar (min.) for all buildings. This DP is sufficient to overcome pressure losses over the heat exchanger, control valves and connecting piping. The valve will maintain this set point (1.0 bar) independent of the flow variations in the system.

BUILDING NAME: TEACHER'S RESIDENCE

Address: Buildings 180/185
Owner: YTG
Contact: Danny Kassi - YTG Maintenance (966-3151)

Main use: Two separate teachers' houses

Gross floor area: 2500 ft²
Number floors above grade: 1
Number floors below grade: 0
Building age: 20 yrs?

Hours of operation: 24 hr.

Envelope

Walls: Wood frame walls. Insulation unknown.
Roof: Wood frame roof. Insulation unknown.
Floor: Wood frame w/ 4" batt.
Windows: Double-glazed.

Tenants complain of water leakage, but west tenant say that air leakage is not too bad. However, blower test indicates that east unit is much worse than west due to work done on leaky plumbing, when air barrier was compromised. Blower test indicated 3.1AC @ 50Pa, 0.8AC @ 10Pa for the west unit, 6.3AC @ 50Pa, 2.3AC @ 10Pa for the east unit.

Lighting

All incandescent.

Heating

Heating is provided by one oil fired boiler serving hot water radiators. Boiler is located in small shed adjacent to west unit. There is also a fireplace in each living room that is not used at all by east unit but used occasionally by west unit. Appears to be plenty of heat capacity. East unit tenant said that one year heating went down for 2 months and they were able to heat their space with a couple of small electric heaters, although it wasn't coldest period.

B-1: Oil fired boiler. Serves both units. Burnham V-74. Beck AFC burner. 1.35 gph input, 156 MBH output. Supply water temperature set to 200°F. 85 Watt circulation pump runs continuously.

DHW: Electric DHW tank. GSW Series 5.175 L. 3.0 kW. Located in laundry room. One per unit.

Fuel usage: Unknown.

Peak usage: Unknown.

Layout: See sketch

District Heating Potential

Building is already hot water, very easy to convert to district heating. Boiler room is somewhat tight, but should be room for heat exchanger/valving. As is residential, DHW usage should be somewhat higher than other buildings, but would have to be converted to hot water heat. Existing boiler could be used for peaking purposes. The building is located 150 m east of the power plant.

BUILDING NAME: 3 BAY GARAGE

Address: Building 170

Owner: YTG

Contact: Bobby Benjamin (966-3381), Danny Kassi - YTG Maintenance (966-3151)

Main use: Fire and water truck parking

Gross floor area: 2200 ft²

Number floors above grade: 1

Number floors below grade: 0

Building age: 1988.

Hours of operation: M-F, 8 - 4:30.

Envelope

Walls: Wood frame wall with R20 batt between studs and R23 over top of framing.

Doors: Insulated metal garage bay doors, average.

Roof: Metal frame roof w/ R50 insulation.

Floor: Concrete w/ R30 insulation. Insulation unknown.

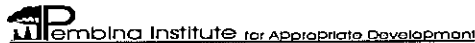
Windows: Triple glazed. Vinyl frame. Minimal window area.

There is a fairly high level of infiltration through garage and other doors. Large cracks around doors.

Lighting

8 - 2 lamp T12 fluorescent strip fixtures on walls per bay (3 bays). Quite bright, even with 25% burnouts still plenty of light. Lights tend to be left on even when building unoccupied.

Heating



Heating is provided by one oil fired unit heater per bay. There are small transfer fans that move air between the bays. There is also a small AHU that recirculates air and heats it to supply the storage room that is no longer used. In addition, an experimental heat pump system has been installed in water truck bay, but is no longer operational.

UH-1,2,3: Oil fired unit heater. Each one serves one bay. 0.75 gph input, 96 MBH output. ~1/4 hp fan motor. Each UH is controlled by space t'stat. In the unused small bay, t'stat set to 32°C, but unit was not running at a space temperature of 23C. In water truck bay, maintaining t'stat setpoint of 28°C. In fire truck bay, maintaining t'stat setpoint of 23°C.

UH-4: Oil fired unit heater. Provides heat to unused small bay by means of short duct run. Controlled by duct stat set to 80°F. Unit is manually turned off, and appears to have been used for some specialized purpose in the past. Not required for heating the bay.

AHU-1: Oil fired air-handling unit. Located at high level in fire truck bay. Serves storage room. According to staff, this unit is no longer used. This would mean temperature in this room is just maintained by conduction from the fire truck bay. T'stat is located in storage room.

HP-1: Ground source heat pump with refrigerant evaporator coils below floor slab. 11 kW heating capacity. 1/4 hp supply fan. Believed to have been installed as a research project. No longer used, but supply fan continues to run.

DHW: Electric DHW tank. John Woods Space Saver. 30 L. 1.5 kW. Located under washroom.

Fuel usage: 12,770 L per year. May not be particularly accurate.
Peak usage: Unknown.

Layout: See drawing

District Heating Potential

The easiest way to convert to hot water would be to install new hot water unit heaters in each bay. Heat exchangers/valving could be located at high level in one of the bays, or in the storage room. The existing unit heaters would remain and could be used for peaking purposes by setting their t'stat setpoint below those of the hot water UHs. Existing t'stats would probably need to be re-calibrated or replaced. The building is located 30 m east of the power plant.

BUILDING NAME: NURSING STATION

Address: Building 200

Owner: YTG

Contact: Danny Kassi - YTG Maintenance (966-3151), Huey - Custodian, June - Nurse



Main use: Nursing station, light use medical facility. All serious cases are flown out. Also provides apartment style residence upstairs for three nurses.

Gross floor area: 7440 ft² plus 4700 ft² heated crawl space. Approx. 2700 ft² upstairs, 4740 ft² down.

Number floors above grade: 2

Number floors below grade: crawl space

Building age: Various renovations and additions. Major construction 1959 and 1985.

Hours of operation: Open to public M-F, daytime. However, open for emergencies 24 hours. Living areas upstairs 24 hrs.

Envelope

Walls: Double wood frame wall with R12 batt in framing and R28 between walls

Roof: Wood joist with R70 batt

Crawlspace floor: Wood frame with R20 batt and R6 rigid

Windows: New (triple?) glazed with vinyl frames, operable.

Envelope generally seems to be good, but staff complains of drafts. Likely is poor temperature control rather than poor envelope construction. Blower test of building indicated fairly high leakage rate (7.7AC @ 50 Pa, 2.7 AC @ 10Pa) but could not find where leakage occurred. May be in crawlspace.

Lighting

Lighting downstairs is Linear fluorescent with 34W T12 lamps. Replacement ballasts are energy saving magnetic. Upstairs is all incandescent.

Heating

Heating is provided by three forced air furnaces. Two serve the downstairs, one N side, and one S side. One serves all of the upstairs. T'stats are located in space, downstairs in interior zones on each side, upstairs in S side living room. Temperature control is very poor, largely due to zoning and t'stat location. During site visit, with OAT at -10°C, upstairs S side windows were open in order to maintain heat on N side. There are complaints of insufficient capacity in the furnaces on very cold days, but indications are this is also more due to poor temperature control.

F-1, 2: Oil fired furnace. Serves downstairs (N and S zones). Airco D-189. 1.0 gph input, 117 MBH output. 1/3 hp fan motor. Furnaces are old, but maintained regularly, however, F-2 was not running during site visit and had been broken for 3 weeks according to nurse. New burners last year. Furnace have a common return and OA is provided by common 10"Ø duct. Supply is down to crawlspace, where transitions to 18"Ø duct, one per furnace. There is a manual damper that will allow the supply ducts to flow into each other. There is room to install heating coils in crawlspace ductwork.

F-3: Oil fired furnace. Serves upstairs apartments. Airco D-189. 1.55 gph input, 155 MBH output. 1/3 hp fan motor. Furnace is 15 years old, but maintained regularly. New burner last year. 8"Ø OA duct, but manual damper closed. Supply is 18" x 18" up, then

transitions to smaller round ducts. Main supply duct section is only 22" long, will be difficult to get a coil into this.

DHW: Oil fired DHW tank. Aero CE501. 50 USG. 0.75 gph input, 97 gph recovery. Temp setpoint 140°. 15 years old, good condition. New burner last year. Has fractional hp recirc pump. Located in furnace room.

Fuel usage:

Peak usage: Unknown. Staff indicates usage of 20 gal/day fuel oil on coldest days.

Layout: See drawing

District Heating Potential

This building will not be easily converted to hot water. New HW coils could be provided in the supply ducts located in the crawlspace for the lower floor, but it will be difficult to install a coil in the main upper floor supply. However, if two small coils were used in the upper floor branch ducts, temperature control for the upper floor would be greatly improved. There may be a problem with supply fan static pressure with the addition of the coils, and the motors may have to be replaced with larger ones. Use of the furnaces for peaking would likely be difficult due to control issues with the on/off furnaces. Heat exchangers/valving would likely be located in the crawl space. The building is located 290 m east of the power plant.

BUILDING NAME: FOREMAN'S RESIDENCE

Note: No survey done, all info from drawings.

Address: Buildings 180/185

Owner: YTG

Contact: Danny Kassi - YTG Maintenance (966-3151)

Main use: house

Gross floor area: 2500 ft²

Number floors above grade: 1

Number floors below grade: 0

Building age: 1986

Hours of operation: 24 hr.

Envelope

Walls: Wood frame walls, R20 batt in framing w/ 2" styrofoam over.

Roof: Wood frame roof, R60 batt.

Floor: Wood frame, R20 batt in framing.

Windows: Double-glazed.

Lighting



Assumed incandescent.

Heating

Heating is provided by hot water radiators from hot water boiler. Boiler is located in adjacent shed. Originally served from old school.

B-1: Thought to be Weil-Maclean 468, 1.25 gph input, 151 MBH output. This should be confirmed. 1/12 Watt circulation pump runs continuously.

DHW: Electric DHW tank. 6.0 kW. Located in laundry room.

Fuel usage: Unknown.
Peak usage: Unknown.

Layout: See drawing

District Heating Potential

Building is already hot water, should be easy to convert to district heating. The building is located 120 m east of the power plant.

BUILDING NAME: MAINTENANCE GARAGE

Address:
Owner: YTG
Contact: Bobby Benjamin (966-3381), Danny Kassi - YTG Maintenance (966-3151)

Main use: Vehicle storage, maintenance, small office and storage areas

Gross floor area: 4500 ft² plus 600 ft² mezzanine.
Number floors above grade: 1 + mezzanine
Number floors below grade: 0
Building age: 1990.

Hours of operation: M-F, 8 - 4:30.

Envelope

Walls: Metal panel wall w/ R20 batt.
Doors: Insulated metal garage bay doors, average. Other doors poorly insulated.
Roof: Metal roof w/R20 batt.
Floor: Concrete slab on R40 rigid.
Windows: Double-glazed. Minimal window area.

Envelope thought to be fairly poorly insulated. According to staff, very drafty, quite cold. Before ceiling fans installed first year, building froze up during cold weather.

Lighting

Lighting in main bay is metal halide. Turned off at night. Linear fluorescent in other areas.

Heating

Heating is provided by one forced air furnace that serves the office and storage areas. The main garage area is served by 4 oil fired radiant heaters. Ceiling fans used to circulate air.

F-1: Oil fired furnace. Serves office, WC, and storage areas. Duomatic HTL100B. 0.85 gph input, 97 MBH output. 1/7 hp fan motor. Furnace is old and currently not working. An electric heater is being used in the office. Original Duomatic burner. Furnace supplies up and would be difficult to get a coil in. No OA is provided. T'stat in office.

Rad-1,2,3,4: Oil fired overhead radiant heaters. 0.65 gph, 105 MBH input. One heater in each corner of the garage, with two heaters ducted to one exhaust on the east and west sides of the building. Apparently NW heater is not working. Heaters are controlled by t'stats, one for west side and one for east side. These are located near the interior of the building. These would need to be replaced by unit heaters for DH purposes.

DHW: Oil fired DHW tank. Aero CE501. 50 USG. 0.75 gph input, 97 gph recovery. Temp setpoint 140°. 15 years old, good condition. New burner last year. Has fractional hp recirc pump. Located in furnace room.

Fuel usage: 35,165 L per year. May not be particularly accurate.
Peak usage: Unknown.

Layout: See drawing

District Heating Potential

The easiest way to convert to hot water would be to install new hot water unit heaters in the main garage area. Probably only 2 or 3 would be required. Heat exchangers/valving could be located at high level. The existing radiant heaters would remain and could be used for peaking purposes by setting their t'stat setpoint below those of the hot water UHs. Existing t'stats would probably need to be re-calibrated or replaced. The furnace is probably not worth converting and would remain to serve the office and storage areas. The building is located 500 m west of the power plant.

BUILDING NAME: RCMP BARRACKS

Address: Building 504

Owner: RCMP

Contact: Lorna Sands - RCMP Whitehorse (633-8618), Cst. Darren Michels - RCMP Old Crow



Main use: Office, cell block.

Gross floor area: 2500 ft²
Number floors above grade: 1 + crawlspace
Number floors below grade: 0
Building age: 1989

Hours of operation: 16 hrs/day, 7 days per week.

Envelope

Walls: wood frame walls, thick, appear to be well insulated.
Roof: Wood joist. Insulation unknown.
Windows: Triple glazed with vinyl frames.

Envelope generally seems to be good, no staff complaints of drafts.

Lighting

Lighting is linear fluorescent with 34W T12 lamps. Quite bright, somewhat overlit.

Heating

Heating is provided by three forced air furnaces. One serves the office areas, while the other two serve the cells from a common t'stat and return duct.

F-1: Oil fired furnace. Serves office. Olsen WTL 100H. 0.85 gph input, 100 MBH output. New Riello 40 burner. Energuide 82.4% AFUE. Aug 99 combustion test 84.3%. 4"Ø OA duct. Furnaces are well maintained. Unit supplies down and distributes in crawlspace.

F-2,3: Oil fired furnace. Serves cells. Olsen WTL 100H. 0.85 gph input, 100 MBH output. New Riello 40 burner. Energuide 82.4% AFUE. Aug 99 combustion test 84.6% F-2, 83.4% F-3. Furnaces are well maintained. Common t'stat controls both furnaces, common return ductwork. Unit supplies down and distributes in crawlspace.

DHW: Elec DHW tank. Rheem EnergyMiser. 175L, 3.0 kW input. Tank is cool to touch. Located in furnace room.

Fuel usage: Estimated by RCMP at 21,000 L per year for all 4 buildings. From Sep 1 - Dec 27, 2000 used 9934 L. From Dec 27, 2000 - Mar 2, 2001 used 8452 L.
Peak usage: Unknown.

Layout: See sketch

District Heating Potential

Was not able to see distribution ductwork in crawlspace. Presumably, new HW coils could be provided in the supply ducts. There may be a problem with supply fan static

pressure with the addition of the coils, and the motors may have to be replaced with larger ones. Use of the furnaces for peaking would likely be difficult due to control issues with the on/off furnaces. Heat exchangers/valving would likely be located in the crawl space. The building is located 800 m east of the power plant.

BUILDING NAME: RCMP DUPLEX

Address: Building 502/3
Owner: RCMP
Contact: Lorna Sands - RCMP Whitehorse (633-8618), Cst. Darren Michels - RCMP Old Crow

Main use: Apartments.

Gross floor area: 3600 ft² (both units)
Number floors above grade: 2 + crawlspace
Number floors below grade: 0
Building age: 1989

Hours of operation: 24 hr

Envelope

Walls: Wood frame walls, insulation unknown.
Roof: Wood joist. Insulation unknown.
Windows: Triple glazed with vinyl frames.

Staff complains of drafts, cold.

Lighting

Lighting is incandescent.

Heating

Heating is provided by forced air furnace, one per suite.

F-1,2: Oil fired furnace. Each serves one unit. DMO WTL 100H. 0.85 gph input, 100 MBH output. New Riello 40 burner. Furnaces are well maintained. Unit supplies down and distributes in crawlspace.

DHW: Elec DHW tank. Rheem EnergyMiser. 175L, 3.0 kW input. Located in furnace room. One per unit.

Fuel usage: Estimated by RCMP at 21,000 L per year for all 4 buildings. From Sep 1 - Dec 27, 2000 used 9934 L. From Dec 27, 2000 - Mar 2, 2001 used 8452 L.
Peak usage: Unknown.

Layout: See sketch

District Heating Potential

New HW coils could be provided in the supply ducts. There may be a problem with supply fan static pressure with the addition of the coils, and the motors may have to be replaced with larger ones. Use of the furnaces for peaking would likely be difficult due to control issues with the on/off furnaces. Heat exchangers/valving would likely be located in the crawl space. The building is located 850 m east of the power plant.

BUILDING NAME: RCMP OLD BARRACKS

Address: Building 501
Owner: YTG
Contact: Lorna Sands - RCMP Whitehorse (633-8618), Cst. Darren Michels - RCMP Old Crow

Main use: Apartments, exercise gym.

Gross floor area: 3250 ft²
Number floors above grade: 2 + crawlspace
Number floors below grade: 0
Building age: 1960

Hours of operation: 24 hr.

Envelope

Walls: Wood frame walls. Insulation unknown.
Roof: Wood joist. Insulation unknown.

Tenants complain of poor insulation, cold walls.

Lighting

Lighting is all incandescent.

Heating

Heating is provided by two forced air furnaces, one per unit. Small exercise area also served by south unit furnace.

F-1,2: Oil fired furnace. Airco D189. 1.35 gph input, 153 MBH output. New Riello burner. Aug 2000 combustion test 78.9% N unit, Aug 99 combustion test 81.5% S unit. 4"Ø OA duct. One furnace per unit.

DHW: Elec DHW tank. Giant 152-3WSM. 38.5 gal, 4.5 kW input. Supplies both units. Located in furnace room.

Fuel usage: Estimated by RCMP at 21,000 L per year for all 4 buildings. From Sep 1 - Dec 27, 2000 used 9934 L. From Dec 27, 2000 - Mar 2, 2001 used 8452 L.
Peak usage: Unknown.

Layout: See sketch

District Heating Potential

Was not able to see distribution ductwork in crawlspace. Presumably, new HW coils could be provided in the supply ducts. There may be a problem with supply fan static pressure with the addition of the coils, and the motors may have to be replaced with larger ones. Use of the furnaces for peaking would likely be difficult due to control issues with the on/off furnaces. Heat exchangers/valving would likely be located in the crawl space. The building is located 800 m east of the power plant.

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**HEAT RECOVERY AND DISTRIBUTION
IN OLD CROW, YUKON**

**Preliminary Feasibility Review
with Reduced System Options**

Prepared by:
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August 14, 2003

Old Crow Heat Recovery and Distribution System

Summary

The results of the preliminary review (report dated July 17, 2003) led to a further investigation of the effects of dropping one of the two farthest buildings from the Phase 1 group of customers. Analysis was carried out for Phase 1 without the YTG Maintenance Garage (Building A), and for Phase 1 without the Nursing Station (Building F).

This analysis also used a plant output model based on actual 1 hour load data from the Old Crow plant, provided by Yukon Electric Company Ltd. (YECL).

The following data summarizes the plant capacity and system loads, and is presented here for convenience in analyzing the project.

Plant Output Estimates for Heating Season Only (Sept 15 to June 15)

Jacket Water Recovery Only

Estimated Plant Peak Thermal Power (kW):	260
Estimated Plant Average Power (kW):	123
Estimated Plant Thermal Output (MWh):	808

Exhaust Recovery on 3412

Estimated Plant Peak Thermal Power (kW):	372
Estimated Plant Average Power (kW):	224
Estimated Plant Thermal Output (MWh):	1,472

Estimated Peak Thermal Demand

Complete Phase 1 (kW):	381
Without YTG Maintenance (BCDEF Only) (kW):	274
Without Nursing Station (ABCDE Only) (kW):	298
Without YTG and ATB (CDEF Only) (kW):	207

Estimated Annual Thermal Energy Requirements

Complete Phase 1 (MWh):	877
Without YTG Maintenance (BCDEF Only) (MWh):	618
Without Nursing Station (ABCDE Only) (MWh):	678
Without YTG and ATB (CDEF Only) (MWh):	475

Estimated Annual Thermal Energy Delivery, JW Only

Complete Phase 1 (MWh):	650
Without YTG Maintenance (BCDEF Only) (MWh):	556
Without Nursing Station (ABCDE Only) (MWh):	610
Without YTG and ATB (CDEF Only) (MWh):	450

Estimated Annual Fuel Displaced	
Complete Phase 1 (litres):	88,400
Without YTG Maintenance (BCDEF Only) (litres):	75,600
Without Nursing Station (ABCDE Only) (litres):	82,900
Without YTG and ATB (CDEF Only) (litres):	64,600
Estimated Capital Cost	
Complete Phase 1 (\$):	1,184,000
Without YTG Maintenance (BCDEF Only) (\$):	1,005,400
Without Nursing Station (ABCDE Only) (\$):	1,009,600
Without YTG and ATB (CDEF Only) (\$):	889,000

Background

At the request of Yukon Electric Company Limited (YECL), Northwest Territories Power Corporation (NWTPC) has carried out a preliminary review of the District Heating System Feasibility Study for Old Crow, Yukon, prepared by the Pembina Institute. The main purpose of the review was to confirm the technical feasibility (loads and plant capacity), and provide a more detailed preliminary capital cost estimate for use by YECL in their analysis of the economic feasibility of the project.

After review of the preliminary NWTPC report (see report dated July 17, 2003), further analysis was requested by YECL. YECL provided actual load data from the power plant, and requested that this information be incorporated into the analysis. Further analysis on reduced customer options, plus operation and maintenance estimates were also requested.

This report addresses the revision in the plant model, as well as three options for reduced customer connections. This report should be read in conjunction with the original Preliminary Feasibility Review dated July 17, 2003.

Power Plant Heat Production

The load model for the power plant was revised to incorporate the load data received from YECL. The load data consists of 1 hour generation figures for each unit, and for the plant, over 1 calendar year. YECL indicates that demand growth is negligible. The load data was used to generate an annual load duration curve and a heating season load duration curve, with the peak loads as indicated by the 1-hour data. A summary of the model output is included in Appendix A. The revised model indicates that the actual generation figures are about 15% lower than the original estimate, resulting in slightly less thermal energy available over the heating season.

Building Loads

Building fuel consumption information from the Pembina study and load estimates from the Kattner study were combined to estimate the peak system demand and annual energy requirements for both phases of the project. Peak system load is estimated at 381 kW for Phase 1, 274 kW for Phase 1 without the YTG Maintenance Garage, 298 kW for Phase 1 without the

Nursing Station, and 207 kW for Phase 1 without the YTG Maintenance Garage or the new Air Terminal Building. Annual energy requirements were estimated at 877 MWh, 618 MWh, 678 MWh and 475 MWh for the above combinations respectively.

System Capability

The power plant does not have the thermal capacity to meet the peak heating loads of any combination above with the exception of a system comprising Phase 1 without the YGT Maintenance Garage and Air Terminal Building.

Based on the above information and some experience with both electrical and thermal loading of these types of systems, it is estimated that the amount of energy the system could deliver is about 75% of the Phase 1 requirements, 85 to 90% of the requirements for a system without one of either the Nursing Station or the YTG Garage, and 95% of the requirements for a system without the YTG Garage and the Air Terminal Building.

Addition of exhaust heat recovery to the 3412 only will boost delivery to an estimated 90% of the Phase 1 energy requirements, and 95% of the reduced system requirements.

Fuel Displaced

Fuel displaced by the system is a function of the energy delivered and the building system efficiencies. The building system efficiencies were assumed to be 75% in the energy estimates developed for this review, which were based on the Lower Heating Value (LHV) of the fuel. While it may be argued that this value for system efficiency is high, it results in a more conservative estimate of the fuel displaced, and accounts for some inefficiencies in the Energy Transfer Stations. Also, it appears that the Pembina and Kattner studies used High Heating Values for heating oil, which would normally result in lower building system efficiency estimates.

The Phase 1 energy requirement estimate, from above, is 877 MWh. Using fuel LHV of 9.8 kWh/litre (typical of P-50 Arctic Diesel), a 75% conversion efficiency, and 74% delivery (650 MWh), the amount of fuel displaced by the system in Phase 1 is estimated at 88,400 litres per year. Similar calculations for the reduced customer options resulted in the figures presented in the Summary. .

Exhaust recovery installation on the 3412 (initially) will increase the fuel displaced in Phase 1 to an estimated 113,400 litres. The additional capacity will add approximately 5,000 litres per year of displaced fuel to the reduced customer options.

Capital Cost Estimate

A preliminary capital cost estimate was developed for the three reduced customer options based on building information from the Pembina study, as well as the conceptual system layout, and estimated flow requirements.

Yukon Electric Company

Old Crow Heat Recovery and Distribution – Reduced System Options

The estimate does not include cost for exhaust recovery installation on any of the units. A reasonable assumption is that addition of exhaust gas recovery to the Cat 3412 will increase the In-Plant capital cost by \$150,000 to \$200,000, depending on space availability.

Table 1 - Old Crow Project Capital Cost Estimate

Item	Phase 1 Only				Total	ABCDE Only				Total
	Equip & Mat'l	Labour	Accom			Equip & Mat'l	Labour	Accom		
	(\$)	(\$)	(\$)	(\$)		(\$)	(\$)	(\$)	(\$)	
In-Plant Work	95,000	76,000	33,500		204,500	95,000	76,000	33,500		204,500
Distribution Piping	183,000	236,000	84,250		503,250	126,400	185,000	66,000		377,400
ETS	108,900	57,600	12,000		178,500	87,230	48,000	10,000		145,230
Engineering		90,000			90,000		80,000			80,000
Site Supervision		28,000	10,000		38,000		24,500	8,750		33,250
Site Engineering		16,200	3,000		19,200		16,200	3,000		19,200
Freight					150,000					150,000
Totals	386,900	503,800	142,750		1,183,450	308,630	429,700	121,250		1,009,580

Item	BCDEF Only				Total	CDEF Only				Total
	Equip & Mat'l	Labour	Accom			Equip & Mat'l	Labour	Accom		
	(\$)	(\$)	(\$)	(\$)		(\$)	(\$)	(\$)	(\$)	
In-Plant Work	95,000	76,000	33,500		204,500	95,000	76,000	33,500		204,500
Distribution Piping	108,300	156,500	56,000		320,800	84,300	119,600	42,750		246,650
ETS	89,650	48,000	10,000		147,650	71,500	38,400	8,000		117,900
Engineering		80,000			80,000		70,000			70,000
Site Supervision		24,500	8,750		33,250		22,400	8,000		30,400
Site Engineering		16,200	3,000		19,200		16,200	3,000		19,200
Freight					200,000					200,000
Totals	292,950	401,200	111,250		1,005,400	250,800	342,600	95,250		888,650

Table 1 notes and assumptions:

- Plant work assumed to be absolute minimum required for installation of jacket water heat recovery equipment.
- Distribution pipe size optimized for flow requirements.
- Distribution piping assumed to be above ground, supported on piles.
- Distribution piping layout as shown in accompanying map (i.e., as presented in Pembina study).
- Building connections assumed to be direct connections for air system, indirect for hydronic system.

- Energy Transfer Station (ETS) installation labour simplified as 1 mechanical tradesman and helper for 6 days per unit.
- 10% is added to the ETS equipment and materials to account for control & power cable and miscellaneous small bore pipe & fittings.
- Site supervision based on time estimate for distribution piping portion of work, assuming other work carried out simultaneously.
- Accommodations estimated at \$250 per man per day including meals.

Operation an Maintenance Costs

The main operational cost of the heat distribution system is pumping power. Some administration costs arise from meter reading, billing, and records management. Preventive maintenance normally consists of strainer blowdowns, control valve checks, and the odd minor leak. Heat exchanger flushing should be carried out once about every two years. Major maintenance would normally be pump repair or replacement, and control valve repair or replacement. These components should normally give several years of trouble-free operation.

Budget estimate for O&M, apart from pumping costs, is about 2 man-days per month administration, and 0.5 man-days per month per building preventive maintenance and troubleshooting.

Piping systems for the four options discussed above were modelled using Flo-Series software, and preliminary pump selection was carried out to generate an estimate for power required for each of the options. The results of the calculations are shown below.

Table 2 - Distribution Pumping Power and Energy

System	Total Flow (l/min)	100% Power (kW)	Annual Energy at 70% (kWh)
Complete Phase 1	405	2.88	17,660
BCDEF Only	290	1.42	8,707
ABCDE Only	317	2.2	13,490
CDEF Only	220	1.4	8,585

General Comments

Plant Load Model Revision

The incorporation of actual load data into the plant load model revealed a lower output than originally estimated. This is due to the lower peak and average loads and lower total generation. The engine hours generated by the load model differ slightly from the actual hours, especially for the 3508. This is largely due to the model not accounting for overlapping operations during normal engine changes, and not allowing low load operation. This is also evident in the average load for the 3508 generated by the model, which is considerably higher than that reported in the data (310 kW from the model vs. 211 kW from the data).

The heat delivery estimate for the complete Phase 1 was reduced slightly as a result of the revised load duration curve. The estimate results in about 80% of the plant heating season energy being delivered to the system.

System Options

The options shown do not include the option of eliminating the YTG Maintenance Garage and the Nursing Station. The option of eliminating the Air Terminal Building along with the YTG Garage was chosen to assess the effect of eliminating one entire piping branch to the west of the power plant. This results in a single-direction main branch. Review of the results suggest that there would be very little difference in the system cost if the Nursing Station was eliminated along with the YTG Garage, instead of the Air Terminal Building. However, this would result in the loss of an additional 55 MWh of potential energy sales.

Customer Connection Considerations

Three of the potential Phase 1 customers (YTG Maintenance Garage, Hamlet 3-Bay Garage, and Nursing Station) use forced-air in the existing heating systems. While the two garages are easily modified using hydronic unit heaters, the Nursing Station will require 3 hot water coils to be installed at some point in the furnace ductwork. With no details on the building layout and existing duct installation, it is difficult to estimate how much work will be involved. The furnaces in the Nursing Station will probably also require a retrofit for the fan motor due to the added resistance of the heating coils. The Nursing Station Energy Transfer Station estimate has therefore the highest uncertainty. This may be a consideration during evaluation of a downsized system.

Conclusions

The reduced customer options presented result in capital cost reduction of 14.7% to 24.9% over the complete Phase 1 costs. This is accompanied by fuel displacement reductions of 6.2% for the highest cost option to 26.9% for the lowest cost option.

The best option for cost reduction combined with fuel displacement is the option of Phase 1 without the Nursing Station. This option also appears to be the best stand-alone option when compared with all others, including the complete Phase 1, and Phase 1 & 2, as indicated by the comparatively low ratio of capital cost to fuel displaced.

APPENDIX A – PLANT LOAD MODEL SUMMARY

Old Crow Plant Load Model Typical 2003						
Forecast Peak (kW):	355					
Forecast Generation (MWh):	1748					
Forecast Minimum (kW):	92					
Unit Dispatch at	0.9	% Rated Load				
Unit	G1	G2	G3	G4	G5	Plant
Type	Cat06	Cat412	Cat508			
Rating (kW)	175	320	480			
Switch Load (kW)	157.5	288	432	0		
Operating Hours	1,708	6,833	219	0	0	8,760
Total Generation (kWh)	234,418	1,446,539	67,934	0	0	1,748,890
Average Load (kW)	137	212	310	--	--	200
Fuel Consumed (litres)	66,217	397,485	18,456	0	0	482,158
Average Fuel Rate (kWh/l)	3.540	3.639	3.681	--	--	3.627
JW Heat Output (kWh)	154,745	830,360	50,234	0	0	1,035,340
Exhaust Heat Output (kWh)	110,726	715,604	21,497	0	0	847,828
Radiant Heat Output (kWh)	35,215	185,800	16,140	0	0	237,155
Average JW Heat (kW):						118
Average Exhaust Heat (kW):						97
Average Radiant Heat (kW):						27
Peak JW Heat (kW)	98	161	260	0	0	260
Peak Exhaust Heat (kW)	73	146	112	0	0	146
Peak Radiant Heat (kW)	23	32	78	0	0	78
Notes:	Load Duration Curve is actual curve from YECL Data, using 1 hour load intervals (Peak is a 1 hour average peak) Engine Heat Rejection data taken from latest generation engines so may have slight errors Load Switch set to insure 3508 is used before paralleling G1&G2 Exhaust Recovery based on final exhaust stack temperature of 177°C					

APPENDIX A – PLANT LOAD MODEL SUMMARY

Old Crow Plant Load Model Typical Heating Season, Sept 15 to June 15, 2003						
Forecast Peak (kW):	355					
Forecast Generation (MWh):	1373					
Forecast Minimum (kW):	109					
Unit Dispatch at	0.9	% Rated Load				
Unit	G1	G2	G3	G4	G5	Plant
Type	Cat06	Cat412	Cat508			
Rating (kW)	175	320	480			
Switch Load (kW)	157.5	288	432	0		
Operating Hours	822	5,524	230	0	0	6,576
Total Generation (kWh)	118,467	1,183,483	70,725	0	0	1,372,674
Average Load (kW)	144	214	307	--	--	209
Fuel Consumed (litres)	32,992	324,946	19,294	0	0	377,232
Average Fuel Rate (kWh/l)	3.591	3.642	3.666	--	--	3.639
JW Heat Output (kWh)	76,545	678,512	52,493	0	0	807,549
Exhaust Heat Output (kWh)	55,501	586,645	22,450	0	0	664,597
Radiant Heat Output (kWh)	17,591	151,314	16,923	0	0	185,828
Average JW Heat (kW):						123
Average Exhaust Heat (kW):						101
Average Radiant Heat (kW):						28
Peak JW Heat (kW)	98	161	260	0	0	260
Peak Exhaust Heat (kW)	73	146	112	0	0	146
Peak Radiant Heat (kW)	23	32	78	0	0	78
Notes:	Load Duration Curve is actual curve from YECL Data, using 1 hour load intervals (Peak is a 1 hour average peak) Engine Heat Rejection data taken from latest generation engines so may have slight errors Load Switch set to insure 3508 is used before paralleling G1&G2 Exhaust Recovery based on final exhaust stack temperature of 177°C					

APPENDIX B – CUSTOMER LOADS

Building Description	Building ID	Total Boiler Capacity (kW)	Annual Fuel Cons (litres)	Annual Fuel Energy (net MWh)	ETS Design Power (kW)
Maintenance Garage	A	128	35,165	258	107
New Air Terminal Building	B		19,456	143	67
3-Bay Garage	C	69	12,770	94	48
Foreman's Residence	D	35	4,752	35	14
Teachers Residence	E	46	20,134	148	62
Nursing Station	F	113	27,000	198	83
RCMP Old Barracks	G	90	6,757	50	36
RCMP Barracks/Stn	H	88	5,198	38	28
RCMP Garage	I	29	1,559	11	7
RCMP Duplex	J	57	7,485	55	40
Power Plant	K				25
Northern Store	L				
Community Hall	M				
Youth Centre	N				
Admin Building	O				
Yukon College	P				
Totals	ABCDE		92,277	678	298
	BCDEF		84,112	618	274
	CDEF		64,656	475	207
	BCDE		57,112	420	191
	Phase 1		119,277	877	381

Notes: ETS Design Power from FVB Peak Heat Load, FVB Study Table 1, p.10

DHWS Power from FVB Appendix - Building survey

Fuel from Pembina Report

Fuel LHV (kWh/l): 9.8

System Efficiency 0.75