District Energy System Pre-Feasibility Study City of Whitehorse, Yukon

A study to assess the viability of establishing a District Energy System in the City of Whitehorse, Yukon

Prepared for:

Sean MacKinnon
Senior Energy Advisor
Energy Solutions Centre, Department of Energy Mines and Resources,
Government of Yukon
206A Lowe Street, Yukon
Ph: (867) 393 - 7067

Prepared by:

Stantec Consulting Ltd.
111 Dunsmuir, Suite 1100
Vancouver, BC V6B 6A3
Ph: (604) 696-8000
Fax: (604) 696-8100

And

Earthvoice Strategies

Contact:
Gary Wheating, P.Eng.
Alex Hutton, P.Eng.

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Executive Summary

Stantec is pleased to present this report to the City of Whitehorse (the City), as well as the Energy Solutions Centre (ESC) and the Property Management Division (PMD), two branches of the Yukon Territory Government (YTG). The report summarizes the results of the District Energy Pre-Feasibility Study for the City of Whitehorse, Yukon.

The purpose of the Pre-Feasibility Study was to evaluate the economic and technical viability of a District Energy System (DES), which would supply heat energy to municipal and territorial buildings in the City of Whitehorse, Yukon.

The scope of the report is in keeping with the Terms of Reference section of the RFP, and can be summarized by the following tasks:

- Task 1: Load Intensity Analysis
- Task 2: Energy Input Discussion
- Task 3: Preliminary System Concept
- Task 4: Greenhouse Gas (GHG) Emissions and Air Quality
- Task 5: Financial Analysis / Projections
- Task 6: Recommended Course of Action

The load intensity analysis revealed that three zones within the City (Zone 1: Lewes Blvd, Zone 2: Hospital Road, & Zone 3: Downtown Core) have sufficient heating energy intensity and scale to be considered viable, even without connecting any non-government buildings. Connecting to some key non-YTG/City buildings (such as hotels) would only improve the heating intensity and thus viability within each of these zones.

Three other zones within the City (Zone 4: Range Road, Zone 5: Quartz Road, & Zone 6: Airport) have potential to be viable options for either connected expansions or stand-alone district systems; however, they likely require some non-government buildings to connected.

The scenarios that were considered for the District Energy System (DES) for the City of Whitehorse included heat only systems and combined heat and power systems utilizing various fuels including biomass, heating oil and electricity. Most of the options explored are deemed technically viable.

The system that appears to represent the best case for the DES is the heat only system utilizing biomass in the form of wood pucks as the fuel. This scenario was used as the basis for financial analysis and projections.

The financial analysis showed that the recommended DES option is financially viable even when using the conservative assumptions made throughout (providing that the Client is willing to pay heating charges about 6% higher than business as usual (BAU), and is willing to fund the cumulative operating deficit projected to reach $1,311,000 before cash flow after debt service and sinking fund payments turns positive).

It is recommended that the project proceed to a Feasibility Study in order to refine and confirm all aspects of this study by going into more detail. Specific political, business, technical, and financial recommendations and next steps are outlined in the report.

Acknowledgements

The following is a summary of the contacts who have provided input and assistance in the development of this report including members of the Client partnership organizations.

Table 1: Summary of Acknowledgements

Organization	Name	Contact Info	Role / Input
City of Whitehorse	Brian Crist	brian.crist@whitehorse.ca	Input on cost of borrowing, other resources
	Shannon Clohosey	Shannon.Clohosey@whitehorse.ca	Site tour and building information
Yukon Territory Government	Colin McDowell	Colin.Mcdowell@gov.yk.ca	Report review
	Bob Collins	Bob.Collins@gov.yk.ca	Report review
	Sean MacKinnon, Energy Solutions Centre (ESC)	Sean.MacKinnon@gov.yk.ca	Client Project Manager, input through out the process and review of the report
	Shane Andre, ESC	Shane.Andre@gov.yk.ca	Input on biomass fuel suppliers
	Cathy Cottrell, ESC	Cathy.Crottrell@gov.yk.ca	Input on the Public Buildings Energy Tracking System (PBETS)
	Josh Mickelborough, Property Management Division (PMD)	Josh.Mickleborough@gov.yk.ca	Led tour of numerous YTG buildings
	Satch Atchison, PMD		Led tour of numerous City buildings
Pinnacle Pellet	Peter Brandt	Principal www.pinnaclepellet.com/	Input on availability of biomass pellets
Yukon North Biomass Company	Terrance Taite	yukonbiomass@gmail.com	Wood puck information
Sawmill	Dimok Timber	http://dimoktimber.com/	Input on availability of waste biomass
Yukon Energy Corporation (YEC)	Hector Campbell, Director, Domestic Sales & Marketing	hector.campbell@yec.yk.ca	Info in secondary sales of electricity
Yukon Electrical Company Ltd. (YECL)	Phil Borgel	Phil.Borgel@atco.com	Info in secondary sales of electricity

Limits of Liability

This report was prepared by Stantec Consulting Ltd. for the Client. The material in it reflects our professional judgment based on previous experience, research, engineering principles, and visual observation and operations personnel comments for the facilities during the site visit of September 29th, 2009. Assumptions presented in this report should be reviewed and any discrepancies brought to the attention of the appropriate Stantec contact. All results are estimates with a margin of uncertainty and are not guaranteed. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of the decisions made or actions based on this report. Some assumptions have been made for parameters of the operation or performance of equipment and materials. The use of these values and parameters shall in no way imply endorsement of a specific product or manufacturer.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1 OVERVIEW

Stantec is pleased to present this report to the City of Whitehorse (the City), as well as the Energy Solutions Centre (ESC) and the Property Management Division (PMD), two branches of the Government of Yukon (the Territory). The report summarizes the results of the District Energy Pre-Feasibility Study for the City of Whitehorse, Yukon. The project and resulting report were conducted according to the scope of work outlined in our proposal (dated July 30th, 2009), which in turn references the Request for Proposals (dated June 24th 2009), and based information collected during the one day site visit, which took place on September 29th, 2009. The partnership (the City, ESC, and PSD) are referred to herein as "the Client".

1.1.1 Purpose

The purpose of the Pre-Feasibility Study was to evaluate the economic and technical viability of a District Energy System (DES), which would supply heat energy to municipal and territorial (and possibly commercial) buildings in the City of Whitehorse, Yukon.

1.1.2 Objective

Drawing directly from the Terms of Reference document, the key objective is to determine whether or not a DES would be technically and economically viable to implement in Whitehorse, Yukon.

1.1.3 Context

This study was instigated and completed within the broader context of numerous city and territory-wide sustainability initiatives including the following:

- 2002 Official Community Plan (OCP)
- Local Action Plan to Reduce Greenhouse Gas Emissions (2004)
- Integrated Community Sustainability Plan (2007) (ICSP)
- Climate Change Report for Whitehorse (PCIC 2008)
- Whitehorse Strategic Sustainability Plan (WSSP 2008)
- City of Whitehorse Sustainability Plan See-it™
- Energy Strategy for Yukon (2009)
- Yukon Climate Action Plan (2009)

A district energy system has the potential to contribute toward the first two and possibly three of the four strategy focuses outlined in the Energy Strategy for Yukon (January 2009):

1. Conserving energy and using it more efficiently;
2. Increasing the supply and use of renewable energy;
3. Meeting our current and future electricity needs; and
4. Managing responsible oil and gas development.

This study responds specifically to one of the priority actions listed within the renewable energy focus: “Conduct pilot studies to assess the feasibility of renewable energy initiatives [including] new or expanded district heating systems.”

The Yukon Climate Action Plan (February 2009) identifies four key goals:

1. Goal 1: Enhance our knowledge and Understanding of Climate Change
2. Goal 2: Adapt to Climate Change
3. Goal 3: Reduce our Greenhouse Gas Emissions
4. Goal 4: Lead Yukon Action in Response to Climate Change

This study responds to Goal 3, since one of the key benefits of a DES is the economies of scale created, which facilitate the implementation of alternative and renewable energy technologies and strategies that can reduce GHG emissions.

Both the OCP and ICSP reference District Energy as an opportunity to reduce GHG emissions, shelter the community from rising fuel prices, and improve environmental sustainability. Figure 1 shows a screen capture from the City of Whitehorse’s “see-it” web based model which summarizes visually the Principles, Strategies, and Actions within the City of Whitehorse’s ICSP.

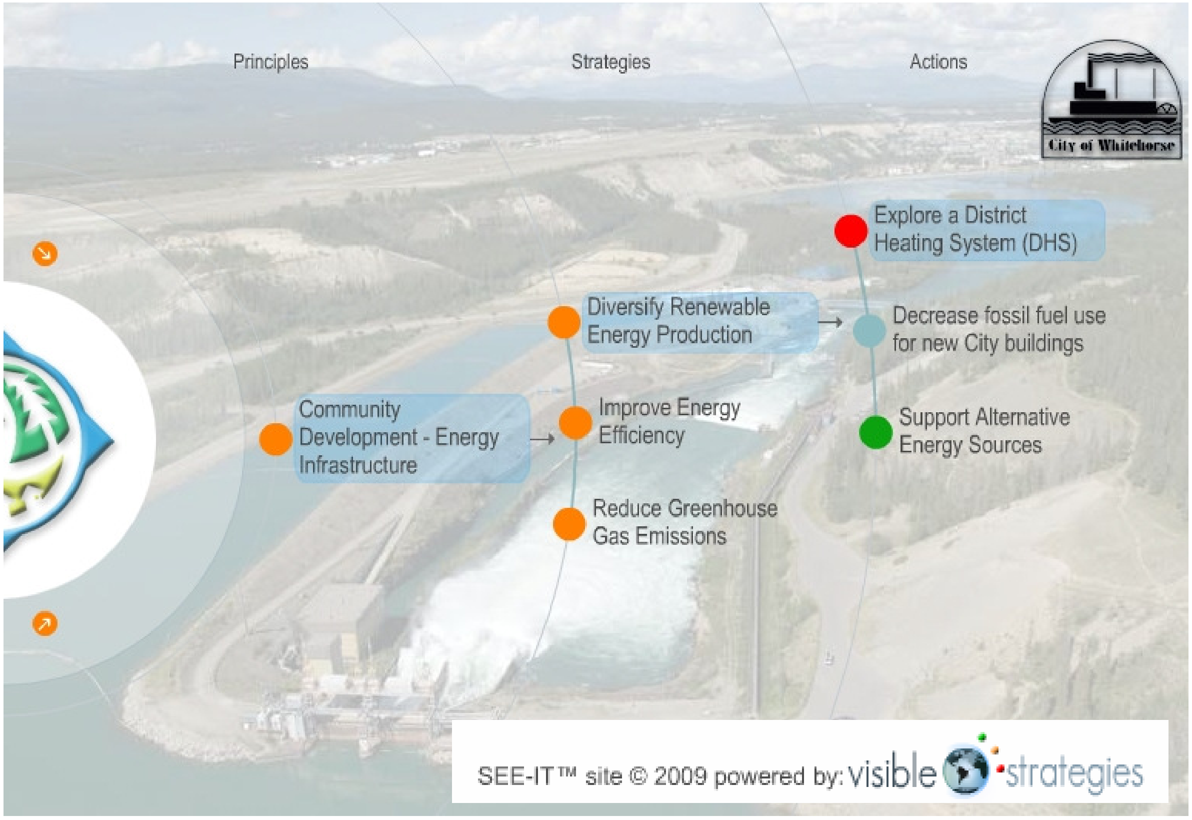

Figure 1: Screen Capture from On-line Visualization of Strategic Goals[1]

1.1.4 Scope

The scope, as outlined in our proposal and in keeping with the Terms of Reference section of the RFP, can be summarized by the following tasks:

- Task 1: Load Intensity Analysis
- Task 2: Energy Input Discussion
- Task 3: Preliminary System Concept
- Task 4: GHG Emissions and Air Quality
- Task 5: Financial Analysis / Projections
- Task 6: Recommended Course of Action

District energy systems can include heating, cooling, and/or electricity. For the purpose of this study, heating energy is understood to be the primary focus. Opportunities to generate electricity as well as heat (combined heat and power) are also explored; however, cooling is not

[1] Source: http://whitehorse.visiblestrategies.com

explored, due to the small portion of cooling loads compared to heating and domestic hot water loads.

1.2 ORGANIZATION OF THE REPORT

As stated in the Terms of Reference, the assessment will deliver results focused on the following six key areas, which correspond with the above six tasks and are summarized in the sections indicated in bold and square brackets:

- Potential system loads and their relative locations (load intensity) to be used in financial analysis for economic viability **[Section 2.0 - Task 1: Load Intensity Analysis]**
- Initial energy input screening and energy/fuel-type recommendations **[Section 3.0 - Task 2: Energy Input Discussion]**
- Preliminary system design concept (including energy centre locations and distribution system layout options) **[Section 4.0 - Task 3: Preliminary System Concept]**
- Anticipated effect on GHG emissions and air quality implications (especially if fuel input recommendations include fossil fuel, biomass, or bio-fuels) **[Section 5.0 - Task 4: GHG Emissions and Air Quality**
- High level financial analysis/projection to compare “business as usual” to district energy costs in order to determine “go or no-go” status of project **[Section 6.0 - Task 5: Financial Analysis / Projections]**
- Recommendations for next steps **[Section 7.0 - Conclusions, Recommendations, and Next Steps]**

Although the six tasks are described in a linear sequential fashion through the report, many of the tasks are in fact inter-related. In reality, the process of developing the report is an iterative process moving through successive levels of detail. For example, some high level decisions need to be made with respect to the preferred input technology before the final choice with respect to inclusion of various zones can be made. As such, references to the conclusions made in a later task may be referenced in an earlier task.

In order to balance the desire for a concise and easy to read report with the need for sufficient depth of information, supporting and detailed information is located in the Appendices.

1.3 DISTRICT ENERGY OVERVIEW

In order to provide a high level context for this study, some key background information, advantages, determinants, and challenges associated with district energy are summarized.

1.3.1 Background

It is worth noting that district energy systems are not a new phenomenon. It is a concept that dates back to the Roman times when this approach was used to heat baths and green houses. The technologies can be very simple; the barriers and challenges are typically not of a technical nature.

1.3.2 Benefits

There are a number of potential benefits of moving to a district based heating system; they stem primarily from the economies of scale that are created, are summarized below:

Reduced costs - Centralization of heating offers possible cost savings through reduced equipment requirements (due to load diversification), economies of scale in equipment costs, savings in operating costs from more efficient equipment and optimized operations, lower financing rates, and longer amortization periods for capital. These potential cost savings must, however, be weighed against any additional costs associated with centralization such as the cost of the distribution system and the additional costs of establishing operating and administering a utility. In addition, cost savings associated with centralization may in part be offset by investment in more environmentally-friendly forms of heat production.

Improved quality of service – A district heating system is designed to utility grade reliability standards, which incorporate “n-1” redundancy. As centralized equipment is operated and maintained by trained professionals, the reliability of district heating systems is generally better than stand alone boilers.

Improved environmental performance - Economies of scale and other cost savings from centralization of heat sources can increase efficiency and facilitate the use of alternative technologies for the same or in some cases lower costs as more conventional on-site technologies. Furthermore, with longer amortization periods and lower financing rates, a utility can more easily use alternative technologies with higher capital costs and lower operating costs while remaining competitive with conventional on-site technologies.

Reduced risk and increased flexibility - Financial and operating risks can be pooled across a larger number of customers; implementation of more efficient and alternative technologies can further reduce customer exposure to fluctuating fuel prices; hydronic heating systems are also more adaptable to new technologies over time.

Figure 2 shows how the fuel source for the Municipality of Linköping, Sweden changed dramatically from almost 100% oil to less than 20% fossil-fuel between 1980 and 2008.

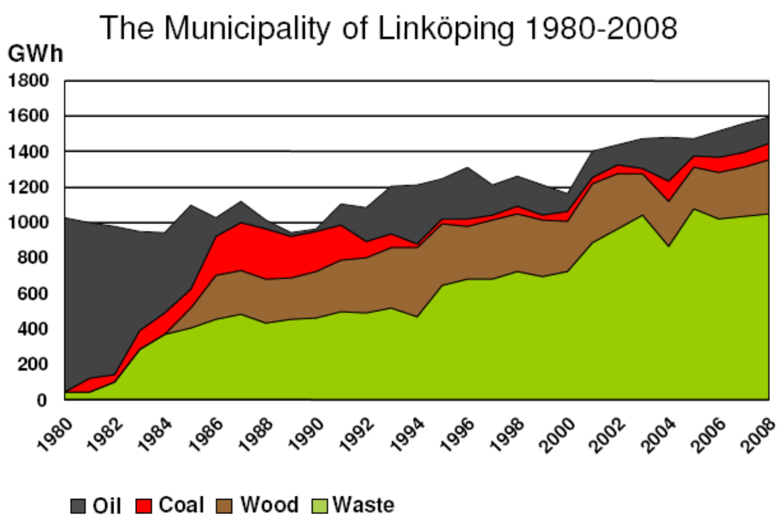

Figure 2: Changing Fuel Sources for Municipality of Linköping DES (Source: Usitall)

1.3.3 Determinants

Three of the major determinants of viability for a DES are summarized as follows:

- **Density** – A minimum density of heating load is required such that the cost to connect the buildings is balanced by the magnitude of heating energy delivered. The density of heating load is dependent on a combination of the density of buildings (m^2 of floor area per hectare) and the intensity of the heating load (kWh/year of heating load per m^2 of floor area). A generally accepted minimum threshold is approximately 1,500 MWh/hectare.

- **Low Cost Energy Source** – The availability of an energy source that is lower in cost than the competing "business as usual" (BAU) energy source(s) will greatly improve the viability of a DES. A centralized heating plant can typically achieve higher seasonal efficiencies than a number of individual heating systems within stand-alone buildings; therefore, a lower cost energy source further increases the fuel cost differential between the DES and a BAU scenario.

- **Scale and Rate of Development** – There is a minimum scale (which varies depending on plant technology and other factors) that is required. The rate of new development, particularly for a DES serving only new development, is also a determining factor since it greatly affects the financial analysis (by affecting the rate at which revenues increase etc.)

An ideal scenario is one in which there is a high density of buildings with high heating intensities, a secure supply of a low cost energy source, and sufficient buildings to be of an appropriate scale for the chosen plant technology.

Today there are approximately 6,000 systems in North America and they are concentrated in downtown cores, on medical and educational campuses, as well as for government and military installations; these are examples where the above determinants are typically met.

There are also district energy systems in operation in the Yukon. Some examples of utility models for heat delivery include Watson Lake, Old Crow, and Burwash Landing (see Figure 3).

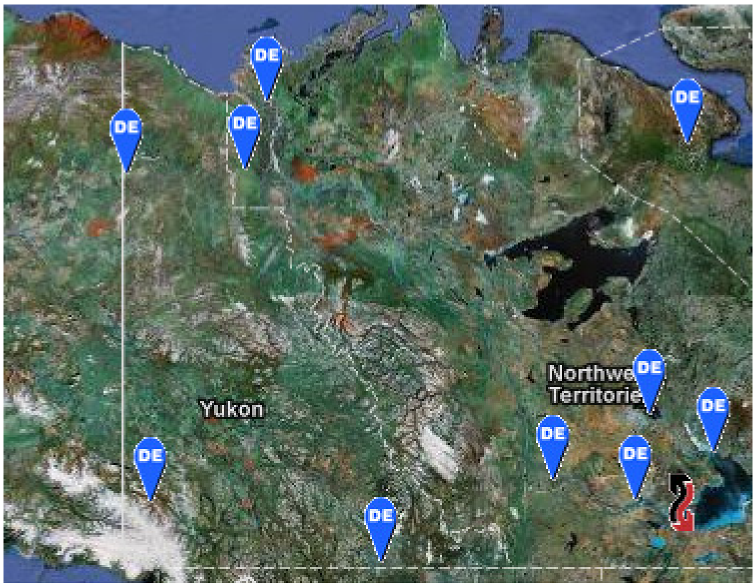

Figure 3: District Energy Systems in the Yukon and Northwest Territories[2]

The 6,000 systems in North America are supplying far less than 1% of total heating load. For comparison internationally, Lithuania, Sweden, Poland, Denmark, and Finland all have over 40% of their heating supplied by district systems. This leads to the question of why there are not more systems in place in North America.

1.3.4 Challenges

Some of the key challenges and barriers to implementing DES systems are summarized as follows:

- **Initiation** – having the leadership, coordination, vision, and partnerships necessary to initiate a DES project is a major challenge in many cases.
- **Policy** – Lack of policy framework to encourage and support
- **Financial** – Understanding short versus long-term benefits and the comparison between DES and BAU costs

For this project, the partnership that issued the RFP for this study has demonstrated excellent leadership, coordination, vision, and partnership toward initiating a DES. The references to

[2] Ref: http://cdea.ca/resources/district-energy-across-canada/

GHG reduction and district energy specifically within the Yukon Energy Strategy, the Yukon Climate Action Plan, the OCP and the ICSP provide some policy framework in support of a DES. This study will provide a clear step toward understanding the financial implications. These factors combined place the City of Whitehorse in a good position to overcome the challenges.

2.0 Task 1: Load Intensity Analysis

This section summarizes the sources, assumptions, methodology, and results of Task 1: Load Intensity Analysis. More specifically, this section summarizes the sources of data used to estimate the heating loads for buildings within the study area; how these estimates were conducted; and how the loads were analyzed in order to determine the most feasible combination of buildings that could be served by one or more district energy systems.

2.1 LOAD DATA ACQUISITION

Understanding current and projected loads is the starting point for assessing the financial viability and technical feasibility of a district energy system. Hence, collection of energy consumption data was an integral part of Task 1. Data for the purposes of load analysis has been collected from a variety of sources as summarized in Table 2. Refer to Appendix A – Load Intensity Data for more information and detailed data. Where available, utility data was obtained to characterize space and water heat loads. Where utility data was not available, energy use intensity estimates from referenced sources were combined with floor area data to estimate loads. While appropriate for a concept design, detailed utility data for all proposed buildings which connect to the system will be required for completion of a detailed feasibility study.

Table 2: Summary of Load Data Sources

Data Type	Description	Data Source
Utility data	Historical utility data (2001-2007) for 57 Yukon Territory Government (YTG) buildings	YTG buildings database
	Historical utility data for 26 additional buildings within ASHRAE[3] Climate zone 7[4].	Stantec internal database of utility data from previous projects called “Energy Map”.
Aggregate Statistical Data	Average energy intensity data by end use and by region within Canada (BC and the Territories are grouped). Data is from existing building stock in 1999.	Office of Energy Efficiency, Natural Resources Canada[5]
	EPA Target Finder, which references average energy intensity data by fuel and by specific locations within US.	2003 CBECS data[6]

[3] ASHRAE is the American Society of Heating, Refrigerating and Air-Conditioning Engineers
[4] ASHRAE Climate Zone 7 includes most of Yukon and Alaska, as well as northern parts of other Canadian provinces and territories.
[5] Information is obtained from the Office of Energy Efficiency, Natural Resources Canada. The data pertain to 1999. They do not represent data from specific buildings, but rather are generated by dividing total energy consumption for each building activity and end-use by total floor space for that building activity.
[6] Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures. http://www.eia.doe.gov/emeu/cbecs/

Data Type	Description	Data Source
Building Descriptions	Description of an additional 90 YTG buildings (including floor area, building type, and location).	YTG buildings database
	Description of City buildings (including floor area, building type, and summary of heating equipment).	Summary sheet provided by Client
Site Visit	Observations made during the site visit and in discussion with operations staff.	Site visit and discussion with operations staff

How the various sources of information summarized in Table 2 are used is summarized in the following sections.

2.1.1 Utility Data

The main source of information, and the most reliable source, is the historical (2001 to 2007) utility data for 57 existing City-owned buildings that was provided by the Client. The average energy consumption value, for the years available, was used in calculations.

An internal Stantec resource called the "Energy Map" summarizes utility data for completed projects based on location, climate zone, building type, and level of LEED Certification[7] (where applicable). The LEED standard requires a minimum level of energy performance over and above a minimum energy code; therefore, projects that are LEED Certified are likely to be more energy efficient than standard construction. The 26 buildings within the Energy Map that are within the same climate zone as Whitehorse (ASHRAE Climate Zone 7) are used to supplement the 57 buildings. Half (13 of the 26 buildings) pursued LEED or CBIP[8], therefore suggesting that they are more energy efficient than standard construction.

2.1.2 Aggregate Statistical Data

Canadian and US average heating energy intensity (HEI) data based on aggregate building stock data from 1999 and 2003 respectively by location was also used to supplement and confirm the utility data. Canadian data used is for "BC and the Territories" and therefore is expected to be an underestimate of heating for buildings in Whitehorse specifically (since most of the buildings within this aggregate data are located in milder climates within BC).

US data for Fairbanks Alaska is used to represent Whitehorse since it has closest heating degree day (HDD[9]) value to Whitehorse. The HDD18 value (i.e., relative to a base temperature of 18°C) is 8,642 for Whitehorse and 7,744 for Fairbanks.

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[7] Leader in Energy and Environmental Design (LEED) is a green building rating system, which is used to measure performance of buildings under 5 main categories, one of which is "Energy and Atmosphere."

[8] The Commercial Building Incentive Program (CBIP), which has been replace by the ecoENERGY Validation Program, used to provide incentives for new construction projects that could demonstrate at least 25% energy savings over a Model National Energy Code for Buildings (MNECB-1997) baseline.

[9] A location's climate, as it pertains to heating energy consumption, can be summarized by the number of heating degree days, a qualitative measure of the time which the outside temperature is below the indoor

2.1.3 Building Description Information

In addition to the 57 Yukon Territory Government (YTG) buildings for which there is actual utility data, the YTG database included the name, address, building type, and floor area for another 90 buildings. From the floor area and building type, a rough estimate of heating energy consumption was estimated (as described further in later sections).

The City also provided the name, address, building type, and floor area for over 50 City-owned buildings. Most of these are very small buildings, such as pump houses, which are too small to consider connecting to a DES and were therefore excluded from the study. However, for 12 of the largest buildings from this list, the City provided a mechanical system description to facilitate consideration of these buildings, which are more likely to be feasible for connection.

2.1.4 Site Visit

The above information sources were supplemented by the one day site visit, which took place on September 29th, 2009. The site visit consisted of a meeting at the Energy Solutions Centre and a tour of several buildings. During the meeting a variety of useful background and contextual information as well as previous studies were downloaded to Stantec. Following that a large number of the key buildings were toured with the assistance and guidance of several individuals including City staff members and building operators.

The following are some of the key issues that were reviewed and types of information gathered during the site visit at the broader project level as well as the individual building scale in order to improve our understanding:

Project-wide considerations and issues

- Regulatory context (safety authority, GHG legislation, energy codes, etc.)
- Locally available fuels in region (such as biomass)
- Utility rate structures (including secondary electricity sales)
- Public perception (with respect to district energy and specific technologies)
- Demand side management strategies (degree and rate at which being implemented)
- Client's financial performance targets
- Client's risk tolerance and perceived risks
- Community context (sustainability goals, emission reduction targets, expected growth, etc.)
- Site / topographic factors that could influence trenching costs for piping (such as bedrock or permafrost)
- Proximity of key buildings (those with potential for connection) to each other
- Possible sources of waste heat
- Location of sewage outfall
- Possible sites for the district energy plant

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temperature. Heating requirements for a given structure at a specific location are considered to be directly proportional to the number of HDD at that location. HDD are defined relative to a base temperature - the outside temperature above which a building needs no heating.

Building specific considerations

- Heating system description (both heat generation and heat distribution equipment)
- Heating energy source(s) used for space and domestic water heating
- Operating temperatures (supply and return water temperature) of the building heating loop
- Observations for significant potential future demand side management strategies
- Compatibility of heating systems in the buildings (hot water versus steam, supply and return temperatures, flow regimes, etc.)
- Service life of key pieces of equipment

A summary of information gathered and observations made during the site visit are summarized in Appendix B – Site Visit Summary and key issues will be referenced through the report as the decision-making methodology is explained.

2.2 LOAD INTENSITY ANALYSIS

This section describes how the data collected was used to determine the most feasible combination of buildings, loads, and zones that can be served by one or more district energy systems.

2.2.1 Summary of Known Heating Loads

Table 3 provides is a summary of the known heating loads for YTG buildings for which utility data is available. Refer to Appendix A – Load Intensity Data for a summary of the estimated energy consumption for each individual building.

Table 3: Summary of Utility Data

Total No. of Buildings	Total Floor Area	Total Heating Load[10]		Average Heating Energy Intensity	Estimated Annual Peak Heating Demand[11]
	m^2	(GJ/year)	(MWh/year)	($kWh/m^2/year$)	(MW)
57	175,270	172,500	47,910	273	16.4

It is noted that this study does not include consideration of demand side management (energy conservation strategies) that might be implemented within existing building. The impact of potential DSM strategies should be incorporated into future studies.

[10] Based on total fuel consumption including space heating and domestic water (unless domestic water heating is provided by electricity)
[11] The annual peak heating demand is estimated based on a factor of 0.40213 (taken from the RETScreen tool for Whitehorse), which is an average used to convert annual heating energy consumption to annual peak heating demand using the following formula:

Peak load factor = Peak load (kW) / Energy consumption (MWh/yr).

2.2.2 Average Energy Intensity

The estimates in the absence of utility data are based on the floor area (m^2) of the facility multiplied by average heating energy intensity (HEI) values in kWh/m^2/year for each building type.

Figure 4 summarizes the HEI averages for each building type based on the different sources of data. The various building types are summarized along the X axis, including an indication of the sample size (i.e., number of buildings) in brackets from the two sources of individual building data (YTG Buildings, "Energy Map").

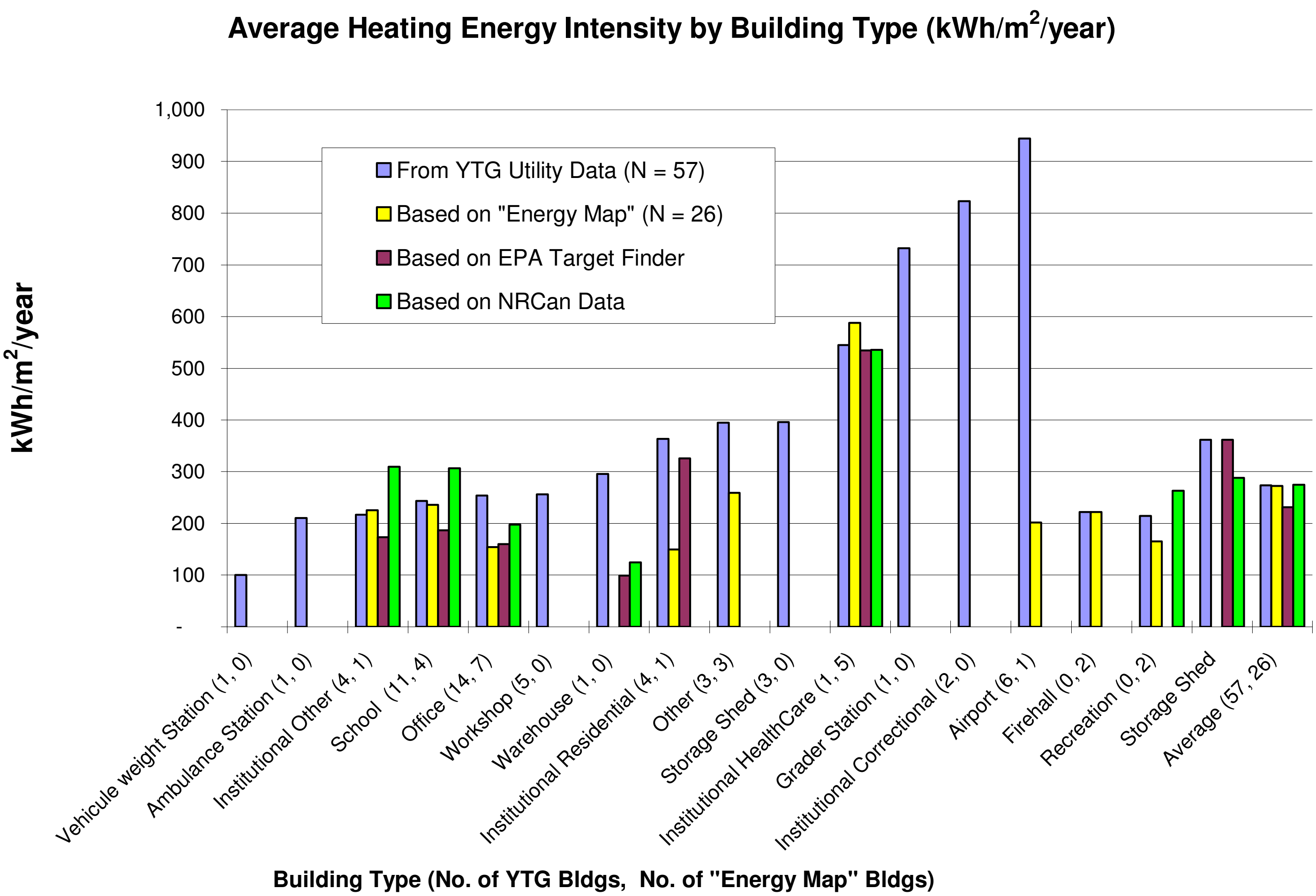

Figure 4: HEI Data by Building Type from Various Sources (kWh/m^2/year)

Figure 4 shows the high degree of variation in heating energy intensity for different building types. This shows that unless there is a good understanding of the building type, it is difficult to estimate resulting heating energy intensity.

Figure 4 also shows a degree of consistency between the various different sources of information, which is clear when looking at building types including school, office, and health care for which there is data from all 4 sources. There is also a high degree of consistency between the average intensity determined from the various sources, providing a level of confidence in using an average value for high-level approximations, such as a pre-feasibility stage study.

The resulting average HEI values that were used to predict heating energy consumption for each building type are summarized in Table 4, and range from 217 kWh/m^2/year to 944 kWh/m^2/year. An average value for the purposes of prediction is calculated only for the building types for which there are at least three buildings in the sample data, or for which there is statistical data; all other building types will reference the overall average (273 kWh/m^2/year), which is based on the total known heating energy divided by total known floor area.

Table 4: Average HEI Values used to Predict Heating Load (kWh/m2/year)

Space Type	Heating Energy Intensity (HEI) kWh/m^2/yr
Institutional Other	217
School	244
Office	254
Airport	944
Warehouse	295
Hotel	362
Institutional Residential	363
Institutional HealthCare	545
Workshop	256
Other (based on average)	273

The same HEI values are used to predict heating energy consumption throughout the 25-year period considered within the financial analysis. It is recognized that over time some of the existing buildings may undergo energy efficiency upgrades that result in reduced heating energy consumption. No attempts are made within this study to account for potential energy efficiency upgrades; however, it is recommended that future studies consider this level of detail.

2.2.3 Predicted Heating Loads and Intensity (YTG and City Bldgs)

Using the values in Table 4 and the floor areas, Table 5 summarizes the total predicted heating load and intensity for all of the buildings for which the floor area was provided by the Client.

Table 5: Summary of Estimated Heating Load for YTG and City Buildings

Total No. of Buildings	Total Floor Area	Total Heating Load[12]		Average Heating Energy Intensity	Estimated Annual Peak Heating Demand[13]
	m^2	(GJ/year)	(MWh/year)	(kWh/m^2/year)	(MW)
166	244,000	232,200	65,000	264	26.1

Table 5 shows that the total estimated peak heating demand for the YTG and City buildings included is approximately 26 MW. Refer to Appendix A – Load Intensity Data for a summary of the estimated energy consumption for each individual building. The YTG and City buildings are shown visually in Figure 18: Identifying Buildings and Zones within Study Area, located in Appendix A – Load Intensity Data.

Figure 18 is developed using an interactive excel-based tool that was developed for the purpose of this study. The figure shows a map of the study area overlaid on top of a grid of cells. Each cell is equivalent to 22 m^2 or 0.002 hectares. The approximate location of each building is denoted by placing the Building ID number in the cell that most closely corresponds to the building's location on the overlain map. Each cell that represents a building is also colour-coded to signify the energy intensity of that individual building. Three colours are used: red for those that consume more than 900 MWh/year (3,240 GJ/year), orange for those that consume between 550 and 900 MWh/year (between 1,908 and 3,240 GJ/year), and blue for those that consume less than 550 MWh/year (1,908 GJ/year).

2.2.4 Predicted Heating Loads and Intensity (Other Bldgs)

It is recognized that there are many non-YTG/City buildings (commercial, industrial, and residential) within City of Whitehorse that could also be considered for connection to a DES. It is recommended that these opportunities be explored further in subsequent studies.

In order to provide a sense of the heating energy intensity including all buildings within the core study areas of City of Whitehorse, Figure 19 was developed. Figure 19 is located in Appendix A – Load Intensity Data, and provides an Energy Intensity Map for all buildings within the study area. Figure 19 represents an order of magnitude estimate of energy intensity across most of the developed areas of the city. The intensities are based on estimated density factors (i.e., building density in square meters of conditioned building floor area per hectare, m^2/ha) and the average HEI value estimated for Whitehorse (273 kWh/m^2/year), based on the utility data provided (and correlated by statistical data).

[12] Based on total fuel consumption including space heating and domestic water (unless domestic water heating is provided by electricity)
[13] The annual peak heating demand is estimated based on a factor of 0.40213 (taken from the RETScreen tool for Whitehorse), which is an average used to convert annual heating energy consumption to annual peak heating demand using the following formula:

Peak load factor = Peak load (kW) / Energy consumption (MWh/yr).

The intensity (annual MWh of heating energy per hectare, MWh/ha) is indicated using three colours: red for areas that are very likely to be viable (>1,500 MWh/ha), orange for areas that appear to be marginally viable (1,000 to 1,500 MWh/ha), and yellow for areas that do not appear to be viable at this time (< 1,000 MWh/ha).

2.2.5 Predicted Heating Loads and Intensity (Future Bldgs)

It is recognized that new buildings that are constructed are likely to be more energy efficient than the existing buildings, especially if energy code requirements become more stringent. For the purpose of this study no attempt is made to quantify the reduction in heating intensity of future buildings since there is little basis upon which to make such predictions and since the margin of uncertainty with respect to the type of new buildings that might be constructed is already high. Future studies should take into account increases in energy efficiency of new construction.

2.2.6 Summary of Heating Intensity by Zone

Most district energy systems start out providing service within a single zone, then expand to other zones as additional customers sign on. The initial zone will likely be the hospital or a comparable “anchor” tenant. To permit analysis of different zones and the impact of phasing, an interactive spreadsheet based tool was developed in order to quickly estimate the energy intensity within a given area or zone of the city. The tool allows the user to define an area on a map of City of Whitehorse (study area only) by shading cells and then to calculate the energy intensity (annual MWh per hectare) for this area. This allowed zones of the city to be identified for further study based on achieving the minimum rule of thumb energy intensity required to make a DES financially viable (1,500 MWh/ha).

For this analysis, only YTG and City owned buildings were included. As shown in Figure 18 located in Appendix C – Heating Energy Intensity Map, six key regions, or zones, of the city were identified and analyzed. Table 6 provides a high level summary of the heating energy intensity for each region based on including all of the government buildings from Table 5 that are within the six key zones; the buildings that are not within any of the key zones are excluded. Refer to Appendix A – Load Intensity Data for a detailed summary listing heating load and intensity on an individual building basis within the six key zones.

Table 6: Summary of Heating Energy Intensity by Zone (All YTG and City Buildings)

Zone	Total Building Floor Area m2	Total Zone Area Ha	Total Energy Consumption MWh/year	Total Heating Energy Intensity MWh/ha/year	Total Peak Load MW
Zone 1: Lewes Blvd	30,493	2.4	9,915	4,128	4
Zone 2: Hospital Road	25,514	1.1	10,592	9,570	4
Zone 3: Downtown	66,695	5.0	15,858	3,199	6
Zone 4: Range Road	58,112	3.6	12,307	3,416	5
Zone 5: Quartz Road	17,399	2.1	4,999	2,372	2
Zone 6: Airport	21,733	2.5	5,506	2,196	2
Total	219,945	16.7	59,176	3,547	24

Any zone with a total annual heating energy intensity of 1,500 MWh/ha or greater is considered potentially viable. As such, based on this high-level screening, all zones are considered viable (the lowest intensity being the airport with 2,196 MWh/ha/year) based on inclusion of all YTG and City buildings studied.

2.2.7 Preliminary Screening

Some preliminary screening was conducted for the buildings within each zone to remove those buildings that are incompatible based on heat delivery temperatures (supply and return temperature) and/or mechanical heating deliver equipment within the building (i.e.; air based heating systems), as well as those that are deemed to have too low an annual heating consumption to make the cost of the energy transfer station viable.

Table 7 provides a summary of the heating energy intensity for each zone after screening out buildings that were deemed incompatible or for which the annual heating energy consumption is less than 330 MWh/year[14] (or $32,000/year). More detailed analysis could reveal opportunities to use one energy transfer station for multiple buildings, thus making the connection of some of the buildings with a smaller heating load more financially viable.

[14] This cut-off value is estimated based on a maximum acceptable simple payback of 10 years and an assumed 15% savings on heating energy costs associated with connecting to the DES.

Table 7: Summary of Heating Energy Intensity by Zone (After Screening Level 1)

Zone	Total Building Floor Area m2	Total Zone Area Ha	Total Energy Consumption MWh/year	Total Energy Intensity MWh/ha/year	Total Peak Load MW
Zone 1: Lewes Blvd	30,493	2.4	9,152	3,810	4
Zone 2: Hospital Road	25,514	1.1	9,663	8,731	4
Zone 3: Downtown	66,695	5.0	9,417	1,900	4
Zone 4: Range Road	58,112	3.6	4,844	1,344	2
Zone 5: Quartz Road	17,399	2.1	1,754	832	1
Zone 6: Airport	21,733	2.5	934	373	0.4
Total	219,945	16.7	35,764	2,144	14.4

2.3 MOST FEASIBLE ZONES AND BUILDINGS

Based on the analysis described previously, the following is a commentary on the most feasible zones and buildings.

2.3.1 Zones

When determining the viability of connecting certain zones, it is necessary to also consider decisions surrounding the technology used to generate heat. For example, the economies of scale required to implement a waste to energy heating plant are greater than the scale required for a biomass combustion based plant. In Section 3.0 - Task 2: Energy Input Discussion, it is concluded that the preferred input technology is a combustion system fueled by biomass in the form of wood pucks. Based on this conclusion there is a threshold capacity below which a stand-alone biomass combustion system is not considered viable (technically and/or financially). This is related to the minimum viable plant capacity, cost of duplicating emission control equipment, and potential increases in operating cost associated with having more than one plant. This threshold is considered to be approximately 2 MW, as a preliminary estimate.

Based on the results summarized in Table 7 and the conclusions from Section 3.0 noted above, zones 4, 5, and 6 are deemed to have too small a plant capacity and/or too low a heating energy intensity to make them viable as stand-alone systems without connecting to additional non-government buildings in their respective zones. For the purpose of this study, and in order to demonstrate viability using conservative assumptions, the additional complications associated with connecting buildings with diverse owners resulted in the conclusion to consider only Zones 1, 2 and 3. This does not mean that a DES is not viable in the other zones, but it would likely require connecting additional non-YTG/City buildings, and/or a different heat input technology.

2.3.2 Buildings

The most viable buildings are those that are within the most viable zones, with large enough heating consumption to warrant the cost of an energy transfer station, and with compatible heating systems (i.e.; those that were not removed during the preliminary screening). These 20 most viable buildings are summarized in Table 19 of Appendix A – Load Intensity Data, and are represented in Figure 18 by cells with a black border.

2.3.3 Future Expansion

A rough estimate of the potential growth in building floor area within each zone was developed based on the assumption that building floor area grows at the same rate as population (estimate at 6% over a 5 year period)[15], and that 50% of new growth within each zone connects to the DES. The growth rate was applied to an estimate of the total building floor area within each zone, based on an estimated average density factor of 1.5,[16] resulting in an average estimated growth of 765 m^2 each year.

The assumption that 50% of new buildings connect to the DES is a very rough estimate. It is noted that from the sensitivity analysis (summarized Section 6.4), the impact of not connecting any new growth in buildings does not have a negative impact on the overall financial viability. Further study in later stages of implementation would be required to optimize which new buildings should be connected to the DES.

These estimates are coarse and should be refined in subsequent studies. The downtown zone likely has greater potential for growth; it is noted that several of the recommended buildings fall within the areas identified in the City of Whitehorse Downtown Plan[17] as “Core Areas Under-Utilized”.

[15] Source: http://www.eco.gov.yk.ca/pdf/families06.pdf
[16] In other words, 1.5 m^2 floor area per m^2 of land, which is equivalent to 15,000 m^2/ha
[17] As shown in Figure 4.2 (http://ww3.whitehorse.ca/planning/downtown%20plan/finalplan.pdf)

3.0 Task 2: Energy Input Discussion

The following section discusses the energy input / energy source options (including fuel oil, electricity, biomass, etc.) and heat generation technology options (including combustion, combined heat and power, heat pump, etc.) for the district energy system.

The discussion is based on the heating energy required for the Downtown, Hospital Road and Lewes Boulevard areas of Whitehorse since these are the most viable zones. Should additional viable buildings be identified within other zones, such that they exceed the minimum required energy intensity and scale for a viable DES, the results of this analysis are expected to be applicable to other zones.

3.1 ENERGY INPUT CHARACTERISTICS, PRICING, AND AVAILABILITY

This section provides a summary of the characteristics, pricing, and availability of the energy inputs/sources that were considered for the City of Whitehorse district energy system.

3.1.1 Wood Waste

A limited supply of wood waste is available in the Yukon Territory for use in the Whitehorse DES. Wood waste includes sources such as sawdust and hog fuel produced during the processing of lumber. The wood processing industry in the Yukon provides a very small portion of the lumber to meet the domestic demand in the Yukon which is primarily met by lumber imported to the Territory. There is no lumber export market due to the long distance required for the transport of the product to the export markets. The lack of a lumber export industry results in a very small supply of waste wood. This supply of waste wood is not found in the vicinity of the City of Whitehorse.

The fuel considered as wood waste for the study is actually wood harvested specifically for use as fuel. The cost used for this fuel is based on the estimated cost to harvest the wood. The cost includes the cost of labour, fuel for harvesting equipment, and transportation.

3.1.2 Wood Pellets

Wood pellets are produced through a process of grinding, drying and extruding wood fiber into small cylindrical pellets approximately 5 mm in diameter and 10 mm long. These pellets are a dry, easily handled biomass fuel with a high heating value. The advantage of pellets as a biomass fuel is the ease of handling due to the constant sizing and the lower cost of transportation due to the higher heating content per unit volume due to the lower moisture content.

It is understood that the construction of a wood pellet plant is under consideration for the Whitehorse area. The advantage of such a facility would be the capability to provide fuel for the

DES from a local source which would be insulated from the global market conditions. This should help to maintain a relatively stable fuel cost for the DES.

The technology for the production of wood pellets is well proven in British Columbia with approximately one million tonnes of pellets being exported annual for use in power generation and related combustion processes in Europe. The establishment of a wood pellet processing facility in the Yukon would not require the use of new technology or new processes.

3.1.3 Wood Pucks

Wood pucks are produced through a process of grinding and drying of the wood fiber and then pressing into a cylindrical shape which is about 75 to 100 mm in diameter. Segments of the cylinder approximately 25 mm thick are referred to as pucks. The pucks are a dry, high heating value biomass fuel that is easily transported and handled.

It was found through an internet search and subsequent telephone conversation that there is an enterprise in Whitehorse with the potential capacity to supply the City of Whitehorse with sufficient wood pucks for fuel for the DES. This company (Yukon North Biomass Company) is currently in the start-up phase with a small production capability for the retail market. It was confirmed with the company representative that the production can be ramped up as the demand for the product grows. It is estimated that the DES would require an annual fuel flow of 10,000 tonnes. The supply of this quantity was confirmed as possible by the representative of Yukon North Biomass Company.

The process for the production of wood pucks is similar to the production of wood pellets with the exception that the form of the final product is such that the individual pieces are larger that the pellets. This fuel is acceptable for combustion in grate type of furnaces such as those envisioned for the Whitehorse DES.

It is recommended as the project moves forward that additional discussions take place with the fuel suppliers to confirm the capacity, future expandability and fuel cost.

3.1.4 Heating Oil

The heating oil considered is the same fuel that is currently widely used in Whitehorse for building heating. Heating oil for the DES would be purchased at bulk or wholesale prices. The pricing is based on the average of the bi-weekly cost for the previous four years. This approach has the effect of minimizing the volatility that has occurred over the recent years.

3.1.5 Propane

The propane case was used as a comparison to the other studied heating sources. It is currently used for a small portion of the heating in Whitehorse. The currently published cost of propane was used for this study.

3.1.6 Electric – Firm

Electric input to the system by firm electrical energy is shown to illustrate the relative cost of the uninterruptible electrical power source for the DES.

3.1.7 Electric – Secondary

The secondary electrical supply to the DES is considered as an interruptible electrical source. This supply should be considered as a heat source that must be backed up by an alternative heat input source. The pricing for the secondary electrical supply is approximately 70% of the firm electrical pricing. It should be noted that the secondary electrical supply is expected to be available during periods of maximum hydro generation and lowest electrical consumption. This is generally in the summer months. The secondary electrical supply may be cut off with as little as two hours notice. The secondary electrical supply is not recommended as a long term energy supply to the DES due to the possible interruptions.

3.1.8 Municipal Solid Waste

Municipal Solid Waste (MSW) is a potential energy source. The cost of using MSW should include the operating cost (or potentially revenue) associated with collection of the fuel as well as fuel sorting to ensure the recyclable materials are removed from the fuel stream. Using MSW as a fuel for district heating has been demonstrated successfully, particularly in Europe[18]. The scale of operation that is required to make these systems viable is assumed to be too large for consideration as fuel source for the initial phases of a DES. The use of MSW as a fuel is not explored further within this study; however, it is recommended that this be explored further as a potential future energy source option.

3.1.8.1 Solar Energy

Direct capture of solar energy is a potential energy source, using a technology such as solar hot water collectors. The solar energy itself is free, but there is a capital cost associated with the equipment required to capture this energy in a usable form. This is considered a potential supplemental energy source option and is not explored further within this study.

3.1.8.2 Waste Heat Sources

Sewage heat recovery was discussed as an option (using heat pumps); however, it was discounted for the following reasons:

- 1) heat should not be extracted from the sewage prior to it reaching the wastewater treatment plant (WWTP) since this is understood to negatively affect the sewage treatment process (i.e.; heat might need to be re-added at the WWTP), and

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[18] The Municipality of Linköping, Sweden is a good example. Household waste from Linköping and approximately 30 other municipalities as well as waste from industries is transported to the Gärstadverket WTE plant where 400,000 tons of waste are incinerated every year, producing heating and electricity and displacing over 100,000 tons of oil.

- 2) Heat could be extracted at the sewage outfall, but the distance to the sewage outfall (near Porter Creek) makes this infeasible.

No other specific waste heat sources (such as industrial processes resulting in waste heat) were identified within the study area. Waste heat sources are not likely to serve as the primary source of heating and therefore are not explored as an individual scenario. Waste heat sources should be examined on a case by case basis and are often best captured within the specific building (to directly reduce heating requirements within that building) or used by a new adjacent building that can design a system specifically to take advantage of the waste heat[19]. Waste heat sources are considered a potential supplemental energy source option and are not explored further within this study.

3.1.8.3 Geo-Thermal Heat

It is understood that there are significant geo-thermal heat sources within the Whitehorse region; however, no such source is known to be within sufficiently close proximity to the study area to warrant further analysis at this stage. This energy source option is not explored further within this study.

3.1.9 Summary

The pricing and key characteristics of the energy source options that are considered further within this study are summarized in Table 8.

Table 8: Costs and Characteristics of Fuels Considered

Fuel	Cost, $/GJ	Characteristics
Wood waste	19.13	50% moisture 10.5 GJ/ tonnes $200 / tonnes
Wood pellets	16.44	7% moisture 16.7 GJ/ tonnes $275 / tonnes
Wood pucks	14.26	7% moisture 18.6 GJ/ tonnes $265 / tonnes
Heating oil	22.90	$0.894/l 38.2 MJ/l
Propane	31.61	$0.817/l 25.3 MJ/l

[19] An excellent example of this is the Centre for Interactive Research on Sustainability (CIRS), which is a new building being designed on the University of British Columbia campus in Vancouver, BC. This building will utilize heat pumps to capture sufficient waste heat from an adjacent laboratory exhaust system to provide the majority of heating for the new building and return some of the waste heat back to the adjacent building to reduce their heating requirements.

Fuel	Cost, $/GJ	Characteristics
Electric – Firm	29.06	Non-interruptible
Electric – Secondary	20.30	Interruptible

3.2 HEAT GENERATION TECHNOLOGIES CONSIDERED

The heat generation technologies considered include the following:

- Combustion (Heating Only)
- Organic Rankin Cycle (ORC) (Combined Heat and Power)
- Steam Turbine (Combined Heat and Power)
- Waste to Energy (WTE)
- Solar Thermal Collectors
- Ground Source Heat Pump (GSHP)

The first three technology options listed above are described in the following sections in combination with energy input options that they can be combined with. The last three options are discussed but not included in any of the scenarios considered; the reasons are described in their respective sections.

3.3 ENERGY INPUT AND TECHNOLOGY SCENARIOS CONSIDERED

This section provides a description of the general characteristics of the 17 cases considered for the DES. It should be noted that each case represents a combination of an energy input source (as described in Section 3.1) and a heat generation technology (as described in Section 3.2). The cases are listed and ranked in Section 3.4. The cases considered for the DES include heating only of the circulated water and combined heating of the circulated water and electrical power production (CHP). The CHP cases considered two technologies. These are the Organic Rankin Cycle (ORC) and the Steam Turbine Generator (STG) technologies.

3.3.1 Combustion Only (Cases 1-5):

These cases are based on the combustion of the fuel in a hot water heater. The combustion takes place in the furnace which chemically releases the energy contained in the fuel in the form of heat. The heat in the flue gas is then transferred via the heat exchange surface to water which is then circulated to the buildings which are connected to the DES.

The biomass cases (1, 2 & 3) are very similar to each other with the major differences in the systems being the sizing and design of the fuel handling equipment and the sizing of the furnace to accommodate the expected higher moisture content of the waste wood fuel. The furnace for the wood waste fuel (case 1) may have a radiant arch that is used to direct the flow of the flue gas through the furnace allowing sufficient residence time for complete combustion before the flue gases enter the heat exchange surface. The furnace for the wood pellets and the wood pucks (cases 2 and 3) are typically smaller than the furnace size required for the wood waste fuel. This is due to the lower moisture content of the fuel and the shorter required residence time for compete combustion.

The boiler efficiency of the biomass fired units is dependent on the moisture content of the fuel. The efficiency drops as the moisture content rises due to the heat required to evaporate the moisture in the fuel. It is expected that the efficiency difference between the waste wood fired unit and the wood pellet or wood puck fired unit (similar moisture content) to be in the range of 8-10%.

The biomass fired units are equipped with ash handling systems that are used to remove the ash from the furnaces. The ash is generally placed into bins or hopper for disposal. The quantity of ash from wood waste (greater than 1%) is expected to be greater than the quantity of ash from the wood pellets (less than 1%) due to the different quantities inherent in the different fuels.

The fuel handling system (including the fuel storage) for the wood waste case must be sized to handle fuel of lower heating value than the wood pucks or wood pellets as well as designed to handle the irregular shape of the wood waste. Figure 5 shows an example image of a wood pellet boiler system.

Figure 5: Wood Pellet Boiler

The heating oil and propane fired hot water heaters are less complicated relative to the biomass fired cases due to the easier handling and control of oil and propane fuels. The combustion takes place in a burner where the fuel and air mixture is ignited and the heat released in the form of hot flue gas. The hot flue gas flows over the heat exchange surfaces transferring heat to the water to be circulated in the DES. The furnace sizes are smaller than the biomass heaters due to the generally higher allowable heat release rate in the heater of the liquid or gas fuels than the solid fuels. The furnace sizes are also smaller due to the shorter residence time for complete combustion. The efficiency of the heating oil and propane fired hot water heaters are in general higher than the biomass units due to the lower moisture content of the fuel and better control of the combustion air and the resultant lower losses due to higher excess air.

3.3.2 Combined Heat and Power (CHP) – Organic Rankin Cycle (ORC) Technology (Cases 6-10):

In the ORC cases the heat produced by the combustion of the various fuels is used to heat thermal oil which is circulated to a heat exchanger which in turn heats an organic expandable fluid to a temperature above the saturation temperature which results in a pressurized vapour form of the organic fluid. The vapour expands through a turbine where the energy in the fluid is converted to mechanical energy. The turbine is coupled to the generator where the mechanical energy is converted to electrical power. The fluid (in vapour form) exits the turbine and is condensed to liquid before being pumped back to the heat exchanger to repeat the cycle. The heat removed from the fluid in the condenser in used as heat input to the DES. This is accomplished by the flow of the circulated water through the condenser to cool and condense the organic vapour.

The combustion system for the ORC cases vary based on the fuel that is used but in general they are similar to those as described in the combustion only cases. The main difference in the combustion system of the ORC system compared to the heat only cases is that the heat in the hot flue gases exiting the furnace is transferred to the thermal oil which is then used as a heat source in the heat exchanger evaporate the organic expandable fluid in the heat exchanger.

The advantage of the ORC cases is the closed system for the thermal oil which is used for the transfer of heat from the combustor to the evaporator and the closed system for the organic fluid for the transfer of the energy from the evaporator to the turbine and condenser. The use of the closed systems eliminates the requirement for make-up water which in turn will minimize operating cost while retaining the system capability of producing electricity and heat. Also the thermal oil / ORC system operates at a lower pressure and temperature which contributes to the lower operating costs as fewer operating engineers are required with lower level certification.

It should be noted that the ORC systems of the size required for this project are delivered as skid mounted equipment to ease installation. There are ORC systems of this type installed and in operation in Europe. Figure 6 shows an example ORC unit.

Figure 6: Organic Rankin Cycle Unit

The advantage of the capability to generate electricity while providing heat input to the DES may be important in the future as the electrical requirement in the region grows.

3.3.3 Combined Heat and Power – Steam Turbine Technology (Cases 11-15):

The combined heat and power cases that make use of the steam turbine technology use similar combustion technology to the ORC cases however the heat of combustion is used to evaporate water in a boiler to generate high pressure and high temperature steam. The steam flows from the boiler to the steam turbine where it expands thus converting the energy in the steam to mechanical energy. This rotational mechanical energy is used to drive a generator which produces electricity for the grid. The steam exhausting from the turbine is condensed back to water and pumped back to the boiler as part of the feed water cycle. The heat that is removed from the condensation of the steam is used as heat input to the DES. This is accomplished by the flow of the circulated water through the condenser to cool and condense the steam vapour.

The advantage of the steam turbine CHP cases is the conversion of the chemical energy in the any of the fuels to both heat (for the DES) and electrical power for the grid. This would provide a back-up electrical power supply to the City of Whitehorse while still providing heat to the DES. There are many examples of installations of this technology.

The disadvantage of the steam turbine cases is the design requirements of the boiler and steam turbine to operate at high steam pressure and temperature. This is required to facilitate the efficient transfer of energy from the fuel to the steam turbine. The high operating pressure and temperature will necessitate a more complicated boiler design and more robust boiler components as well as higher licensed operating engineers than the heat only or the ORC cases. Also the boiler will require treated make up water to ensure long term reliability of the boiler pressure parts. This will add to the overall operation cost.

3.3.4 Heat Only by Electric (Cases 16 – 17)

The cases of heat only by electric (firm and secondary) were added for comparison to the combustion based systems.

The advantage of electrical based scenarios is the relatively simple system in that no combustion in required. As more heat is required for the system increased current is applied to the electric heater and additional heat is input to the system. The system simplicity has the effect of a minimizing the operating cost.

The disadvantage is the higher cost of heat input to the system on a $/GJ basis for the firm electrical basis and an interruptible supply for the secondary supply scenario. A system based on an interruptible secondary supply would require a back-up input supply for times when the secondary supply is not available.

3.3.5 Ground Source Heat Pump (GSHP) System Option

Ground Source Heat Pump (GSHP) systems are an efficient and typically lower emission heating and cooling source. They can be designed for either a single building application or a district system application. This kind of heat pump system takes advantage of the relatively constant temperature of the ground – heat is rejected from the system in the summer so that cooling is provided and extracted in the winter so that heating is provided.

The efficiency of the heat pumps is quite high with a typical coefficient of performance (COP) of 3. A COP of 3 means that for every unit of electricity used to power the units, 3 units of heating energy are produced thanks to the amount of energy extracted from the ground.

A GSHP system consists of two main components – a well field and a heat pump array. The well field is a series of either open or closed loop pipes that are bored into the ground either horizontally or vertically. The location and design of the well field are significant factors in determining how well the GSHP system will work. The soil conditions and the presence or absence of ground water will vary the ability of the well field to transfer heat in and out of the ground. The higher the soil conductivity, the better the system's cost effectiveness – the better the heat transfer, the shorter the well needs to be for the same system capacity. The other component of the system is the heat pump array. Heat pumps can vary widely in terms of size and efficiency. Matching the appropriate technology with the desired system configuration is obviously necessary for optimal performance.

Clearly, this energy benefit makes them an attractive technology option but there are a number of additional issues that must be addressed to determine if this kind of system is appropriate for a service area. In order to obtain the maximum efficiency from a GSHP system and to make the cost associated with drilling the required wells worthwhile, soil conditions, system type and loop temperature and GHG issues must all be considered. An overview of these considerations is presented here in the context of the Whitehorse study area.

3.3.5.1 Site Potential

Some significant investigation has already been completed to assess the technical feasibility of GSHP systems in the study area. Notably, Gartner Lee described the potential for all of the areas under consideration for this study in their 2003 "Yukon Groundwater and Ground Source Heat Potential Inventory". In summary, the area near the Hospital has reasonably good potential thanks to the presence of some form of groundwater. Most other areas under consideration seem to present low or low-moderate potential thanks to the soil conditions. Lewes Boulevard does not seem to have very favorable soils but the same groundwater that makes the Hospital area favorable may also be present here.

3.3.5.2 Compatibility Issues

GSHP systems are low temperature water systems on the heating side, generally limited to a maximum temperature of 60 degrees C. Because of this design consideration, a GSHP-fueled district energy system must be paired with buildings that can utilize low temperature water or those buildings must be equipped with booster boilers that will increase the temperature of the water to a compatible temperature. Unfortunately, the buildings in the potential Whitehorse district energy precincts are all likely higher temperature (generally 80 to 90 degrees C) than would be easily compatible with a GSHP system, especially the Hospital. Booster boilers would be necessary to provide water of the appropriate temperature. The capital cost of providing these boilers would likely be prohibitive, especially when the on-going maintenance and servicing costs are included.

A second compatibility issues is the match between heating and cooling loads. Generally, heat is rejected in the summer to re-charge the ground field, and then extracted over the winter. In this way a ground field may be considered a seasonal storage device for thermal energy. A challenge in Whitehorse is the imbalance between heating and cooling loads. In the long term, this may lead to deterioration of the ground field, particularly in locations with poor conductivity and low water permeability.

3.3.5.3 GHG Issues

Reductions in carbon or greenhouse gas emissions are a valid and significant reason to consider a GSHP system. Provided the carbon signature of the electricity in the jurisdiction is low enough, the use of an electrically-fueled system like a GSHP will reduce the carbon signature of the system compared to a gas-fired system. In the Yukon, the average GHG intensity of electricity is 0.249 kg CO2e/kWh whereas natural gas is 0.204 kg CO2e / kWh according to Natural Resources Canada. (Note that propane and most other fossil fuels are even higher) So long as boosting boilers are not required, the overall system emissions signature is lower with a GSHP choice. If, however, significant numbers of booster boilers are required, the emissions signature would be higher, reducing the benefit of selecting a GSHP system.

3.3.5.4 Summary

GSHP systems are an important system to investigate for any district system. However, the soil conditions in the Whitehorse areas under investigation do not seem to present significant potential for cost-effective, efficient GSHP installations. The only area where there is potential based on the soil conditions is the area around the Hospital. Unfortunately, the Hospital's mechanical systems will require high temperature water and the GSHP system is unlikely to prove cost effective with the amount of boosting required.

3.3.6 Waste to Energy Options

Waste to energy (WTE) is the process of creating energy in the form of electricity and/or heat from the incineration of a waste source, such as municipal solid waste (MSW).

A WTE technology could be used as the primary or a secondary heat input component for the district energy system. Energy contained within the waste stream would be converted to heat through any one of a number of thermal technologies such as incineration, gasification, thermal depolymerization, pyrolysis, or plasma arc gasification. This heat could then be used as an input to the DES by passing the hot flue gas over the heat exchange surfaces to transfer the heat to the circulation water of the DES. Non-thermal technologies such as anaerobic digestion, fermentation and mechanical biological treatment may also be used to convert the waste to a form that is useable for the production of heat.

The incineration type combustion system represents the most mature technology for a WTE system and most appropriate for the City of Whitehorse DES.

In addition to supplying heat input to the City of Whitehorse DES the implementation of a WTE option could provide the advantage of long term waste disposal. It is expected that the most appropriate system would use a combustion system to heat hot water which would then be used as heat input for the distribution system of the DES. The use of the WTE system would effectively result in a reduced input requirement from the other heat sources for the DES which would result in a larger back-up or stand-by capability if the WTE system was added in the future.

The cost of using a WTE system should include the increased operating cost required for collection and transportation of the waste to be used as fuel as well as fuel sorting to ensure the recyclable materials are removed from the fuel stream. The cost for the emissions clean up equipment must also be included in the capital cost of the WTE system. It is expected that the operational cost of the WTE system will be higher than the biomass system due to the impurities in the waste fuel.

A WTE scenario is not included in the analysis since sufficient information is not available to develop a complete scenario; however, this option is recommended for further analysis.

3.4 COMPARISON OF OPTIONS

This section discusses the DES heat input sources and technology options for each of the cases studied. The results of the comparison are listed in **Error! Reference source not found.** which shows the relative ranking of each of the cases. The purpose of the ranking of the cases was to determine the most economically attractive case from those reviewed. The selected case was then used as the basis for the financial analysis / projection of Section 6.

Table 9: Ranking of Technology and Fuel Alternatives

Case	Fuel	Technology	Technically feasible, y/n	Ranking
1	wood waste	Heat only by combustion	Y	9
2	wood pellets	Heat only by combustion	Y	2
3	wood pucks	Heat only by combustion	Y	1
4	heating oil	Heat only by combustion	Y	7
5	propane	Heat only by combustion	Y	15
6	wood waste	combined heat and power - ORC	Y	12
7	wood pellets	combined heat and power - ORC	Y	6
8	wood pucks	combined heat and power - ORC	Y	4
9	heating oil	combined heat and power - ORC	Y	10
10	propane	combined heat and power - ORC	Y	16
11	wood waste	combined heat and power - steam turbine	Y	14
12	wood pellets	combined heat and power - steam turbine	Y	8
13	wood pucks	combined heat and power - steam turbine	Y	5
14	heating oil	combined heat and power - steam turbine	Y	13
15	propane	combined heat and power - steam turbine	Y	17
16	electric - firm	heat only	Y	11
17	electric - secondary	heat only	Y	3

The ranking was based on a high level evaluation of the expected total annual cost for each of the cases. The evaluation considered the base and peak load analysis taking into account the heat input required by the system, the required heat input in the fuel, the unit fuel cost and the annual fuel cost based on the results of Section 3.1. The income from electrical sales for the CHP cases was also included in the evaluation. An estimated capital cost for each of the cases was used as an input to determine the estimated annual financial charge used in the determination of the total annual cost to operate the system.

It was found that the most economically attractive option is Case 3 (heat only by combustion using wood pucks as the fuel). This case consists of a combustion system which utilizes wood pucks as the biomass fuel. Case 2 (heat only by combustion using wood pellets as fuel) was ranked second. The use of wood pellets for fuel for the DES may be considered as an alternative to the wood pucks in the event that a supply of wood pucks is not available for the DES. It is expected that the capital cost of the combustion equipment will be similar for either of these biomass fuels. The characteristics of the fuels that were considered are described in Section 3.1.

In each of the cases analyzed the base heating load was provided by the various fuels as listed in the **Error! Reference source not found.**. The heat required for the peak load was supplied by heating oil fired equipment. The heat input for the base load component is handled by the equipment operating continuously at full load. This equipment typically has a higher capital cost but is capable of using lower cost fuel thus minimizing the operating costs of the system. In case 3, the biomass (wood pucks) fired hot water combustion system provides the heat input for the base load. The peak load is handled by heating oil fired hot water heaters.

The details of the ranking of the cases that were considered are shown in Appendix D.

The CHP cases (ORC and STG) were ranked lower (more expensive) than the combustion only systems mainly due to the higher capital costs of the equipment even though an income stream due to the electrical production was possible.

3.5 CONCLUSIONS

Various energy input sources (fuels) and heat-input technologies to the district energy system were screened at a high level by comparing the expected fuel costs, expected capital costs, and expected operating and maintenance costs.

Case 3 (heat only by combustion using wood pucks as the fuel) was the combination of energy input and technology that was found to represent the lowest annual cost. The advantages of a locally supplied fuel using proven equipment are an expected low cost operation with a minimal of unplanned downtime due to such factors as fuel availability, equipment failures or mis-operation. This scenario was selected for further financial analysis as shown in Section 6.0 - Task 5: Financial Analysis / Projections.

The combined heat and power options were encouraging however it appears that the relatively high capital cost of these systems combined with the low expected income due to the electrical power produced resulted in these systems being ranked lower than heat only system.

The GSHP system also showed promise but the area with the best soil condition for a GSHP system (hospital area) had to supply the hospital's mechanical systems with high temperature water that would require temperature boosting and the associated extra expense of a booster boiler.

4.0 Task 3: Preliminary System Concept

4.1 SERVICE AREA

The service areas under consideration for the Whitehorse are the Lewes Blvd areas, Hospital Rd area and the Downtown area as previously explained. The DES may also be able to capture additional existing or new buildings within the service area, but given the uncertainty this creates, these are not considered in this analysis.

4.2 SYSTEM CONCEPT

The district heating system includes a distribution network of pipes, a central energy plant and energy transfer stations within each building served. A brief description of each component is presented below.

4.2.1 Distribution Network

The proposed district energy system would supply the space heating and domestic hot water (DHW) needs of compatible buildings throughout the service area via a network of insulated, hot water distribution pipes (see Figure 7). A variable temperature variable flow concept is recommended to minimize line losses and pipe size. As the system will be serving primarily existing buildings, the supply and return temperatures will be defined by the heat transfer equipment within each building. Generally the system operator will strive to minimize the supply temperature (usually about 80 C for existing systems) and maximize the temperature drop across the building heat exchanger.

Stantec recommends utilization of welded thin wall steel pipe designed to En253 specifications for all piping installation to ensure long and trouble free operation. A leak detection system is an optional component of the pipe network that is recommended. For this study, compatible buildings were those with hydronic heating and with a minimum annual load of 330,000 kWh.

Figure 7: Example District Heating Distribution Pipe Installation

Figure 8 shows a purely notional piping layout for the recommended DES.

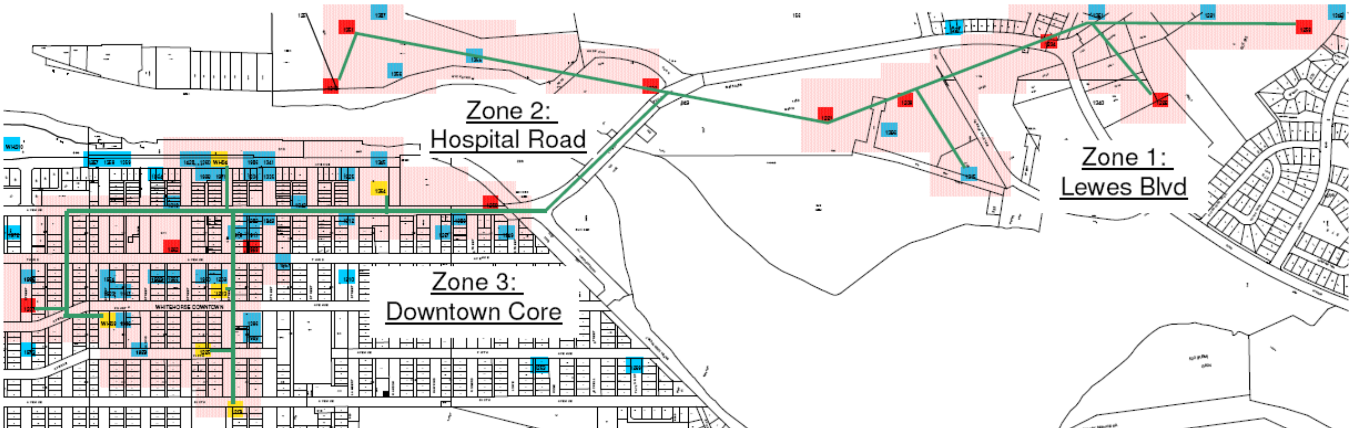


Figure 8: Schematic Layout of Proposed DES

The interconnection of the DES piping from Zones 1 and 2 to Zone 3 requires the piping to use the bridge as support for the river crossing. This will require the piping to be designed to operate from below grade to above grade in a harsh winter climate. This requirement will necessitate the use of a suitable insulation system and a heat tracing system if required to ensure trouble free operation. Access to the bridge during the construction phase must be confirmed however the impact is not expected to be to significant. It is envisioned that the installation of the piping could be timed to take place during routine bridge maintenance such as lane paving.

4.2.2 Plant

Heat will be produced and/or distributed from a central heat plant. The recommended fuel for the heating plant is wood pucks which will provide between 70 and 95% of annual heat demand. Peaking and back-up heat would be supplied by near condensing oil-fired boilers. As the loads (existing buildings) are already in-place, the biomass plant will be built in conjunction with the distribution system and buildings will be connected as the system is built.

A detailed description of the recommended heat input plant is as follows:

The energy plant is envisioned to consist of biomass fired hot water heaters, the required auxiliary equipment, back-up heat input equipment, buildings and infrastructure.

The proposed combustion systems are capable of firing the dry biomass fuel in the form of wood pucks. The pucks are essentially disks of dried compressed wood fibers of approximately 100 mm in diameter and 25 mm thickness. This fuel is uniform and capable of being easily handled and fed into the combustor.

The auxiliary equipment used for this plant includes the fuel supply and ash handling system, fans and motors, automatic cleaning system, ignition and control systems, emissions control equipment, flues, ducts and a stack.

The peaking and back-up hot water heating system is envisioned to be heating oil fired equipment capable of providing heat input to the system in the event that the biomass heat systems are out of service for any reason or the heating requirement is at its seasonal peak.

The following are some other back-up options that could be considered:

- Utilization of the existing heating equipment in the buildings that will be connected to the DES. The majority of the existing heating equipment is fired by heating oil. In the event that back-up heat is required to the DES the existing equipment could be placed into service. This scenario would provide back-up heat during periods of peak operation. In addition, a number of the existing heating plants include electric boilers, which make use of the surplus electricity at reduced rates. It may be advantageous to use these to meet some of the summer base load when there surplus electricity. This concept has not been included within the financial analysis.

- The capital cost for the DES energy input system has considered the requirement for additional heat input capacity to satisfy the N-1 case. The N-1 designation is used to describe the case where the required capacity of the system can be supplied with one of the components out of service. In this case N is the total number of components and N-1 represents one unit out of service or not available. In this case, the additional capacity is supplied by heating oil fired hot water heaters.

- During periods when the demand is less that than peak, the peaking biomass boilers can also act as back-up capacity if some of the base load equipment is shut down.

An example biomass plant is presented in Figure 9.

Figure 9: Biomass District Heating Plant in Revelstoke BC

The plant will be fully manned, and supervision requirements will need to be reviewed with the jurisdiction having authority. Plant operators will be responsible for operation of the plant, delivery of heat, monitoring of in-building performance and collection of heat sales for billing.

4.2.3 Energy Transfer Stations

Individual buildings will be served using an Energy Transfer Stations (ETS) located on the customer premises that are owned and operated by the utility (Figure 10). The utility would meter and bill for consumption. Building owners or landlords will be responsible for allocating costs to individual businesses/tenants within the building. No sub-metering costs are included in this analysis. Flow control valves and energy meters are interfaced with a communications network to allow for continuous monitoring of all systems remotely.

Figure 10: Energy Transfer Station Installation

4.2.4 System Operation

The system is a heating only concept, since cooling loads in Whitehorse are small and not economic to service from a centralized system. The concept utilizes hot water distributed through the insulated pipes. A variable temperature variable flow operating schedule is recommended, where operating temperature ranges from 75C to 95 C, and re-set to outdoor temperature. Operating pressure is generally at 150 PSI. The system efficiency is dependent on achieving a low return temperature. Therefore, control valves at the energy transfer station should be return temperature limiting.

A steam based systems is not recommended for the current application due to relatively high losses and miss-match of primary and secondary supply temperatures. Similarly, an ambient loop concept is not recommended due to the minimal cooling load anticipated for this system.

4.2.5 System Control

It is ideal if the individual building heating systems are designed for variable volume flow operation, preferably with variable speed pumps to minimize the pumping (power) requirements. Based on observations made during the site visit, many of the existing buildings have a constant flow design. The details of how these buildings will be connected should be explored within a subsequent feasibility study.

All control valves (terminal units and zone valves) should be of 2-way modulating type (or on/off for Fan Coil Units). The secondary supply temperature (from the ETS) shall be reset based on outside air temperature. Ideally the maximum ETS secondary supply temperature should not exceed 70^{o}C. Flow control valves will be set to be return temperature limiting.

A LonWorks[20] communications protocol is recommended for system communication, as vendors such as TA Canada have developed controllers for district energy applications. The communications network may be supported off an internet platform or utilizing a copper or fibre optics cable that may be installed with the pipe network. This will permit automated billing collection, trouble shooting and system control.

[20] LonWorks is a networking platform specifically created to address the needs of control applications. (http://en.wikipedia.org/wiki/LonWorks)

5.0 Task 4: GHG Emissions and Air Quality

A key benefit of the district energy concept relative to the business as usual (BAU) scenario includes reduced greenhouse gas (GHG) or carbon emissions and reduced local air pollutants in Whitehorse.

The BAU scenario is fuel oil fired boilers for the majority of buildings, and a limited amount of propane fired boilers and electric boilers. The proposed DES scenario includes moving to a biomass fired heating plant with fuel oil used only for peaking and backup (~20% of total output).

5.1 EMISSION FACTORS

The quantification of GHG emissions is a relatively new and evolving phenomenon for organizations and government bodies in North America. There are many subtleties associated with GHG emissions quantification, which are evolving with the industry. One important issue is the emission factor that is applied to various energy sources. Emission factors are published by many different sources, sometimes with contradictory results.

For direct emissions from fuels such as natural gas, fuel oil, and propane there is minimal variation between emission factors stated by different information sources. For indirect emissions associated with electricity generation there are many different emission factors available from different sources. The results vary depending on many factors including year(s) reported (for example, single year data versus average over several years); regions included (for example, Whitehorse specifically versus Yukon Territory in general); and calculation methodology (for example, if imports and exports of electricity are included in analysis).

Some of the different GHG intensity or emission factor values researched, for each of the fuel alternatives are presented in Table 10.

Table 10: GHG Intensity by Fuel

Fuel	Emissions Intensity kg/kWh	Source
Heating Oil	0.310	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2005[21]
Heating Oil	0.254	Emission Factors for Use in Reporting Public Sector Greenhouse Gas Emissions, September 15, 2009
Electricity	0.249	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2004. Environment Canada, April 2006 (for "Northwest Territories, Nunavut, & Yukon Territories")
Electricity	0.030	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2005
Biomass	0	Based on assumption that biomass is considered renewable (i.e., carbon neutral)
Biomass	0.190	Emission Factors for Use in Reporting Public Sector Greenhouse Gas Emissions, September 15, 2009

For the purpose of this study, the emission factors assumed are 0.249 kg CO_2e/kWh for electricity and 0.310 kg CO_2e/kWh for fuel oil, and zero kg CO_2e/kWh for biomass. These assumptions should be confirmed if the project moves forward.

5.2 RESULTS

Based on the above emission factors and the proposed build out of a biomass-based district heating system, GHG emissions from oil are forecast to decrease by approximately 9,500 tonnes per year by 2034, as detailed in Table 11. Accounting for a small increase in electricity consumption associated with the DES, the overall GHG reduction is approximately 9,190 tonnes CO_2e/year by the year 2034. This is also based upon the assumption that GHG emissions associated with biomass combustion are considered carbon neutral.

[21] Value for fuel oil is a composite value based on proportions of diesel fuel oil and light fuel oil in Canada for the specific inventory year.

Table 11: Summary of Energy Consumption and GHG Emissions for BAU and DES Scenarios (Year 2034)*

Energy Consumption	Units	BAU Scenario	DES Scenario	Savings (BAU - DES)
Fuel Oil	MWh/yr	35,669	5,024	30,645
Electricity[22]	MWh/yr	0	1,238	(1,238)
Biomass	MWh/yr	0	28,470	(28,470)
Total	MWh/yr	35,669	34,732	937
GHG Emissions	**Units**	**BAU Scenario**	**DES Scenario**	**Savings (BAU - DES)**
Fuel Oil	tCO_2e	11,057	1,557	9,500
Electricity	tCO_2e	-	308	(308)
Biomass	tCO_2e	-	-	-
Total	tCO_2e	11,057	1,866	9,192

*Brackets indicated negative values (ie; increases rather than savings).

5.3 AIR QUALITY IMPACTS

Air quality impacts are equipment dependent. Emissions cleanup equipment may be specified for either oil fired or biomass equipment to reduce common air contaminants. For the biomass system installation of a precipitator is assumed that would reduce stack emissions of particulate matter to required limits (assumed < 15 mg/nm3). Costs for post combustion cleanup equipment to achieve this level of particulate emission are included in the financial analysis. Additional limits for NOx (<120 mg/nm3), CO (<400 ppmv), and opacity (<5%) are also achievable. These costs were not included in the financial analysis and would be included only if the City of Whitehorse has exceedances relative to the Canada-wide standards. Including this level of emissions control could be considered as a means to improve air quality and public perception associated with a combustion based district energy. Additional direction is required to understand local air quality issues.

[22] It is noted that some of the heating in the BAU scenario (~6%) is provided by propane and electricity; however, these are insignificant and therefore ignored for the purpose of this study. Electricity consumption under the DES scenario is for equipment and pumping energy associated with the DES plant and distribution network.

6.0 Task 5: Financial Analysis / Projections

6.1 ASSUMPTIONS

This section summarizes the key assumptions used to develop financial projections for the Business as Usual (BAU) scenario and the preferred District Energy System (DES) scenario, including the cost of fuel oil, electricity, biomass and carbon offsets during the 25 year study period (2010-2034). **All dollar figures within the financial model are in real 2009 dollars unless otherwise noted.** The assumed rate of inflation for the 25 year period is 2%, which is consistent with the long-term Bank of Canada target.

The study period begins in January, 2010 since an anticipated time at which operation could be commenced is not known given this is a pre-feasibility study. A 25-year study period ending in 2034 has been used because district energy systems have assets with a relatively long useful lifetime and a number of years are required to recoup the customary operating losses in the initial years.

Regarding governance structure, after discussion with the client, it was decided to assume that the DES would be a utility owned by the City of Whitehorse.

It is important to note that there is a good deal of uncertainty when projecting energy costs, particularly over a 25-year horizon. Given the uncertainty in projecting energy pricing beyond 10 years, it is recommended that the projections beyond 10 years be viewed as an indication of likely trends only.

6.1.1 Energy Costs

Average energy costs for fuel oil, electricity and biomass were researched for the Whitehorse market in 2009 and used as the basis for projecting energy costs over the 25-year study period. It was assumed that customers purchase fuel oil at commercial rates in the BAU scenario whereas the DES utility purchases the fuel oil it requires at wholesale rates. Wholesale rates were about 2% lower than commercial rates in 2009.

In the case of fuel oil, the projected annual rates of increase for light crude developed by Sproule were used to escalate the price of fuel oil. Sproule is a world-wide petroleum consulting and research firm and is considered a reputable source for oil and gas price forecasts. Gas companies, financial organizations, and government agencies use Sproule reports for technical and financial planning. The analyst responsible for developing the Sproule oil and gas forecasts was contacted and confirmed that it was reasonable to apply the price increase projections for Edmonton par light crude to fuel oil in the Yukon market. Table 12 shows the Sproule forecast for Edmonton par dated 31 December 2009. Although the average price for 2009 was $66.87/Bbl, by December, 2009 the monthly average price had recovered to $74.65/Bbl. The Sproule forecast projects light crude reaching a price of around $91/Bbl by 2013, about 14%

below the average price of $105/Bbl for 2008. Beyond 2013, the price of light crude is forecast to remain constant in real dollars or increase annually at a rate of 2% nominal. These price increase projections were applied to fuel oil unless otherwise noted.

Table 12: Oil Price Forecasts

OIL PRICE FORECASTS (Real $2010)

Year	Edmonton Par Price 40 API $/Bbl		10 year CAGR
1998 Act	24.82		
1999 Act	33.10	33.4%	
2000 Act	52.13	57.5%	
2001 Act	45.56	-12.6%	
2002 Act	45.88	0.7%	
2003 Act	48.14	4.9%	
2004 Act	57.49	19.4%	
2005 Act	74.26	29.2%	
2006 Act	77.52	4.4%	
2007 Act	80.28	3.6%	
2008 Act	105.08	30.9%	
2009 Act	66.87	-36.4%	7.3%
2010	84.25	26.0%	
2011	88.22	4.7%	
2012	89.01	0.9%	
2013	90.64	1.8%	
2014	90.66	0.0%	
2015	90.67	0.0%	
2016	90.69	0.0%	
2017	90.71	0.0%	
2018	90.72	0.0%	
2019	90.74	0.0%	
2020	90.76	0.0%	0.7%

Constant Prices Thereafter
[1] 40 Deg API, 0.4% sulphur

Source: Sproule & Associates, 31-Dec-09, http://www.sproule.com/Oil---Real

Figure 11, shows the same information graphically.

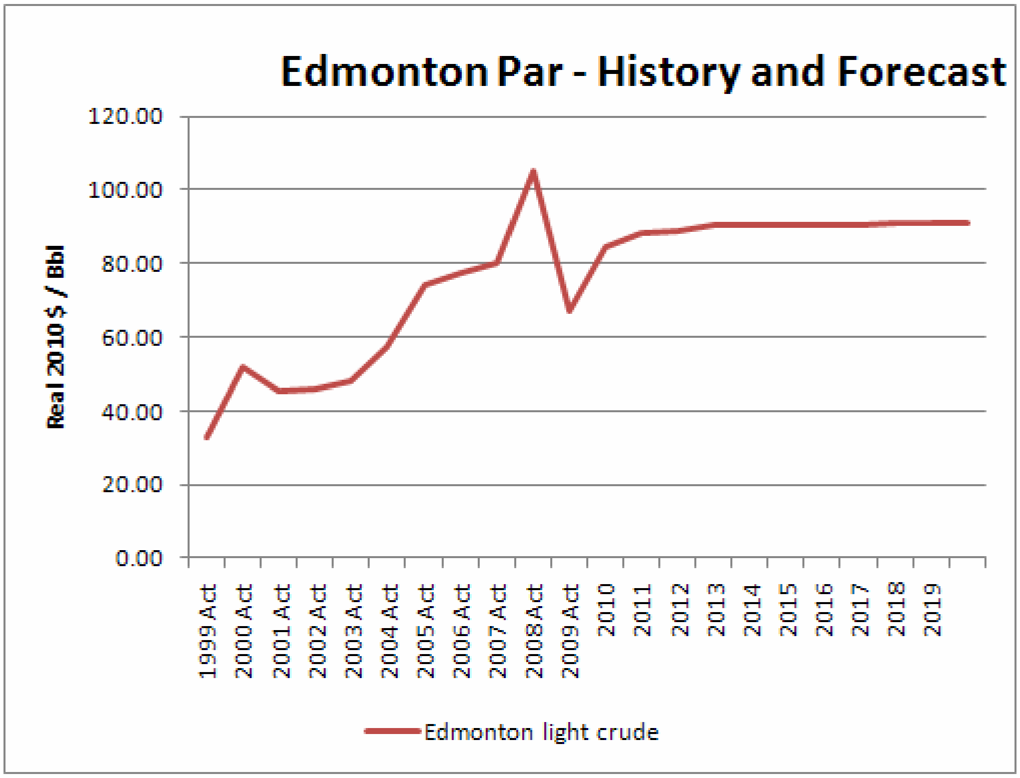


Figure 11: Oil Prices - Historical and Forecast

Electricity was projected to increase at a real rate of 0% or 2% nominal. This is considered conservative given that the real rate of increase in BC Hydro rates is about -1% over the last 20 years and Yukon Energy implemented a 6% rate decrease on December 1, 2008. Furthermore, Whitehorse is supplied by hydro and so its rate should be independent of fluctuations in the price of oil.

Biomass was projected to increase at a real rate of 0% or 2% nominal due to the source of supply being local. This forecast came from a potential supplier of biomass and is considered reasonable given that there is no export market for biomass produced locally owing to a lack of cost-effective transportation.

Figure 12 shows the projected energy costs over the study period based on the above assumptions.

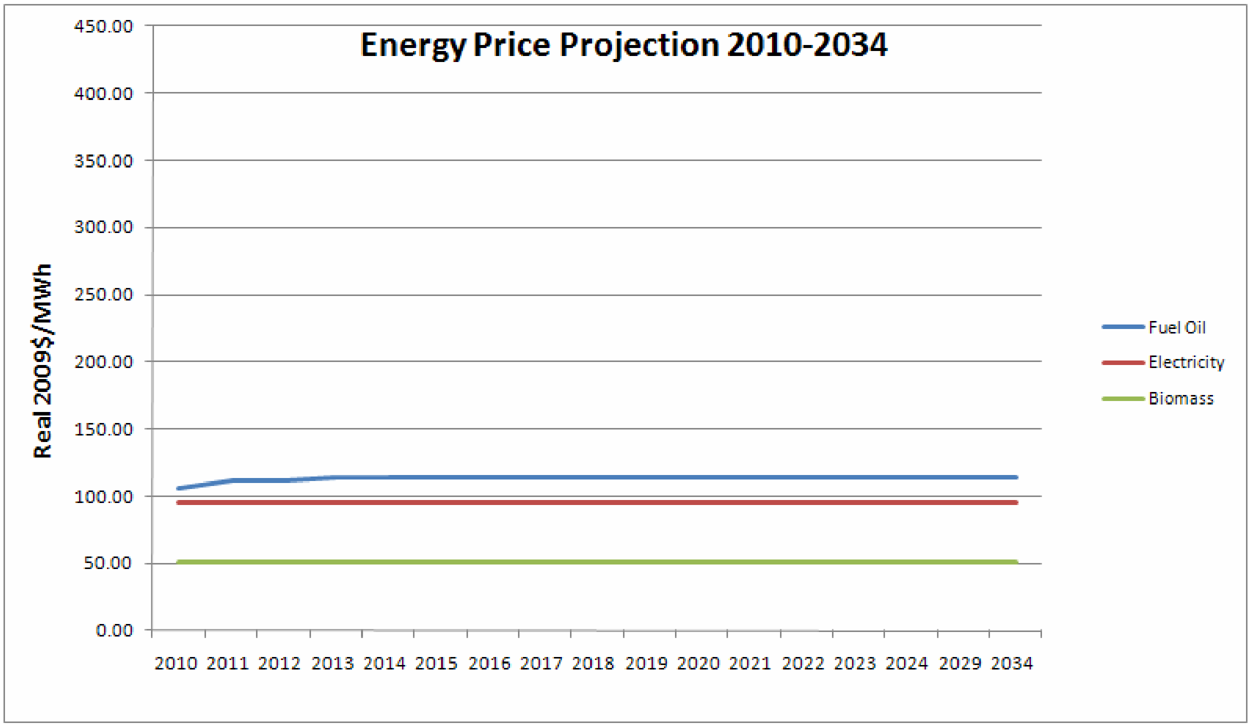


Figure 12: Energy Price Projection 2010 - 2034

For the DES scenario, it was assumed that saleable carbon offsets would be generated from the reduction in GHG emissions compared to the BAU scenario. Pricing of these was based on a forecast by Natsource[23] included in BC Hydro's 2008 Long Term Acquisition Plan. The most likely scenario begins with a midpoint of $14/tonne in 2010 increasing to $39/tonne (real 2008 $) in 2030 which is equivalent to a compound average growth rate (CAGR) of 5.26%. Pacific Carbon Trust is reported to be buying carbon offsets in the range of $14-$20/tonne validating this forecast for the short term. Accordingly, it was assumed that a DES could sell carbon offsets beginning at $14/tonne in 2010 and increasing in value by 5.26% annually in real dollars over the study period.

6.1.2 Taxes

As a city owned utility, it is assumed that the DES revenues would not be subject to income tax. So the financial projections have been prepared on a pre-tax basis. In the event a different governance structure was adopted, provision for taxes would have to be made based on the ownership structure actually put in place.

It has also been assumed that the DES utility would charge GST to any non-YTG customers and thus be entitled to claim a GST rebate for all GST payable on energy and other costs.

[23] BC Hydro 2008 Long Term Acquisition Plan, Appendix G1, Natsource 2007 GHG Offset Forecast Report

Hence, a net GST rate of 0% has been assumed. Heating fuel is zero rated for Yukon sales tax; a similar treatment has been assumed for all energy used by the DES[24].

6.1.3 Revenue

Revenue to the DES is assumed to come from two sources: heating charges for connected customers and the sale of carbon offsets. The assumptions behind the pricing of carbon offsets have been explained previously in Section 6.1.1. The heating charge was developed in two steps. First, a rate is calculated that would yield a cost of heating equal to the fuel costs currently incurred in the BAU scenario. Secondly, a premium over that rate is applied to deliver sufficient revenue to achieve positive cash flow and a positive net present value over the study period. As a simplifying assumption for the BAU scenario, it was assumed that all of the premises in study area used fuel oil as a heating energy source since the overwhelming majority did so.

The initial market for the DES was considered to be 20 Yukon Government and City of Whitehorse buildings, henceforth referred to as the Initial Buildings, in the downtown, Hospital Road and Lewes Boulevard zones with a total area 96,224 m^2. An estimated growth of new buildings was assumed within each area, as described in Section 2.3.3 - Future Expansion. 50% of the estimated annual growth in the three zones was assumed to connect to the DES, amounting to an annual increase in the served floor space of 765 m^2. 40% of the growth was assumed to be government space and 60% private commercial space. It was assumed that the DES would charge the same rate to both government and commercial customers. The growth is assumed to come from new development in both the BAU and DES scenarios.

Heating consumption per m^2 (also known as heating intensity) is assumed to remain constant over the study period and for new growth it is based on the current average heating intensity for the Initial Buildings.

Customers are assumed to be added in the middle of the year; in other words, the DES only has 50% of the annual revenue for a customer in the first year of acquisition. This reflects the fact that in any given year, the exact timing of connection will be determined by issues of customer convenience and when the DES utility can be ready to provide the in-building infrastructure for new customers. All of the Initial Buildings are assumed to connect within the first year.

6.1.4 Capital and Financing

The replacement cost for the heating plant in the Initial Buildings has been estimated at $870,000 or $9.05 per m^2. In the BAU scenario, a replacement plant charge of 1/25th of this amount has been applied each year representing an average expected cost to replace heating plant equipment as it reaches the end of its useful lifetime. Similarly, an allowance for the cost of new heating plant equipment for the new growth has been included based on the same cost

[24] Currently there is no Yukon sales tax on fuel used for heating; it has been assumed that a similar treatment would be extended to other fuel sources used for heating such as biomass.

per m^2. Both of these charges have been treated as expenses in the BAU scenario since together they amount to around $40,000 per year or about 1% of the annual fuel costs.

The capital cost of the DES system has been estimated at $17.5 million plus $200,000 for land costs. That estimate includes 10% for soft costs and 20% for contingency. A further capital cost allowance has been included for upgrades to the DES plant to accommodate growth. Each upgrade is assumed to be made to accommodate projected growth over the next 5 years.

All new capital assets are assumed to come into use January 1 with construction carried out in the previous calendar year during which time the assets are treated as assets under development. Construction financing is assumed to be part of the provision for soft costs.

All assets are depreciated on a straight-line basis over the asset's lifetime.

The funds required to make the DES capital investments are assumed to be funded through the issue of bonds with a coupon[25] of 8.25% and a 25-year term, which is the City of Whitehorse's current cost of borrowing. The discount rate has been assumed to be equal to the cost of borrowing. It has been assumed that the City would establish a sinking fund with annual contributions beginning the year each bond is issued to accumulate the funds necessary to repay the principal of each bond when it becomes due. It has also been assumed that the City could earn an average return of 5% on its sinking funds and this rate has been used to estimate the required contributions for the sinking funds. Since the model is in real dollars, the discount rate, cost of borrowing and the return on sinking funds have all been adjusted by the assumed rate of inflation of 2%. Table 13 summarizes these figures.

Table 13: Financial Figures

	Nominal	**Real**
City's cost of borrowing	8.25%	6.25%
Discount rate	8.25%	6.25%
Sinking fund return	5.0%	3.0%

The NPV calculation includes a terminal value or salvage value equal to the book value of the assets for the period over which the NPV is being calculated plus the value of the assets under development in the last year of the period.

6.2 PROJECTIONS

Two scenarios were modeled, a BAU scenario estimating the costs of supplying heating to the three zones in the study with the existing heating systems burning fuel oil and assuming that new development also uses fuel oil-fired heating plants, and a DES scenario implementing the preferred DES solution.

[25] Another term for interest rate, used in the context of bonds

6.2.1 BAU Projections

Table 14 shows the financial projections for the BAU scenario.

Table 14: BAU Financial Projections

Note: All monetary figures are in real 2009 $

Capital

Initial Replacement Value	$ 870,427
Total Replacement Value	$ 1,043,380

Cashflow & Key Metrics Projections

Payback Period	N/A		
Year Cashflow Turns +ve	N/A	**Year NPV Turns +ve**	N/A

	2010	2014	2019	2024	2029	2034
Project Year	1	5	10	15	20	25
Revenue	$ -	$ -	$ -	$ -	$ -	$ -
Expenses	$ 3,328,000	$ 3,682,000	$ 3,825,000	$ 3,965,000	$ 4,105,000	$ 4,245,000
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Sinking Fund	$ -	$ -	$ -	$ -	$ -	$ -
Cashflow	-$ 3,328,000	-$ 3,682,000	-$ 3,825,000	-$ 3,965,000	-$ 4,105,000	-$ 4,245,000
Cumulative Cashflow	-$ 3,328,000	-$ 17,730,000	-$ 36,566,000	-$ 56,112,000	-$ 76,356,000	-$ 97,299,000
Expenses, $/m2	$ 34.31	$ 36.80	$ 36.82	$ 36.82	$ 36.81	$ 36.80
GHG Emissions - tonnes	9,322	9,617	9,986	10,355	10,724	11,093
GHG Reduction - tonnes	0	0	0	0	0	0

N.B. Cashflow is after debt service and sinking fund contributions.
GHG reduction is in comparision with GHG emissions for the BAU scenario

There are no revenues as the BAU scenario models carrying on with the current situation where each building has its own independent heating plant burning fuel oil.

BAU expenses consist of three components:

- Fuel
- Operating and Maintenance (O&M)
- Other

O&M expenses for the Initial Buildings have been estimated at $105,000 annually. This amount has been prorated as additional growth takes place, with the additional O&M cost being proportional to the additional floor space. Other expenses are the charges for the replacement cost of existing and additional heating plant equipment as discussed earlier.

Total expenses are estimated at $34.31/m^2 in 2010, growing to $36.80/m^2 in 2034. Figure 13 shows the relative contribution of the three components to the annual costs under the BAU scenario. Fuel is far and away the most significant cost element, accounting for 96% of total costs, with O&M and Other accounting for 3% and 1% respectively.

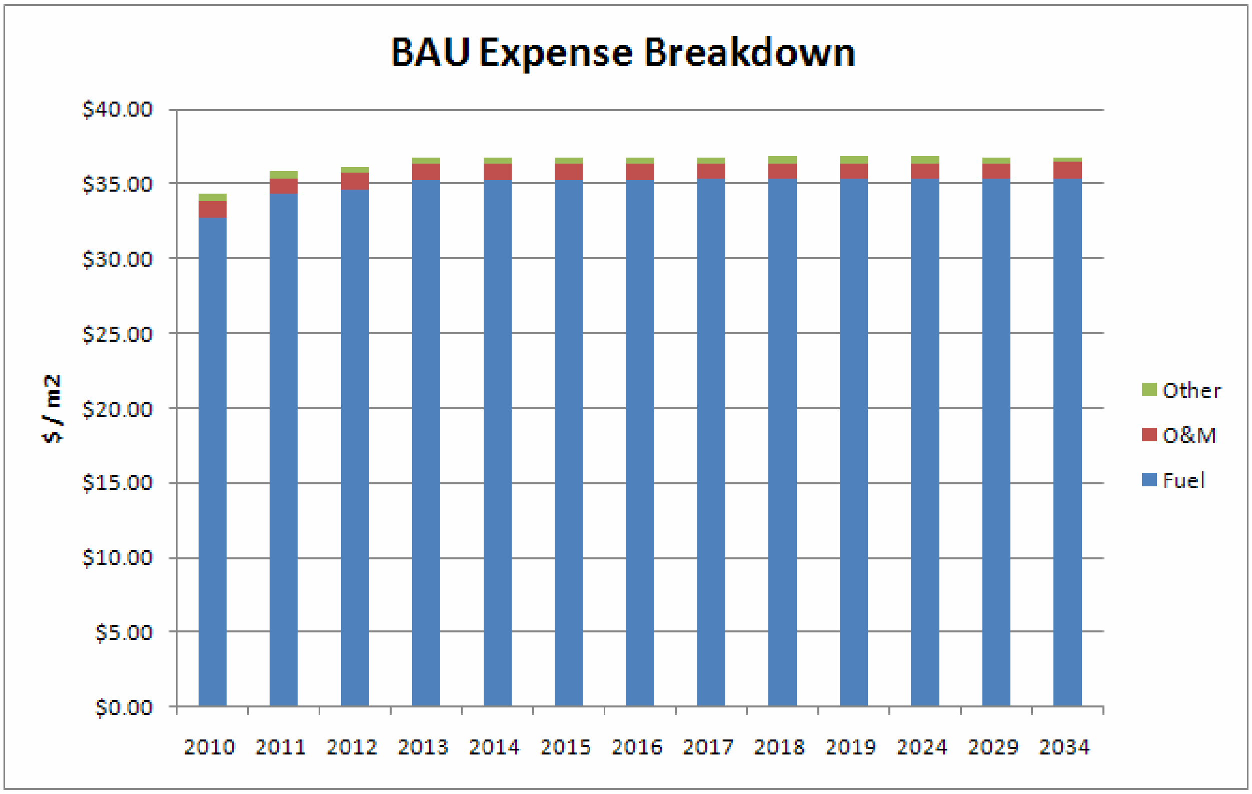


Figure 13: BAU Expense Breakdown

6.2.2 DES Projections

Table 15 shows the financial projections for the preferred DES option.

Table 15: DES Financial Projections

Note: All monetary figures are in real 2009 $

Capital

Initial Capital Cost	$	18,395,443
Total Capital Cost	$	21,477,217

Rate Projections ($/MWh)

	2010	2014	2019	2024	2029	2034
Fuel Oil	$103.79	$111.68	$111.79	$111.81	$111.81	$111.81
Electricity	$94.75	$94.75	$94.75	$94.75	$94.75	$94.75
Biomass	$51.29	$51.29	$51.29	$51.29	$51.29	$51.29
DES Energy Charge	$151.57	$163.10	$163.25	$163.28	$163.28	$163.28
Carbon Offsets ($/tonne)	$14.00	$17.18	$22.20	$28.68	$37.05	$47.87
Model Growth	yes					
Monetize Carbon Offsets	yes		**DES/BAU total heating cost**			
Premium for Energy Sales	10%		**ratio, year 25**			**106.0%**

Cashflow & Key Metrics Projections

Payback Period, years	**12**	**IRR, year 25**	**7.3%**
Year Cashflow Turns +ve	**4**	**Year Cum. Cashflow Turns +ve**	**17**
Max Cumulative Deficit	**-$1,311,000**	**Year NPV Turns +ve**	**13**

	2010	2014	2019	2024	2029	2034
Project Year	1	5	10	15	20	25
Revenue	$ 1,812,000	$ 4,026,000	$ 4,227,000	$ 4,441,000	$ 4,677,000	$ 4,941,000
Expenses	$ 1,365,000	$ 2,298,000	$ 2,386,000	$ 2,475,000	$ 2,563,000	$ 2,651,000
Debt Service	$ 1,150,000	$ 1,150,000	$ 1,193,000	$ 1,237,000	$ 1,311,000	$ 1,355,000
Sinking Fund	$ 505,000	$ 505,000	$ 524,000	$ 543,000	$ 575,000	$ 595,000
Cashflow	-$ 1,207,000	$ 74,000	$ 124,000	$ 188,000	$ 227,000	$ 340,000
Cum. Cashflow	-$ 1,207,000	-$ 1,185,000	-$ 799,000	-$ 123,000	$ 704,000	$ 2,037,000
NPV	-$ 1,232,000	-$ 1,260,000	-$ 544,000	$ 563,000	$ 1,770,000	$ 3,054,000
ROIC	-0.9%	6.1%	6.3%	6.6%	6.8%	7.3%
Expenses, $/m2	$ 28.16	$ 23.06	$ 23.06	$ 23.06	$ 23.06	$ 23.06
GHG Emissions - tonnes	5,302	1,355	1,407	1,459	1,511	1,563
GHG Reduction - tonnes	4,020	8,263	8,580	8,897	9,214	9,531

N.B. Cashflow is after debt service and sinking fund contributions.
*ROIC or Return on Invested Capital = EBIT * (1 - tax rate) / (interest bearing debt + equity)*
GHG reduction is in comparision with GHG emissions for the BAU scenario

The heating plant equipment in the BAU scenario has an estimated average efficiency of 72%. DES customers will be billed for heat delivered to the heat exchanger in the building mechanical room, meaning that from the customer's perspective it is 100% efficient. This means that if the energy charge per MWh of heat delivered to DES customers was identical to the energy cost per MWh of fuel oil burned for BAU customers, DES customers would be paying significantly less for heat. Therefore, to set the DES energy charge to result in equivalent fuel costs to BAU means a multiplier of 1/.72 or 30% has to be applied to the energy cost per MWh of heating with fuel oil to arrive at an estimate of the DES energy charge that would match the energy costs of the BAU scenario.

The DES energy charge has been set at a premium of 10% over the rate needed to match the energy costs of the BAU scenario. This is necessary to ensure that initial operating losses are kept to a reasonable level and that the City earns a return on investment roughly equal to its cost of borrowing. With the energy charge at a 10% premium, the project has a simple payback period of 12 years without taking into account debt service and sinking fund payments. Cash flow after debt service and sinking fund payments turns positive in year 4 and the maximum cumulative deficit before cash flow turns positive is $1,311,000. The effect of having zero or lower premiums over the rate needed to match BAU energy costs is explored in section 6.4 - Sensitivity Analysis.

Figure 14 shows how the DES customer charges compare to the BAU customer costs. Based on the 10% premium, the DES customer charges are about $3.75/m^2 more than the BAU fuel costs but about $2/m^2 more than the BAU total costs or about a 6% increment. A 10% premium is in line with rate strategies adopted by other municipal heating utilities. For example, the City of North Vancouver initially established their rate structure for the Lonsdale Energy Corporation at 15% above the typical rate that a customer would pay for using conventional electric heating; after a few years of operation, they reduced it to be comparable to the rates charged by Terasen Gas. The City of Vancouver has adopted a 2010 rate structure for the Southeast False Creek Neighbourhood Energy Utility that is estimated to result in heating costs about 10% higher than those charged by BC Hydro, Dockside Green, Lonsdale Energy Corporation or Central Heat Distribution.

It should be noted that the possibility of paying a premium is considered a worst case scenario, which could be eliminated after further analysis to optimize other factors. It is also noted that paying a premium has not been reviewed with either the City of Whitehorse or the Yukon government. Such a discussion is recommended as one of the next steps to be undertaken as part of a follow-on Feasibility Study as outlined in section 7.1.2. It should also be noted that it may be possible to eliminate the premium after a few years of operation due to costs being lower than expected or fuel oil prices rising more quickly than the conservative rate of escalation assumed here. This proved to be case with the Lonsdale Energy Corporation as mentioned above.

In addition, we have not accounted for any sinking funds that are likely required under the BAU scenario for boiler replacement and O&M costs by owners. These operating and maintenance costs need to be better understood at the detailed feasibility study stage and accounting for these will likely improve the financial performance of the DES scenario relative to BAU.

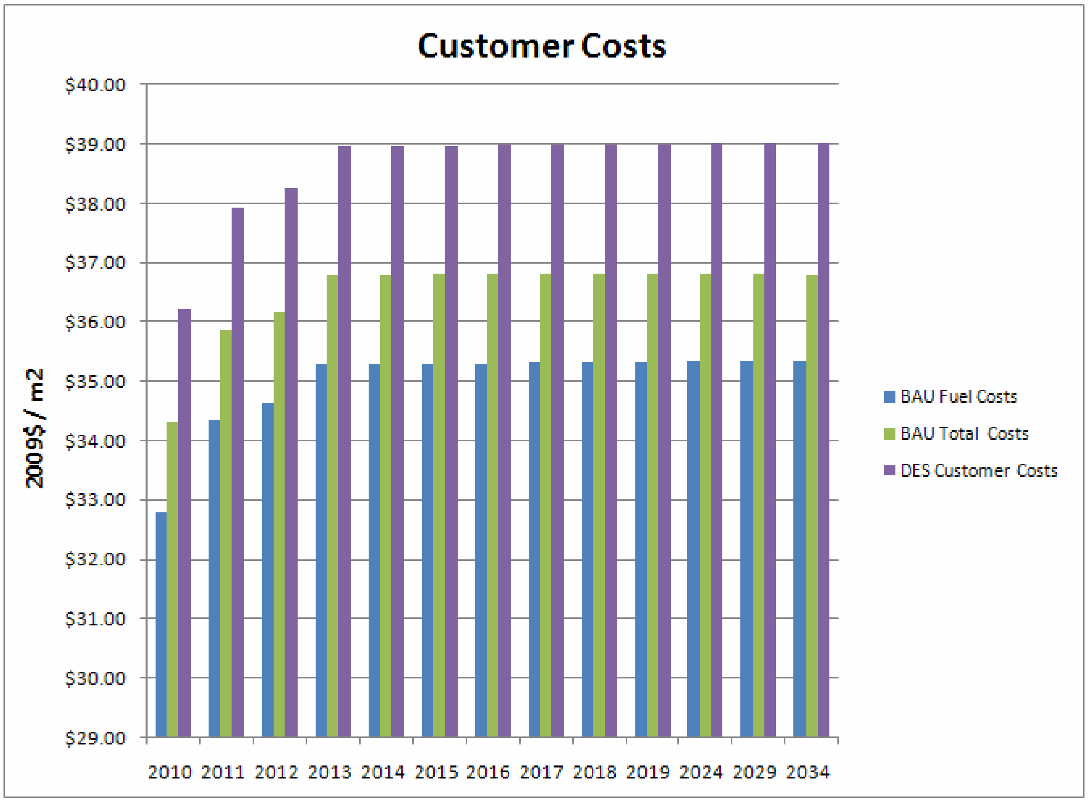


Figure 14: Customer Cost Comparison

NPV is Net Present Value. The project has a 25-year NPV of $3 million, indicating its rate of return is higher than the discount rate and hence a good investment from a financial perspective. IRR is the internal rate of return. The 25-year IRR is 7.3% which is higher than the discount rate of 6.25%, once again indicating a good investment. ROIC is Return on Invested Capital and is frequently used as a financial measure of performance to avoid the distorting effects of leverage on Return on Equity (ROE) and Return on Assets (ROA). Since it is assumed that the DES Utility is entirely financed through debt, and hence is highly leveraged, ROIC is a superior ratio. ROIC is defined as follows:

$$ROIC^{26} = \frac{\text{EBIT (1 – Tax rate)}}{\text{Interest-bearing debt + Equity}}$$

where EBIT = earnings before interest & taxes

ROIC exceeds the discount rate by year 10, indicating that this investment makes sense in the long-term but would not be advisable for an investor seeking short-term results. This is consistent with an approach generally adopted for rate setting for utilities in which costs are under-recovered in the early years to avoid setting initial rates too high and discouraging market acceptance.

[26] Robert C. Higgins, **Analysis for Financial Management**, McGraw-Hill/Irwin, 7th ed, 2004

Figure 15 shows cash flow, cumulative cash flow and NPV over the study period.

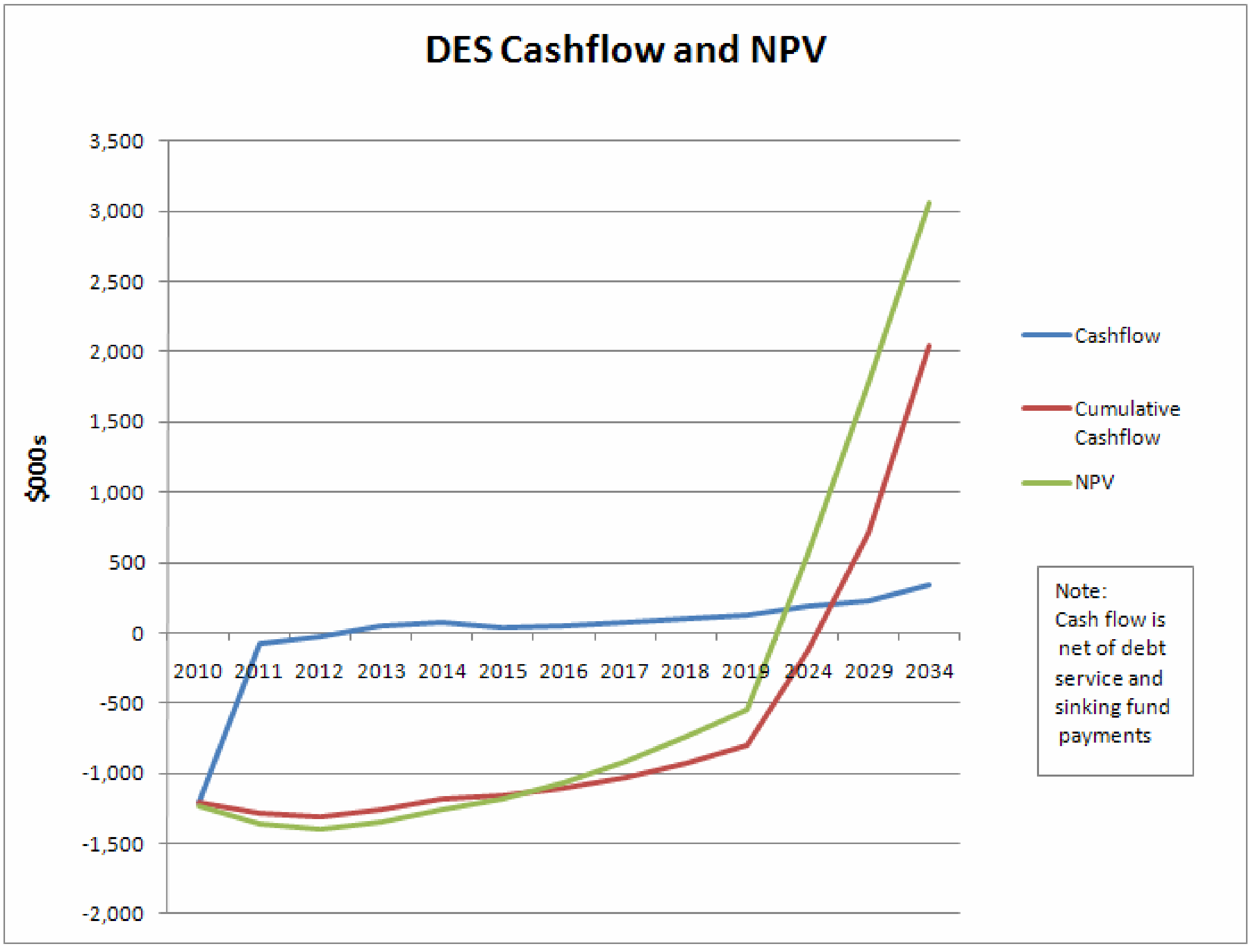


Figure 15: DES Cashflow and NPV

As discussed earlier, there are two components to revenue: heating charges and the sale of carbon offsets. Figure 16 shows the breakdown of these components. Revenue is significantly lower in 2010 because of the assumption that customers are added in the middle of the year, so the DES utility is only earning 50% of normal annual revenues in that year for the Initial Buildings which form the bulk of the customer base over the study period. Heating charges constitute the vast majority of revenues, accounting for well over 90% in the initial years and still accounting for about 90% in year 25 (2034). The relative importance of carbon offsets grows over time since their pricing is predicted to increase at a faster rate than fuel oil.

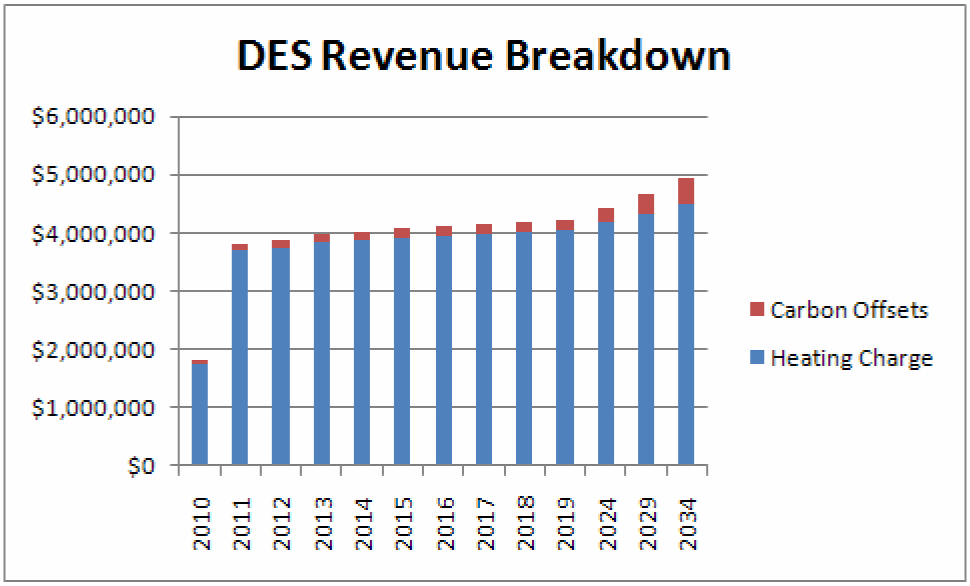


Figure 16: DES Revenue Breakdown

As mentioned earlier, heating charges have been modeled as a single energy charge paid by DES customers based on heat delivered to the heat exchanger in each served building. This is a simplification given this is a pre-feasibility study. Rate setting is a complex process and is beyond the scope of this study.

In practice, a DES utility would typically have a rate structure with two types of charges:

- Connection charge: this monthly charge is based on floor area and is set so as to recover the DES utility's fixed costs. It does not vary with a customer's energy use.
- Energy use charge: This monthly charge is based on the amount of energy consumed and varies accordingly with actual energy consumption. It is set so as to recover the DES utility's variable energy costs.

DES expenses have two components: Fuel Costs and O&M Costs which include insurance. Figure 17 shows the breakdown between these two components. Operating and Maintenance costs have been estimated at $400,000 annually for the Initial Buildings and have been prorated annually to account for the projected growth in floor area served. In 2010, fuel costs are approximately 2/3 of expenses with O&M costs making up 1/3. This is due to the fact that the Initial Buildings are assumed to be customers for half the year only on average, therefore fuel consumption is ½ of what it would be if they were all active customers as of January 1st. In later years, fuel costs account for approximately 80% of expenses with O&M costs making up the remaining 20%.

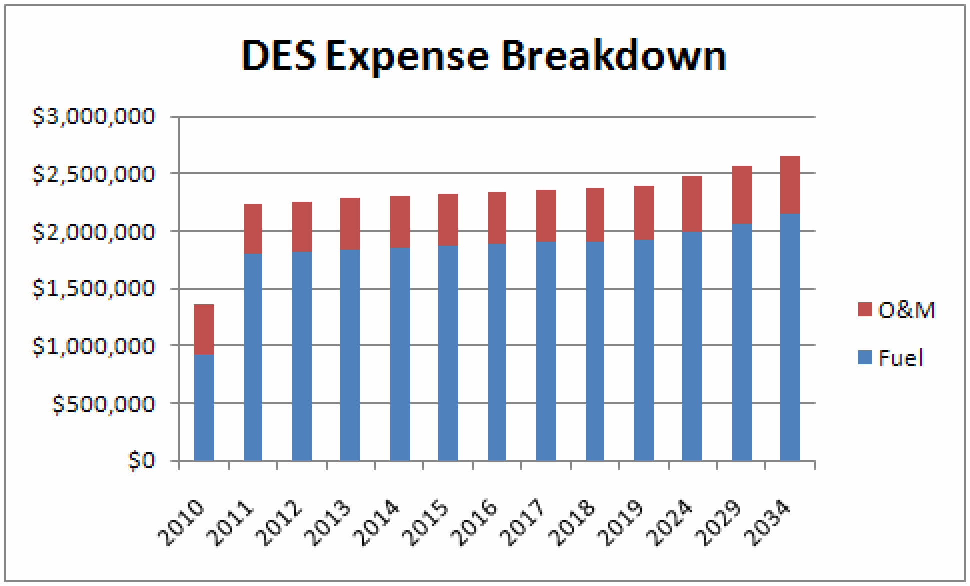


Figure 17: DES Expense Breakdown

6.3 RATE ANALYSIS

As mentioned earlier, an energy charge equal to a 10% premium above the fuel costs projected for the BAU scenario was used in developing the DES financial projections. This results in customer heating costs estimated to be about 6% higher than the total cost of heating under the BAU scenario, once O&M and other costs are taken into consideration. Table 16 illustrates 4 other rate scenarios compared to the base case which has an energy charge equal to a 10% premium and where fuel oil costs are assumed to remain constant in real dollars beyond 2013.

Table 16: Rate Analysis

	Scenario	NPV, year 25	IRR, year 25	Max. Cum. Deficit	Year Cashflow Turns +ve	Year Cum Cashflow Turns +ve	BAU/DES cost ratio, year 25
Base Case, Energy Charge Premium at 10%		$3,054,000	7.3%	-$1,311,000	4	17	106%
Energy Charge Premium @ 0%	1	-$1,339,000	5.1%	-$7,141,000	NA	N/A	96%
Energy Chargge Premium @ 5%	2	$857,000	6.2%	-$2,909,000	20	N/A	101%
Energy Charge Premium @ 5% & $3M grant	3	$3,681,000	7.8%	-$1,017,000	2	9	101%
Energy Charge Premium @ 0% & $3M grant & 1% fuel increase	4	$4,267,000	8.0%	-$1,366,000	5	13	97%

The first scenario is with an energy charge premium of 0% and with all other assumptions unchanged from the base case. The table above shows that in this case, the project is not viable with a negative NPV of $1.3 million and a maximum cumulative deficit of $7.1 million.

The second scenario is with an energy charge premium of 5% and with all other assumptions unchanged from the base case. In this case NPV is positive at $857,000 and the maximum cumulative deficit is $2.9 million; this scenario is marginally viable and might be worthy of consideration if there were other economic development advantages to the project such as leading to the establishment of a biomass fuel manufacturing plant in Whitehorse with the attendant job creation and tax revenue benefits that could be generated.

The third scenario illustrated is with an energy charge premium of 5% and assuming a federal grant in the amount of $3 million is obtained; all other assumptions are unchanged from the base case. In this scenario the maximum cumulative deficit is reduced to $1.1 million, a similar amount to that forecast with a 10% energy charge premium. This leads to a viable project with a 25 year NPV of $3.7 million, an IRR of 7.8%, cash flow turning positive by year 2 and cumulative cash flow turning positive by year 9. The total cost of heating is projected to be about 1% higher than under the BAU scenario.

The 2010 Energy Information Administration (EIA) Early Release Overview projects a 1.1% real increase in light crude for the period 2008-2035[27]. The fourth scenario explores what happens if a higher rate of escalation for fuel oil is assumed, namely, a 1% real increase in fuel oil prices from 2014 onwards. In addition, an energy charge premium of 0% and a federal grant of $3 million were assumed, leading to a viable scenario with a 25 year NPV of $4.3 million, an IRR of 8%, cash flow turning positive by year 5 and cumulative cash flow turning positive by year 13. In this scenario, the total cost of heating is projected to be about 3% lower than under the BAU scenario, while customer fuel costs are the same.

In conclusion, this rate analysis suggests a 10% premium is appropriate for the initial years based on the conservative forecasts for future fuel oil costs in the Sproule forecast and that the project proponents should investigate the possibility of securing a federal grant. Potential sources include the FCM's Green Municipal Fund, federal infrastructure funds and the federal gas tax. The results of the fourth scenario based on using the EIA's long term forecast for light crude pricing combined with obtaining a federal grant suggests that further research should be carried out into long-term fuel oil price forecasts for the Whitehorse area.

6.4 SENSITIVITY ANALYSIS

All of the assumptions used in this financial analysis are conservative in order to demonstrate unequivocally that a DES system is viable. The cumulative result of using conservative assumptions is essentially a worst case scenario. Further study to optimize the factors that are within the Clients control and to refine the assumptions regarding factors beyond the Clients

[27]. US Energy Information Administration, Annual Energy Outlook 2010 Early Release Overview, http://www.eia.doe.gov/oiaf/aeo/, accessed February 3, 2010.

control is likely to result in a more favorable financial outcome. This sensitivity analysis is intended to provide some insight into the factors that have the largest impact on the results.

Sensitivity analysis against a number of factors was carried out for the preferred DES scenario with the results shown in Table 17. The sensitivity factors explored and the results and discussion of the analysis are summarized below.

- **No growth:** This scenario looks at the effect of limiting the DES customers to the Initial Buildings. Financial performance improves slightly, due to the lower capital investment required.
- **Fuel oil @ +/-20%, +/- 10%:** This group of scenarios looks at the impact of fuel oil prices being 20% and 10% higher and lower over the study period. The financial performance of the project is sensitive to fuel oil pricing as the results indicate. Should fuel oil prices be even 10% lower, it would not be viable. Conversely, fuel oil prices even 10% higher would dramatically improve financial performance and would give the utility the ability to lower rates below the equivalent fuel oil costs if that were deemed to be in the interests of the City and other stakeholders.
- **Biomass @ +/- 20%, +/- 10%:** This group of scenarios looks at the impact of biomass prices being 20% and 10% higher and lower over the study period. The financial performance of the project is sensitive to biomass costs as the results indicate, but is not as sensitive as it is to fuel oil prices. Should biomass costs be 10% higher, it would still be marginally viable; at 20% higher it would not be viable. Conversely, biomass costs even 10% lower would significantly improve financial performance and would give the utility the ability to lower rates below the equivalent fuel oil costs if that were deemed to be in the interests of the City and other stakeholders.
- **Capital @ +/- 20%, +/- 10%:** This group of scenarios looks at the impact of capital prices being 20% and 10% higher and lower over the study period. The financial performance of the project is sensitive to capital costs as the results indicate, but again is not as sensitive as it is to fuel oil prices. Should capital costs be 10% higher, it would still be viable provided a $2.9 million maximum cumulative deficit was considered acceptable to the City of Whitehorse as the owner; at 20% higher it would not be viable. Conversely, capital costs even 10% lower would significantly improve financial performance and would give the utility the ability to lower rates below the equivalent fuel oil costs if that were deemed to be in the interests of the City and other stakeholders.
- **City Debt (real) @ 4.25%, 5.25%, 7.25%, 8.25%:** This group of scenarios looks at the impact of the City of Whitehorse's cost of debt being +/- 2% and +/- 1% from current borrowing costs over the study period. The financial performance of the project is sensitive to interest costs as the results indicate, but, once again, not as sensitive as it is to fuel oil prices. Should interest costs be an additional 1% higher, i.e. a real rate of 7.25%, the project would still be viable provided a $3.2 million cumulative deficit was considered acceptable to the City of Whitehorse as the owner; at an additional 2% higher, i.e. a real rate

of 8.25%, it would not be viable. Conversely, interest costs 1% lower, i.e. a real rate of 5.25% would significantly improve financial performance and would give the utility the ability to lower rates below the equivalent fuel oil costs if that were deemed to be in the interests of the City and other stakeholders. IRR is unchanged for all of the scenarios because it is calculated on project cash flow before debt service and sinking fund payments.

Table 17: Sensitivity Analysis

	NPV, year 25	IRR, year 25	Max. Cum. Deficit	Year Cashflow Turns +ve	Year Cum Cashflow Turns +ve
Base Case	$3,054,000	7.3%	-$1,311,000	4	17
No growth	$3,376,000	7.7%	-$1,174,000	3	13
Fuel Oil @ -20%	-$5,401,000	2.8%	-$15,625,000	NA	N/A
Fuel Oil @ -10%	-$1,173,000	5.2%	-$6,794,000	NA	N/A
Fuel Oil @ +10%	$7,281,000	9.3%	-$1,054,000	2	5
Fuel Oil @ +20%	$11,509,000	11.2%	-$900,000	2	3
Biomass @ -20%	$6,221,000	8.8%	-$1,084,000	2	6
Biomass @ -10%	$4,637,000	8.1%	-$1,146,000	2	9
Biomass @ +10%	$1,470,000	6.5%	-$2,081,000	13	N/A
Biomass @ +20%	-$113,000	5.7%	-$4,620,000	24	N/A
Capital @ -20%	$6,894,000	9.9%	-$871,000	2	4
Capital @ -10%	$4,974,000	8.5%	-$1,039,000	2	7
Capital @ +10%	$1,134,000	6.3%	-$2,911,000	19	N/A
Capital @ +20%	-$787,000	5.4%	-$7,100,000	NA	N/A
City Debt (real) @ 4.25%	$8,755,000	7.4%	-$839,000	2	4
City Debt (real) @ 5.25%	$5,662,000	7.4%	-$1,023,000	2	7
City Debt (real) @ 7.25%	$841,000	7.3%	-$3,230,000	20	N/A
City Debt (real) @ 8.25%	-$1,046,000	7.3%	-$7,956,000	NA	N/A

It may be possible to increase financial performance by negotiating agreements to sell heat to nearby buildings at reduced rates during off-peak periods, similar to Yukon Energy's secondary sales rates for electricity. The objective would be to operate the DES plant as close to full capacity as possible so as to optimize its output without requiring additional capital investment to increase its capacity.

The sensitivity analysis on the cost of debt suggests another avenue for exploration: Yukon Energy's current cost of capital is 7.09% or about 1% lower than the City of Whitehorse's cost of borrowing. Thus it would interesting to explore whether Yukon Energy's financial strength could be employed to reduce the project's cost of capital through a different governance structure, thereby permitting the DES to set a lower energy charge while still remaining financially viable.

6.5 OWNERSHIP AND OPERATING MODELS

This section addresses options for ownership and operation of a district heating system in Whitehorse.

6.5.1 Ownership Models

Ownership models can be distinguished at a high level in terms of the extent and type of City ownership as follows:

a. Total
b. Majority
c. Minority
d. Non-distribution assets only
e. Distribution assets only
f. No ownership interest

When evaluating the most appropriate ownership model, as with any other strategic decision, it is important to be clear about the objective. Objectives may be summarized as follows;

1. Financial Implications (cost and availability of capital)
2. Legal Liability Implications
3. Financial Implications (capital spending, operating costs and revenues)
4. Financial, Operational, Hazard and Strategic Risk implications
5. Potential for Third-Party Funding
6. Tax Implications
7. Expertise and Core Business Issues
8. Staffing and Administration
9. Political
10. GHG emissions liability and offset opportunities

Each of these issues is summarised in Table 18 for the different operating models. As can be seen, there are benefits and limitations of all ownership models. It is recommended that the City evaluate its position with respect to each of the above criteria as a next step in developing an ownership model.

Table 18: Ownership Models Assessment

Ownership Model **Objective**	**City 100%**	**City Majority**	**City Minority**	**City Own Distribution**	**City Owns Non-Distribution**	**No City Ownership**
Financial (cost and availability of capital)	Lowest cost City investment 10 – 20 % for Start-up Capital. Expansion phase largely self-funding.	Next lowest cost City investment still > 5 – 10 % Low availability of non-City Start-up Capital. High availability of capital for Expansion	Next highest cost City investment could be < 5– 10 % Very Low availability of non-City Start-up Capital. High availability of capital for Expansion	Similar to City Minority. Capital availability for non-distribution assets would depend on take-or pay contract in which City takes all risk.	Similar to City Majority	Highest cost Otherwise similar to City Minority
Legal Liability	Energy utility assets should be held in a wholly owned Corporation	Possible liability to majority owners	Possible liability to minority owners	Possible liability to owners of non-distribution assets	Possible liability to owners of distribution assets	Possible liability to utility arising from delays in development by City
Financial (capital spending, operating costs, operating revenues)	Similar to all models except lowest cost of capital, hence lowest customer prices.	Similar to all models except customer prices tend to be higher, the higher the non-City ownership				Potentially highest customer prices. Would require rate regulation.
Financial, operational, hazard and strategic risk	City has major influence on prospects for real estate development. Mandatory connection easier.	Timing of partners entry critical to maximizing City value		City risk will be defined by terms of agreement with owner of non-distribution assets	City risk will be defined by terms of agreement with owner of non-distribution assets	Risks include poor performance or abandonment of assets
Potential for third-party funding	The potential for favourable funding under the Green Municipal Fund is higher the greater the municipal involvement. Vendor financing is possible in all cases. No debt financing for Start-up Capital, but very viable for Expansion Capital with good security (customer contracts)					

<table>
<tr><th>Ownership Model
Objective</th><th>City 100%</th><th>City Majority</th><th>City Minority</th><th>City Own Distribution</th><th>City Owns Non-Distribution</th><th>No City Ownership</th></tr>
<tr><td>Tax</td><td colspan="6">Sales taxes similar for all models. Corporate income tax higher for higher levels of non-City ownership</td></tr>
<tr><td>Expertise and core business</td><td colspan="2">Energy utility management and staff would be hired. District energy is basic infrastructure for sustainable development.
.</td><td>Majority owner would likely operate. City would need to check qualifications of initial owners but long-term control would be difficult. Private companies tend to change the focus of their core business over time.</td><td>Similar issues as for minority ownership.</td><td>Similar issues as for minority ownership, but less severe.</td><td>Similar issues as for minority ownership.</td></tr>
<tr><td>Staffing and administrative</td><td>No dedicated City staff after development phase. City representation on Board of energy utility.</td><td colspan="2">Additional legal and administrative burden to select and negotiate with partners.
.</td><td colspan="2">Split ownership would result in the highest legal and administrative burden to select and negotiate with partners.
There would be annual discussions on wholesale pricing, possibly involving complex true-up mechanisms.</td><td>Additional legal and administrative burden to select and regulate private proponents.</td></tr>
<tr><td>GHG Impact/ownership</td><td>The city owns the GHG credits from the DES</td><td>Subject to negotiation with partners</td><td>Subject to negotiation with partners</td><td>Subject to negotiation with partners</td><td>Subject to negotiation with partners</td><td>No GHG benefit accrues to City</td></tr>
<tr><td>Political</td><td colspan="2">The energy utility governance should be designed to streamline political input.</td><td colspan="4">Lack of control could allow issues to arise related to choice of technology.</td></tr>
</table>

6.5.2 Operating Models

Depending on which ownership model is selected, there are a number of possible operating models, including:

1. Operation by City Staff
2. Operation by a special purpose corporation
3. Out-sourcing to a specialist operating company

It is recommended that the City hold its interest in the energy utility through a corporation. Therefore alternative 1, operation by City staff, would not apply.

Out-sourcing might be considered, but the primary disadvantage is increased cost through the introduction of another party who has overhead and must make a profit and pay taxes.

Therefore, operation by a special purpose corporation is recommended.

The design and construction of system components are most efficiently accomplished through the traditional client-engineer relationship in which the client would be the special purpose district energy utility. The relatively small scale and ever evolving scope of district energy projects are not amenable to the design-build approach.

Billing and customer service are sometimes mentioned as suitable functions to outsource. However, our experience has been that for the relatively small number of bills that are needed, the district energy utility itself is more competitive than firms that have the overhead in place to send out thousands of bills.

6.6 FINANCIAL AND OPERATIONAL CONCLUSION

As noted previously, the assumptions are largely conservative; therefore, the results of the analysis represent a worst case scenario, which can be improved with further study. In conclusion, this high-level analysis shows that the recommended DES option is financially viable based on the assumptions made and provided that:

1. The City of Whitehorse and the Yukon government would be willing to pay heating charges about 6% higher than the total costs of heating they currently incur; it is sufficient for these two large customers to accept such a rate since the project is viable without any additional customers as examined through sensitivity analysis; and,

2. The City of Whitehorse is willing to fund the cumulative operating deficit projected to reach $1,311,000 before cash flow after debt service and sinking fund payments turns positive; it is recommended that should the project proceed as a City-owned utility, that the City establish a Rate Stabilization Reserve to fund the projected initial losses and allow for rate stabilization in later years.

It should be noted that the possibility of paying a premium has not been reviewed with either the City of Whitehorse or the Yukon government. Exploring their willingness to do so is recommended as one of the next steps to be undertaken as part of a follow-on Feasibility Study as outlined in Section 7.1.2. However, it is expected that with further optimization of various factors such as which buildings to connect, paying a premium will not be necessary.

In the course of the research on the alternative energy sources, the Consultant became aware of several local groups interested in establishing a plant to manufacture biomass fuel in the vicinity of Whitehorse. Such a development would have additional economic benefits to the City and the Yukon, such as creating green jobs, increasing the City's tax base, reducing the local economy's exposure to volatile international energy markets and retaining the funds currently spent on purchasing fuel oil in the local economy. The BAU scenario forecasts that the $3 million in fuel charges in 2010 would grow to around $4 million by 2034 in real 2009$. These potential economic benefits should also be taken into account if the decision is made to pursue this project further.

It is recommended that the project be operated by a special purpose corporation and that the design and construction of system components be realized through the traditional client-engineer relationship in which the client would be the special purpose district energy utility.

7.0 Conclusions, Recommendations, and Next Steps

This section summarizes the conclusions with respect to whether or not a DES system would be technically and economically viable to implement in Whitehorse; recommendations for a viable system; and next steps toward establishing a DES in Whitehorse.

7.1 CONCLUSIONS

7.1.1 Technical

The scenarios that were considered for the District Energy System (DES) for the City of Whitehorse included heat only systems and combined heat and power systems utilizing various fuels including biomass, heating oil and electricity. Most of the options explored are deemed technically viable.

The system that appears to represent the best case for the DES is the heat only system utilizing biomass in the form of wood pucks as the fuel. This scenario was used as the basis for financial analysis and projections.

7.1.2 Financial

As noted previously, the assumptions are largely conservative; therefore, the results of the analysis represent a worst case scenario, which can be improved with further study. In conclusion, this high-level analysis shows that the recommended DES option is financially viable based on the assumptions made and provided that:

1. The City of Whitehorse and the Yukon government would be willing to pay heating charges about 6% higher than the total costs of heating they currently incur; it is sufficient for these two large customers to accept such a rate since the project is viable without any additional customers as examined through sensitivity analysis; and,

2. The City of Whitehorse is willing to fund the cumulative operating deficit projected to reach $1,311,000 before cash flow after debt service and sinking fund payments turns positive; it is recommended that should the project proceed as a City-owned utility, that the City establish a Rate Stabilization Reserve to fund the projected initial losses and allow for rate stabilization in later years.

7.1.3 Other

In the course of the research on the alternative energy sources, the Consultant became aware of several local groups interested in establishing a plant to manufacture biomass fuel in the vicinity of Whitehorse. Such a development would have additional economic benefits to the City and the Yukon, such as creating green jobs, increasing the City's tax base, reducing the local economy's exposure to volatile international energy markets and retaining the funds currently spent on purchasing fuel oil in the local economy. The BAU scenario forecasts that the $3 million in fuel charges in 2010 would grow to around $4 million by 2034 in real 2009$. These potential economic benefits should also be taken into account if the decision is made to pursue this project further.

It is recommended that the project be operated by a special purpose corporation and that the design and construction of system components be realized through the traditional client-engineer relationship in which the client would be the special purpose district energy utility.

7.2 RECOMMENDATIONS AND NEXT STEPS

7.2.1 Political

Development of a district energy concept will require direction from mayor and council, as well as ongoing support. Creation of a board of directors comprised of elected official and senior staff will facilitate accountability of decision making.

7.2.2 Business

Commence discussions with anchor clients such as the hospital, federal and territorial facilities managers to assess their interest to connect to the District Energy System, as well as characterize load and discuss potential rate structures.

Explore options for grants and loans to reduce the capital costs of the proposed system, including the Federation of Canadian Municipalities, Infrastructure Canada, the Yukon government and gas tax revenue.

Review and confirm the preferred ownership and operating models. Should the City choose to explore third party involvement, development of a risk and cost sharing formula is required. A number of private sector organizations are active in partial ownership models, and discussions with those groups are recommended to understand the implications of outside participation.

Review of the Utilities Commission Act will provide an understanding of the territorial regulations governing the ownership and operational requirements for a DES in Whitehorse.

7.2.3 Technical

It is recommended that the project proceed to a Feasibility Study in order to refine and confirm all aspects of this study by going into more detail. In particular, the feasibility study should address the following:

- Refine present and future estimates of heating energy loads

   i. This could be accomplished by gathering more utility data and refining estimates of potential future expansion, taking into account the impact of changing energy codes on energy consumption of new development.

   ii. Consideration should be given to demand side management (energy conservation strategies) that might be implemented within existing building.

   iii. To this end, consider expanding the Public Buildings Energy Tracking System (PBETS) database to include all buildings within the City through voluntary web-based reporting

- Refine and confirm the most appropriate buildings and zones (with consideration to connecting some non-YTG/City buildings)

   i. To this end, refine the threshold for minimum heating load to make connection viable, and consider connecting multiple neighboring buildings with a single energy transfer station (ETS)

- Evaluate potential waste heat sources from buildings and processes
- Refine the required supply and return water temperatures
- The details of how specific buildings will be connected should be explored within a subsequent feasibility study; for example, buildings without a variable flow operation may require different control strategies for optimal integration with the DES
- Explore how best to take advantage of the existing plant equipment within buildings that connect
- Confirm the quantity, cost, as well as current and future availability of a reliable biomass fuel supply for the project
- Explore the feasibility of a waste to energy (WTE) plant option Using MSW as a potential future energy source as part of an expanding DES

7.2.4 Financial

Should the project partners be interested in proceeding further with the project, the following additional actions are recommended from a financial perspective:

- Given the sensitivity to fuel prices, additional research should be carried out on future trends in fuel oil and biomass pricing for the Whitehorse area.

  i. As noted in the sensitivity analysis, fuel oil prices even 10% higher would dramatically improve financial performance and would give the utility the ability to lower rates below the equivalent fuel oil costs

- Refine capital costs.
- Explore rate setting in more detail to establish appropriate connection and energy use charges.
- Explore the possibility of federal grants
- Validate the eligibility of the GHG reductions forecast in the DES scenario for resale as carbon offsets.
- Explore opportunities to improve the financial performance by negotiating agreements to sell heat to nearby buildings at reduced rates during off-peak periods, similar to Yukon Energy's secondary sales rates for electricity. The objective would be to operate the DES plant as close to full capacity as possible so as to optimize its output without requiring additional capital investment to increase its capacity.
- Assess the economic benefits accruing to the City and the Yukon from establishing a biomass production facility in the vicinity of Whitehorse.
- Determine if City ownership and operation is the preferred option by evaluating ownership and operating options based on relevant criteria.
- Fully assess the willingness of the City and YG to pay a premium for heat in order to assure the financial viability of the DES in the early years

7.2.5 Other

Some additional recommendations for next steps include the following:

- Consider getting the community "on board" through educational efforts to explain the benefits of district energy and specific potential benefits to this community.
- Consider putting voluntary requirements in place to facilitate future connection of new buildings to a growing DES network across the city

Appendices

APPENDIX A – LOAD INTENSITY DATA

YTG and City Buildings Data

The following screen captures from the interactive tool summarize the buildings that were considered within each of the 5 zones corresponding to those identified on the Energy Intensity Map in Appendix C – Heating Energy Intensity Map. The Annual Energy Consumption values are colour-coded to highlight the most energy intensive buildings (>900 MWh/yr) in red, the next most intensive (>500 MWh/yr) in orange, and the least energy intensive (<500 MWh/yr) in blue.

At the bottom of each page is a summary of total estimated heating energy consumption within that zone (including all buildings), the total zone area, and the average heating energy intensity.

ENERGY DENSITY ANALYSIS			Row	Column	>900 MWh/yr
Area Name:	Range Road	Starting Cell:	37	11	>550 MWh/yr
		Ending Cell:	62	65	<550 MWh/yr
Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
1306	Young Offenders Facility	598	648	260.7	1,085
1227	Yukon College (includes Archives an	117	3,927	1579.3	33,429
1314	Archives	217	529	212.7	2,439
1230	WCC Administration Trailer	254	48	19.5	191
1296	Steam Plant Storage WCC	396	40	15.9	100
1313	Arts Centre	217	781	314.0	3,600
1232	Correctional Centre	1,049	2,747	1104.7	2,620
1354	Yukon College Residence	363	109	43.8	300
1279	Workcrew Base Station WCC	395	60	24.1	152
1206	Takhini Elementary School	294	916	368.5	3,112
1295	Workshop #1 Quonset WCC	256	26	10.3	100
1962	Coronoer's Coolers 421 Range Rd.	395	52	20.8	131
1344	461 Range Rd (201 range)	389	545	219.0	1,400
1126	Storage Shed 8' x 12'	396	4	1.4	9
1328	Northern Science Centre	395	79	31.7	200
1969	419 Range Road	254	161	64.5	632
1400	Core Library	25	23	9.1	905
1319	Mine Rescue Station	550	110	44.3	200
1321	Mine Rescue Smoke House	395	20	7.9	50
WHS14	Takhini Arena	214	697	280.1	3,252
WHS5	Fire Hall #2	222	99	39.7	444
1408	Water Resources Building	254	9	3.8	37
1407	Fire Base (Building 722)	254	53	21.4	210
1406	Field Operations-Office Building	151	104	41.7	688
1405	Propane Shed	396	4	1.5	9
1403	Cold Storage Building	396	209	84.2	529
1401	POL Shed	396	9	3.5	22
1411	Storage Building	396	7	2.7	17
1410	Storage Shed	396	7	2.7	17
1409	POL Shed	396	7	2.7	17
1419	PCB Storage Shed	396	2	0.6	4
1418	PCB Storage Shed	396	2	0.6	4
1402	Central Operations Complex	119	233	93.5	1,956
1404	Small Engine Repair Shop	177	45	17.9	251
Total			**12,307**	**4,949**	**58,112**

Average Heating Energy Intensity: **212** kWh/m2/yr

Total Area:	**36,029**	**m2**
	3.603	**ha**
Total Energy Consumption:	**12,307**	**MWh/yr**
Average Heating Energy Intensity:	**3,416**	**MWh/ha/yr**

ENERGY DENSITY ANALYSIS			Row	Column	>900 MWh/yr
Area Name:	Quartz Road	Starting Cell:	20	41	>550 MWh/yr
		Ending Cell:	37	81	<550 MWh/yr
Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
1967	9010 Quartz Road	254	460	184.9	1,812
1379	Portable Storage Shed (temp)	396	6	2.2	14
WHS1	9030 Qtz Rd (Purchasing /Warehouse)	295	55	22.1	186
1343	Hazardous Waste Storage Cont.	396	6	2.4	15
1278	Liquor Warehouse & Offices	254	97	38.9	381
1298	Oxygen/Acetylene shed	396	4	1.4	9
2612	Beaver Lumber Property	395	91	36.7	231
1264	Storage Marwell (Parks Br. Gar.)	396	28	11.3	71
1291	Welding Shop & Storage	256	34	13.7	133
1305	Municipal Service Storage	396	55	22.0	138
1224	Quonset Warehouse	295	59	23.7	200
WHS9	New Animal Shelter	217	64	25.9	297
1271	Workshop/Offices Wildlife	170	194	78.1	1,145
1266	Storage building Grader Station	732	52	20.9	71
1914	M&R Building	254	11	4.6	45
1275	Mechanical Workshop	296	1,754	705.2	5,919
1277	Supply Services & Stores	119	262	105.6	2,207
WHS16	Carpenter Shop (Old Sig Shop)	256	107	43.0	418
1267	Grader Station Main	732	747	300.2	1,020
WHS15	Transit Garage	256	347	139.6	1,356
WHS3	Parks & Rec Maintenance Building	256	131	52.6	511
1216	Tire Shop/Storage	548	82	33.1	150
1215	Bldg Mntc Workshop (sign shop)	330	353	142.1	1,070
Total			**4,999**	**2,010**	**17,399**

Average Heating Energy Intensity: **287** kWh/m2/yr

	21,076	m2
Total Area:	2.108	ha
Total Energy Consumption:	4,453	MWh/yr
Average Heating Energy Intensity:	**2,113**	MWh/ha/yr

ENERGY DENSITY ANALYSIS			Row	Column	>900 MWh/yr
Area Name:	Downtown	Starting Cell:	9	105	>550 MWh/yr
		Ending Cell:	30	140	<550 MWh/yr
Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
WHS10	Freight Shd 2 - Old Motorways	295	110	44.1	372
1357	Log Building Waterfront	395	4	1.7	11
1358	Waterfront Shelter	395	3	1.3	8
1359	Concrete Storage Building	396	10	4.0	25
1420	Train Shed/Roundhouse	395	180	72.2	455
1360	Warehouse Bldg (old firehall)	295	68	27.3	230
WHS4	City Hall & Downtown Firehall #1	222	446	179.4	2,009
1906	Horwoods Mall	254	35	14.0	137
1341	Whitepass Train Building	245	129	51.7	526
1345	Storage Shed Waterfront	215	21	8.6	100
1964	Jarvis Street Building	254	22	9.0	88
1938	Whitepass Bldg/Walkway Carcross	395	116	46.5	293
1971	Yukon Electrical Building	254	50	20.3	198
1336	Waterfront Residence	395	21	8.4	53
1335	Waterfront Residence	395	21	8.4	53
1925	Closeleigh Manor	254	76	30.4	298
1364	Tourism Business Centre/VRC	325	596	239.5	1,830
1910	Tutshi Building	254	144	58.1	569
1942	Professional Building	254	157	63.0	618
1259	Main Administration Building	268	3,740	1504.0	13,957
1202	Mainsteele Building	254	144	57.7	566
1948	Jean Holdings Ltd.	254	150	60.2	590
1912	Financial Plaza	254	245	98.4	963
1308	Human Rights Commission Building	254	27	10.9	107
1972	Silver Centre	254	78	31.5	309
1918	Shoppers Plaza	254	334	134.3	1,316
1911	208b Main Street	254	24	9.5	93
1287	Medical Arts Building	254	84	33.7	331
1949	Parkside Place	254	118	47.4	464
1262	Yukon Justice Centre	101	976	392.4	9,661
1968	Elijah Smith Building	254	915	368.0	3,605
1957	Hougen Centre	254	135	54.3	532
1956	Berska Building	254	301	120.9	1,184
1954	Chocolate Claim Building	254	80	32.0	313
1932	Prospector Building	254	354	142.3	1,394
1966	Three Beans Building	92	25	10.0	269
1960	Yukon Business Services	254	27	10.7	105
1209	TC Richards Building	508	141	56.9	279
1210	Pelly Block, Remand Centre	239	99	39.9	416
1923	Carcare Building	254	84	33.6	330
1917	Whitehorse Performance Centre	254	144	58.0	569
1213	Lynn Building	254	528	212.4	2,081
1937	Sport Yukon Complex	254	67	26.7	262
1207	Whitehorse Elementary School	227	1,340	539.0	5,911
1936	WCB Building	182	321	129.0	1,765
1386	Taylor Building	254	236	94.8	929
1958	Selwyn Building	254	5	1.8	18
1908	Royal bank Building	254	276	110.8	1,086
WHS8	Municipal Services Building	256	968	389.1	3,781
1974	407 Ogilvie Street	254	30	12.0	118
1973	Black Street Building	254	33	13.3	130
1959	Kluhini Holdings/Kluhini Bldg	254	313	125.7	1,232
1225	Wood Street Centre	277	551	221.6	1,990
1253	Mountain Ridge 502 Hoge	363	93	37.4	256
1289	Youth Achievement Centre	251	114	45.8	454
1965	415 Baxter	395	100	40.0	252
1219	Sarah Steele Building	376	454	182.7	1,207
Total			**15,858**	**6,377**	**66,695**

Building Energy Density :	238 kWh/m2/yr
Total Area:	49,569 m2 4.957 ha
Total Energy Consumption:	10,868 MWh/yr
Average Heating Energy Intensity:	2,193 MWh/ha/yr

ENERGY DENSITY ANALYSIS			Row	Column	>900 MWh/yr
Area Name:	Airport	Starting Cell:	54	36	>550 MWh/yr
		Ending Cell:	62	136	<550 MWh/yr
Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
1395	Warehouse - Hanger E	295	166	66.6	561
1384	Sand Storage Building	424	301	121.2	710
1383	Carpentry Shop, Airport	3,669	472	190.0	129
1394	Hangar D Warehouse	295	219	88.0	741
1382	Maintenance Garage, Airport	357	520	209.2	1,456
1385	Combined Services Bldg, Airport	338	497	199.9	1,470
1380	Whitehorse Airport Terminal	176	916	368.2	5,202
1396	Air Tanker Base	263	41	16.7	157
1390	Whitehorse Air Tanker Base	944	78	31.3	82
1399	Cold Storage/Air Tanker Base	396	32	12.8	80
1316	Elijah Smith Elementary School	205	934	375.8	4,549
whs16	Carpenter Shop (Old Sig Shop)	256	107	43.0	418
1205	Keith Plumbing Building	163	735	295.5	4,510
1329	Beringia Centre (Old VRC)	324	410	164.9	1,264
1961	Weather Station	254	57	22.8	223
1397	POL Shed	396	4	1.7	11
1350	Vehicle Weigh Station	101	17	6.8	168
Total			**5,506**	**2,214**	**21,733**

Average Heating Energy Intensity: **253** kWh/m2/yr

Total Area: 25,079 m2 / 2.508 ha
Total Energy Consumption: 4,042 MWh/yr
Average Heating Energy Intensity: **1,612** MWh/ha/yr

ENERGY DENSITY ANALYSIS			Row	Column	>900 MWh/yr
Area Name:	Hospital Road	Starting Cell:	1	125	>550 MWh/yr
		Ending Cell:	7	149	<550 MWh/yr
Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
1307	Ambulance Station	211	144	57.8	682
1351	New Whitehorse Hospital	545	7,088	2850.4	13,006
1355	#2 Hospital Road	548	489	196.6	892
1356	#4 Hospital Road	333	297	119.4	892
1318	Thompson Centre	319	1,213	487.6	3,800
1222	Education Building	218	1,362	547.6	6,241
Total			**10,592**	**4,259**	**25,514**

Average Heating Energy Intensity: **415** kWh/m2/yr

Total Area: 10,479 m2 / 1.048 ha
Total Energy Consumption: 10,592 MWh/yr
Average Heating Energy Intensity: **10,108** MWh/ha/yr

ENERGY DENSITY ANALYSIS

			Row	Column	>900 MWh/yr
Area Name:	Lewes Boulevard	Starting Cell:	1	157	>550 MWh/yr
		Ending Cell:	14	191	<550 MWh/yr

Building ID	Building Name	Average Heating Energy Intensity kWh/m2/yr	Annual Energy Consumption MWh/yr	Peak Load (kW) Based on Peak Load Factor of: 0.4021	Floor Area m2
1361	Storage Shed	396	8	3.0	19
1281	Grey Mountain Elementary School	115	135	54.2	1,174
1346	Portable Vanier Catholic Seconda	244	22	8.7	89
1387	New Modular F.H.Collins	244	56	22.4	229
1258	Vanier Catholic Secondary School	268	1,866	750.4	6,957
1234	Macaulay Lodge	461	1,035	416.0	2,245
1208	Selkirk Elementary School	270	1,053	423.5	3,900
1340	C.K.E.S.Portable Band Room	244	29	11.8	120
1226	Christ the King Elem School	294	907	364.7	3,084
1221	F.H.Collins School	378	4,292	1725.9	11,342
1366	Teen Parent Centre	267	107	42.9	400
1315	Gadzoosdaa Residence	435	407	163.5	934
Total			**9,915**	**3,987**	**30,493**

Building Energy Density : **325** kWh/m2/yr

Total Area: 22,489 m2; 2.249 ha
Total Energy Consumption: 9,886 MWh/yr
Average Heating Energy Intensity: **4,396** MWh/ha/yr

Recommended Buildings for DES

Table 19 summarizes the buildings that are recommended for connection to the DES within the proposed service areas.

Table 19: Summary of Recommended Buildings for Connection to DES

Building Name	Area	Bldg Owner	DES Zone	Existing Thermal Heat Source[28]	Existing Heating System	Energy Consum'n Connected to DES	Peak Load
	m^2					MWh/yr	kW
City Hall & Downtown Firehall #1	2,010	CofW	Downtown	Fuel Oil	HW Boilers	734	295
Main Administration Building	13,963	YTG	Downtown	Fuel Oil	HW Boilers	3,740	1,504
Yukon Justice Centre	9,665	YTG	Downtown	Fuel Oil*	HW Boilers*	976	392
Tourism Business Centre/VRC	1,831	YTG	Downtown	Fuel Oil	HW Boilers	596	240
Whitehorse Elementary School	5,913	YTG	Downtown	Fuel Oil*	HW Boilers*	1,340	539
Municipal Services Building	3,783	CofW	Downtown	Fuel Oil	Steam Boilers	872	351
Lynn Building	2,082	YTG	Downtown	Fuel Oil*	HW Boilers*	528	212
Sarah Steele Building	1,208	YTG	Downtown	Fuel Oil*	HW Boilers*	454	183
Prospector Building	1,394	YTG	Downtown	Fuel Oil*	HW Boilers*	354	142
Wood Street Centre	1,991	YTG	Downtown	Fuel Oil*	HW Boilers*	551	222
Thompson Centre	3,801	YTG	Hospital Rd	Fuel Oil*	HW Boilers*	1,213	488
New Whitehorse Hospital	13,011	YTG	Hospital Rd	Fuel Oil	Steam Boilers	7,088	2,850
Education Building	6,244	YTG	Hospital Rd	Propane	HW Boilers	1,362	548
#2 Hospital Road	892	YTG	Hospital Rd	Fuel Oil*	HW Boilers*	489	197
Macaulay Lodge	2,246	YTG	Lewes Blvd	Fuel Oil*	HW Boilers*	1,035	416
Selkirk Elementary School	3,901	YTG	Lewes Blvd	Elec & Fuel Oil	HW Boilers	1,053	423
F.H.Collins School	11,346	YTG	Lewes Blvd	Fuel Oil	HW Boilers	4,292	1,726
Christ the King Elem School	3,085	YTG	Lewes Blvd	Fuel Oil*	HW Boilers*	907	365
Vanier Catholic Secondary School	6,959	YTG	Lewes Blvd	Fuel Oil*	HW Boilers*	1,866	750
Gadzoosdaa Residence	934	YTG	Lewes Blvd	Fuel Oil*	HW Boilers*	407	163
Total	**96,259**					**29,856**	**12,006**

[28] Fuel oil is assumed as the heating source where unknown, since this was the predominant heating source and in these cases HW boilers were also assumed??.

APPENDIX B – SITE VISIT SUMMARY

The following is a list of the buildings visited (in the order they were visited) on Sept 29th, 2009:

1. City Hall & Downtown Firehall #1
2. Municipal Services Building
3. Takhini Arena
4. Canada Games Centre
5. Mount MacIntyre Recreation Centre
6. Elijah Smith Building
7. New Whitehorse General Hospital
8. Yukon College (includes Archives and Art Centre consumption and area)
9. Takhini Elementary School
10. Law Centre
11. Main Administration Building
12. Tourism Business Centre/VRC
13. Education Building
14. F.H.Collins School
15. Whitehorse Elementary
16. Bldg Maintenance Workshop (sign shop)

The following provides a summary of notes from the site visit for the buildings that were visited and which are included in the recommended buildings. Some of the above buildings were excluded from the recommended buildings due to incompatibility (steam rather than hot water), and others because the total annual energy consumption was deemed too small to make connection worthwhile. Cell without entries were not determined during the site visit.

Table 20: Summary of Site Visit Notes for Buildings Included in DES

Building Name	Heating Fuel		Heat Generation Equipment		Space Htg Loop Temp (Deg C)		Heat Delivery Equipment	Flow Regime
	Space	DWH	Space	DWH	Supply	Return		
City Hall & Downtown Firehall #1	Oil	Elec	HW Boilers	HW Heater	66	54	HW coils in AHU, radiant panels, radiant bb's	Constant
New Whitehorse Hospital	Oil & Elec		Steam boilers, & Elec Boilers		60	50	Glycol and hot water coils	Variable
Education Building	Propane	Elec	HW Boilers	HW Heater	70	60	HW coils in unit heaters, fan coils units, reheat coils	-
Main Administration Building	Oil	Oil	HW Boilers	HW Boiler	-	-	HW coils in AHU's, reheat coils, and HW BB's	-
Tourism Business Centre/VRC	Oil	Elec	HW Boilers	HW Heater	-	-	HW coils in AHU's, perimeter BB's	-
F.H.Collins School	Oil	Elec	HW Boilers	HW Heater	-	-	HW coils in AHU's, unit ventilators, radiant panels, radiant bb's	-
Municipal Services Building	Oil	Oil	Steam boilers	HW Boiler	-	-	HW coils in AHU's, unit ventilators, radiant panels, radiant bb's	Constant

APPENDIX C – HEATING ENERGY INTENSITY MAPS

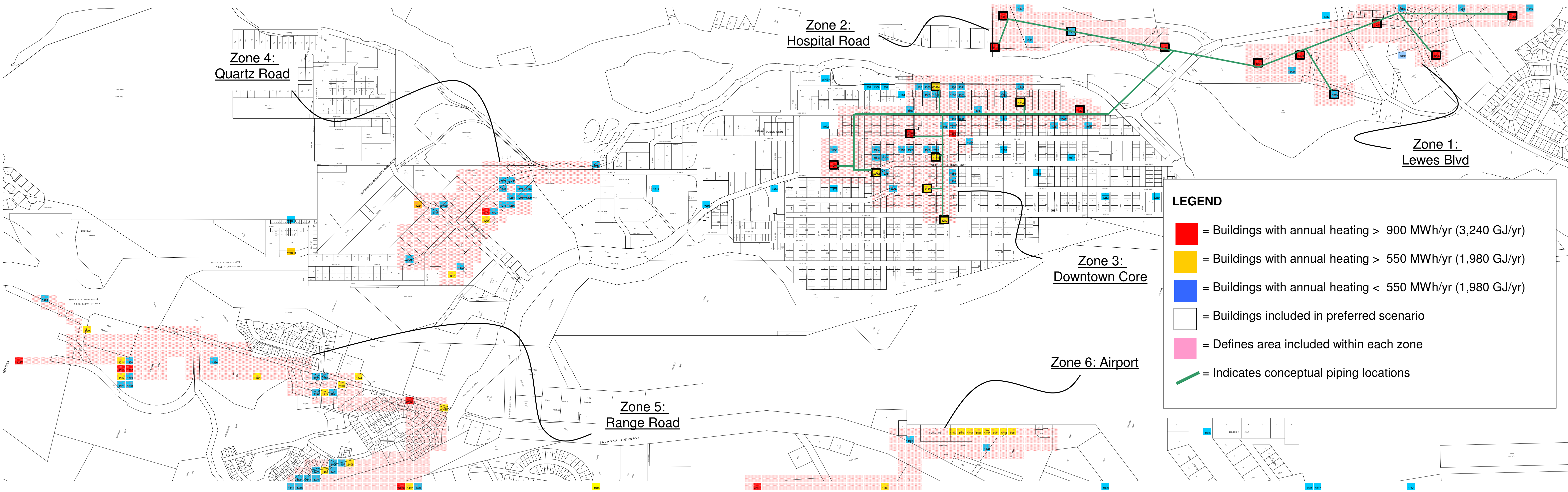
Heating Intensity Maps

Figure 18 is developed using an interactive excel-based tool that was developed for the purpose of this study. The figure shows a map of the study area overlaid on top of a grid of cells. Each cell is equivalent to 22 m^2 or 0.002 hectares. The approximate location of each building is denoted by placing the Building ID number in the cell that most closely corresponds to the building's location on the overlain map. Each cell that represents a building is also colour-coded to signify the energy intensity of that individual building. Three colours are used: red for those that consume more than 900 MWh/year (3,240 GJ/year), orange for those that consume between 550 and 900 MWh/year (between 1,908 and 3,240 GJ/year), and blue for those that consume less than 550 MWh/year (1,908 GJ/year).

Figure 19 was developed in order to provide a sense of the heating energy intensity including all buildings within the core study areas of City of Whitehorse. Figure 19 provides an Energy Intensity Map for all buildings within the study area. Figure 19 represents an order of magnitude estimate of energy intensity across most of the developed areas of the city. The intensities are based on estimated density factors (i.e., building density in square meters of conditioned building floor area per hectare, m^2/ha) and the average HEI value estimated for Whitehorse (273 kWh/m^2/year), based on the utility data provided (and correlated by statistical data).

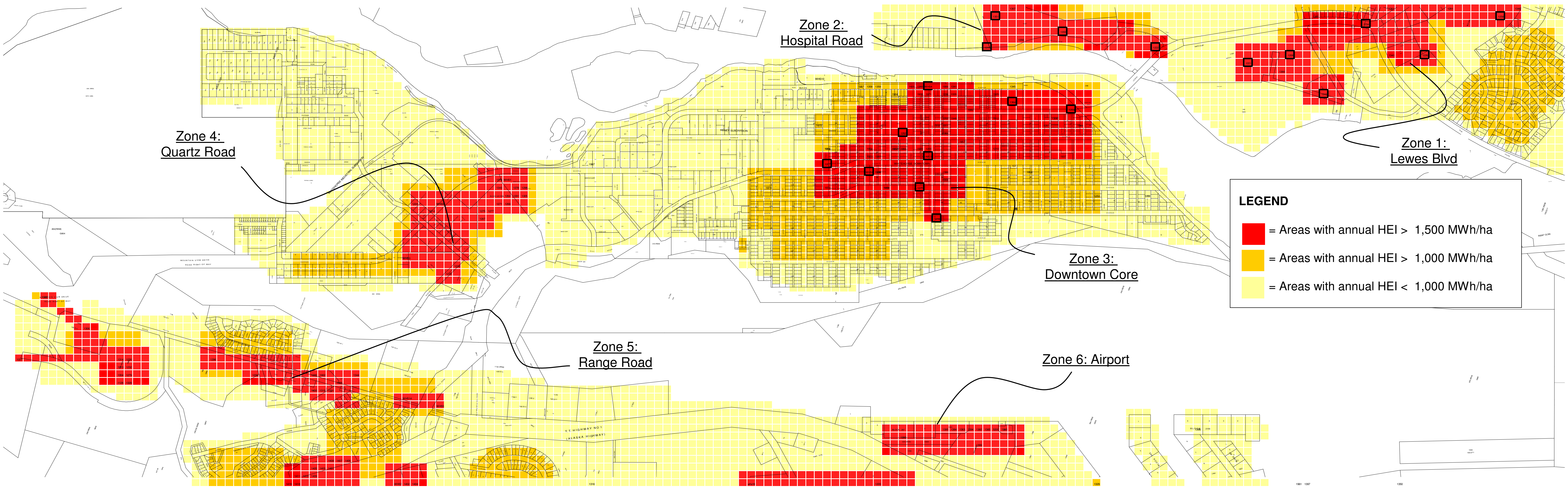
Whitehorse Heating Energy Intensity Analysis

Figure 18: ***Identifying Buildings and Zones***



Whitehorse Heating Energy Intensity Analysis

Figure 19: Estimated Heating Energy Intensity (MWh/ha)



APPENDIX D – ENERGY INPUT DATA

Appendix D

Case: Base and Peak load analysis for areas 3,5,6

least capital, no generation — **higher capital, higher fuel cost, return from electrical sales, moderate operational requirements**

		Combustion Only					Co-generation											
		biomass					ORC (thermal oil system)					Combustion and steam turbine (condensing)					Electric - no generation	Electric - no generation
		wood waste	wood pellets	wood pucks	heating oil	propane	biomass			heating oil	propane	biomass			heating oil	propane	firm	secondary
							wood waste	wood pellets	wood pucks			wood waste	wood pellets	wood pucks				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SYSTEM ANALYSIS																		
Total load 131526	GJ/y																	
Base load 111797	GJ/y																	
Peak load 19729	GJ/y																	
BASE LOAD ANALYSIS																		
heat required by the system	GJ/y	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797	111797
combustion efficiency	%	70%	80%	80%	82%	85%	70%	80%	80%	82%	88%	70%	80%	80%	82%	88%	95%	95%
required heat input in fuel	GJ/y	159710	139746	139746	136338	131526	191652	167696	167696	163606	152451	191652	167696	167696	163606	152451	117681	117681
fuel flow																		
fuel cost	$/GJ	$19.13	$16.44	$14.26	$22.90	$31.61	$19.13	$16.44	$14.26	$22.90	$31.61	$19.13	$16.44	$14.26	$22.90	$31.61	$29.06	$20.30
annual cost of fuel	$/yr	$3,054,777	$2,297,049	$1,992,168	$3,122,320	$4,157,240	$3,665,733	$2,756,459	$2,390,602	$3,746,784	$4,818,619	$3,665,733	$2,756,459	$2,390,602	$3,746,784	$4,818,619	$3,419,811	$2,388,925
electrical output (Note 3)	GJ/y	0	0	0	0	0	24428	24428	24428	24428	24428	20571	20571	20571	20571	20571	0	0
electricity sale price (sec) (Note 1)	$/GJ						$20.30	$20.30	$20.30	$20.30	$20.30	$20.30	$20.30	$20.30	$20.30	$20.30	$0.00	$0.00
Annual electrical sales (sec)	$/yr	0	0	0	0	0	$495,856	$495,856	$495,856	$495,856	$495,856	$417,563	$417,563	$417,563	$417,563	$417,563	$0	$0
Annual cost (fuel - elect sales)	$/yr	$3,054,777	$2,297,049	$1,992,168	$3,122,320	$4,157,240	$3,169,877	$2,260,604	$1,894,746	$3,250,928	$4,322,764	$3,248,170	$2,338,897	$1,973,039	$3,329,221	$4,401,057	$3,419,811	$2,388,925
Capital cost (based on 6 MW sizing)	$	$1,770,000	$1,690,000	$1,690,000	$502,000	$502,000	$8,168,000	$7,915,000	$7,915,000	$3,450,000	$3,450,000	$8,000,000	$8,000,000	$8,000,000	$6,500,000	$6,500,000	$3,000,000	$3,000,000
Annual operation cost																		
Fuel cost (from above)	$/yr	$3,054,777	$2,297,049	$1,992,168	$3,122,320	$4,157,240	$3,665,733	$2,756,459	$2,390,602	$3,746,784	$4,818,619	$3,665,733	$2,756,459	$2,390,602	$3,746,784	$4,818,619	$3,419,811	$2,388,925
Operation and maintenance (Note 2)	$/yr	$400,000	$400,000	$400,000	$320,000	$320,000	$400,000	$400,000	$400,000	$320,000	$320,000	$500,000	$500,000	$500,000	$450,000	$450,000	$200,000	$200,000
Financial costs	$/yr	$171,200	$163,500	$163,500	$48,550	$48,553	$790,000	$765,540	$765,539	$333,700	$333,700	$773,760	$773,760	$773,760	$628,680	$628,680	$290,160	$290,160
income due to electrical sales	$/yr	$0	$0	$0	$0	$0	$495,856	$495,856	$495,856	$495,856	$495,856	$417,563	$417,563	$417,563	$417,563	$417,563	$0	$0
total annual cost (base load)	$/yr	$3,625,977	$2,860,549	$2,555,668	$3,490,870	$4,525,794	$4,359,877	$3,426,144	$3,060,285	$3,904,628	$4,976,464	$4,521,930	$3,612,657	$3,246,799	$4,407,901	$5,479,737	$3,909,971	$2,879,085
PEAK LOAD ANALYSIS		heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil	heating oil
heat required by the system	GJ/y	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729
combustion efficiency	%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%
required heat input in fuel	GJ/y	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060	24060
fuel flow																		
fuel cost		$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90	$22.90
annual cost of fuel		$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$551,000	$551,000
Capital cost (based on 9 MW sizing)	$	$753,000	$753,000	$300,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000	$753,000
(see calc below)																		
Annual operation cost (peak)																		
Fuel cost (from above)	$/yr	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$550,998	$551,000	$551,000
Operation and maint (Included above)	$/yr	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Financial costs	$/yr	$72,830	$72,830	$29,016	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830	$72,830
total annual cost (peak load)	$/yr	$623,828	$623,828	$580,014	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,828	$623,831	$623,831
TOTAL LOAD ANALYSIS:																		
total annual cost (base and peak)	$/yr	$4,249,805	$3,484,377	$3,135,682	$4,114,697	$5,149,621	$4,983,705	$4,049,971	$3,684,113	$4,528,456	$5,600,292	$5,145,758	$4,236,484	$3,870,627	$5,031,729	$6,103,565	$4,533,802	$3,502,916
Rank		9	2	1	7	15	12	6	4	10	16	14	8	5	13	17	11	3

APPENDIX E – FINANCIAL PROJECTIONS

WHITEHORSE DISTRICT ENERGY SYSTEM - PRE-FEASIBILITY STUDY
"BUSINESS AS USUAL (BAU)"

Note: All monetary figures are in real 2009 $

Capital

Initial Replacement Value	$ 870,427
Total Replacement Value	$ 1,043,380

Financial Assumptions

	Amount	Interest	Term
City Debt	$ -	6.25%	25
Sinking Fund Rate		3.00%	
Discount Rate		6.25%	

Energy Cost Projections ($/MWh)

	2010	2014	2019	2024	2029	2034
Fuel Oil	$106.10	$114.17	$114.28	$114.30	$114.30	$114.30
Electricity	$94.75	$94.75	$94.75	$94.75	$94.75	$94.75
Biomass	$51.29	$51.29	$51.29	$51.29	$51.29	$51.29

Cashflow & Key Metrics Projections

Payback Period N/A

Year Cashflow Turns +ve N/A **Year NPV Turns +ve** N/A

	2010	2014	2019	2024	2029	2034
Project Year	1	5	10	15	20	25
Revenue	$ -	$ -	$ -	$ -	$ -	$ -
Expenses	$ 3,328,000	$ 3,682,000	$ 3,825,000	$ 3,965,000	$ 4,105,000	$ 4,245,000
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Sinking Fund	$ -	$ -	$ -	$ -	$ -	$ -
Cashflow	-$ 3,328,000	-$ 3,682,000	-$ 3,825,000	-$ 3,965,000	-$ 4,105,000	-$ 4,245,000
Cumulative Cashflow	-$ 3,328,000	-$ 17,730,000	-$ 36,566,000	-$ 56,112,000	-$ 76,356,000	-$ 97,299,000
Expenses, $/m2	$ 34.31	$ 36.80	$ 36.82	$ 36.82	$ 36.81	$ 36.80
GHG Emissions - tonnes	9,322	9,617	9,986	10,355	10,724	11,093
GHG Reduction - tonnes	0	0	0	0	0	0

N.B. Cashflow is after debt service and sinking fund contributions.
GHG reduction is in comparision with GHG emissions for the BAU scenario

INPUT ASSUMPTIONS
red - input parameter
blue - input parameter copied from elsewhere
black - calculated value

Parameter	Value
Present Year (all $ in real $ for this year unless otherwise noted)	2009
Operations Commence - Year	2010
Inflation Rate	2%
Escalation Factor - Inflation	1.02
Fuel Oil	
commercial price - 2009 $/MWh	84.21
escalation factor 2014-2020	1.00
escalation factor post 2020	1.00
% of energy consumption	100%
GST on fuel oil	0.0%
sensitivity on fuel oil rate	0.0%
GHGs tonnes/MWh	0.3110
Electricity	
commercial price - 2009 $/MWh	94.75
escalation factor	1.00
% of energy consumption	0%
GST on electricity	0.0%
sensitivity on electricity rate	0.0%
GHGs tonnes/MWh	0.0300
Biomass	
commercial price 2009 $/MWh	51.29
escalation factor	1.000
% of energy consumption	0.0%
GST on biomass	0.0%
sensitivity on biomass rate	0.0%
GHGs tonnes/MWh	0.0000
Carbon Offsets	
Carbon offset/tonne - 2010	$14
Carbon offset escalation factor	1.0526
Sensitivity Factor - Carbon Offset	0%
CoWh Cost of Borrowing - nominal	8.25%
CoWh Cost of Borrowing - real	6.25%
Loan term	25
Discount Rate - real	6.25%

Sinking Fund Rate - nominal	**5.0%**
Sinking Fund Rate - real	**3.0%**
Sensitivity Factor for Capital	**0.0%**
% of growth government	**40.0%**
% of growth commercial	**60.0%**
O&M costs - 2009	**$105,000**
Financing from federal grant	**$0**
Financing from other investor	**$0**
Other investor coupon - nominal	**n/a**
Other investor coupon - real	**n/a**
Other investor term	**n/a**

Conversion Factor: GJ => MMbtu	**0.9480**
Conversion Factor: GJ => MWh	**0.2780**
Conversion Factor: sf => m2	**0.0929**

CASHFLOW PROJECTION - $000s

PRO FORMA FOR YEARS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
PROJECT YEARS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
REVENUE		0	0	0	0	0	0	0	0	0	0	0	0	0
EXPENSES														
Fuel		3,180	3,357	3,413	3,503	3,531	3,558	3,586	3,614	3,642	3,669	3,806	3,941	4,077
O&M		106	107	108	108	109	110	111	112	113	113	118	122	126
Other		42	42	42	42	42	42	42	42	42	42	42	42	42
Total		3,328	3,505	3,562	3,653	3,682	3,710	3,739	3,767	3,796	3,825	3,965	4,105	4,245
OPERATING INCOME	0	-3,328	-3,505	-3,562	-3,653	-3,682	-3,710	-3,739	-3,767	-3,796	-3,825	-3,965	-4,105	-4,245
PV OPERATING INCOME	0	-3,132	-3,105	-2,970	-2,866	-2,719	-2,579	-2,446	-2,320	-2,200	-2,086	-1,597	-1,221	-932
INVESTMENTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PV INVESTMENTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CASHFLOW	0	-3,328	-3,505	-3,562	-3,653	-3,682	-3,710	-3,739	-3,767	-3,796	-3,825	-3,965	-4,105	-4,245
CUM. CASHFLOW	0	-3,328	-6,833	-10,395	-14,048	-17,730	-21,440	-25,179	-28,946	-32,742	-36,566	-56,112	-76,356	-97,299
TERMINAL VALUE		0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT NPV	0	-3,132	-6,237	-9,207	-12,073	-14,792	-17,371	-19,817	-22,136	-24,336	-26,422	-35,334	-42,151	-47,360
DEBT SERVICE PAYMENTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SINKING FUND CONTRIBUTIONS		0	0	0	0	0	0	0	0	0	0	0	0	0
TAXES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CF AFTER DEBT PMTS & SF	0	-3,328	-3,505	-3,562	-3,653	-3,682	-3,710	-3,739	-3,767	-3,796	-3,825	-3,965	-4,105	-4,245
CUM CF AFTER DEBT & SF	0	-3,328	-6,833	-10,395	-14,048	-17,730	-21,440	-25,179	-28,946	-32,742	-36,566	-56,112	-76,356	-97,299

REVENUE PROJECTION - real 2009$

REVENUE FOR YEARS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
Markets														
Yukon Government		0	0	0	0	0	0	0	0	0	0	0	0	0
City of Whitehorse		0	0	0	0	0	0	0	0	0	0	0	0	0
Commerical		0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
Heating Revenue $/year		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Carbon Offset Revenues														
GHGs for BAU - tonnes		9,322	9,396	9,470	9,543	9,617	9,691	9,765	9,839	9,912	9,986	10,355	10,724	11,093
GHGs for this scenario - tonnes		9,322	9,396	9,470	9,543	9,617	9,691	9,765	9,839	9,912	9,986	10,355	10,724	11,093
GHG reduction - tonnes		0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Offset Revenues $/year		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Revenues														
Total System Revenues - $/year		0	0	0	0	0	0	0	0	0	0	0	0	0

EXPENSE PROJECTION - $2009

EXPENSES FOR YEARS		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
Area Served															
Annual growth (m2)		**765**	765	765	765	765	765	765	765	765	765	765	765	765	765
Cumulative Growth (m2)		**0**	765	1,530	2,294	3,059	3,824	4,589	5,353	6,118	6,883	7,648	11,472	15,296	19,119
Total Area (m2)		**96,224**	96,988	97,753	98,518	99,283	100,047	100,812	101,577	102,342	103,107	103,871	107,695	111,519	115,343
Annual Fuel Consumption (MWh)															
Demand (m2-years)			96,606	97,371	98,136	98,900	99,665	100,430	101,195	101,959	102,724	103,489	107,313	111,137	114,961
Demand (kWh/m2)	**310.28**														
Demand (MWh)	**%**	29,856	29,974	30,212	30,449	30,686	30,924	31,161	31,398	31,636	31,873	32,110	33,297	34,483	35,669
Fuel Oil	**100%**	29,856	29,974	30,212	30,449	30,686	30,924	31,161	31,398	31,636	31,873	32,110	33,297	34,483	35,669
Electricity	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	**0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total			29,974	30,212	30,449	30,686	30,924	31,161	31,398	31,636	31,873	32,110	33,297	34,483	35,669
Annual Fuel Costs															
Fuel Oil		2,514,120	3,180,327	3,356,693	3,413,249	3,502,844	3,530,599	3,558,359	3,586,121	3,613,888	3,641,658	3,669,431	3,805,694	3,941,303	4,076,911
Electricity		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-Total Fuel Costs $/yr		$2,514,120	$3,180,327	$3,356,693	$3,413,249	$3,502,844	$3,530,599	$3,558,359	$3,586,121	$3,613,888	$3,641,658	$3,669,431	$3,805,694	$3,941,303	$4,076,911
	$/m2	$26.13	$32.79	$34.34	$34.65	$35.28	$35.29	$35.30	$35.30	$35.31	$35.32	$35.33	$35.34	$35.34	$35.35
	%		95.6%	95.8%	95.8%	95.9%	95.9%	95.9%	95.9%	95.9%	95.9%	95.9%	96.0%	96.0%	96.1%
O&M Costs	**$/m2**														
O&M Costs	1.0912	105,000	105,835	106,669	107,504	108,338	109,173	110,007	110,842	111,676	112,511	113,345	117,518	121,691	125,863
Sub-Total O&M $/yr		$105,000	$105,835	$106,669	$107,504	$108,338	$109,173	$110,007	$110,842	$111,676	$112,511	$113,345	$117,518	$121,691	$125,863
	$/m2	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09
	%		3.2%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Other															
Plant Replacement Charge	9.0459		34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817	34,817
Plant for Growth Charge	9.0459		6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918	6,918
Sub-Total Other Costs/yr		$0	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735	$41,735
	$/m2		$0.43	$0.43	$0.42	$0.42	$0.42	$0.41	$0.41	$0.41	$0.40	$0.40	$0.39	$0.37	$0.36
	%		1.3%	1.2%	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%
Total System Expenses		$2,619,120	$3,327,896	$3,505,097	$3,562,487	$3,652,917	$3,681,507	$3,710,101	$3,738,698	$3,767,299	$3,795,904	$3,824,511	$3,964,947	$4,104,729	$4,244,510
	$/m2	$27.22	$34.31	$35.86	$36.16	$36.79	$36.80	$36.80	$36.81	$36.81	$36.82	$36.82	$36.82	$36.81	$36.80

GHG Emissions

Fuel Oil	9,322	9,396	9,470	9,543	9,617	9,691	9,765	9,839	9,912	9,986	10,355	10,724	11,093
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0
	9,322	9,396	9,470	9,543	9,617	9,691	9,765	9,839	9,912	9,986	10,355	10,724	11,093

PROJECT CAPITAL AND FINANCING

OUTLAYS FOR YEARS			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
Year of First Outlay			-2	-1	0	1	2	3	4	5	6	7	8	9	10	15	20	25
PROJECT CAPITAL:																		
Total Capital Cost		**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cum Total Capital Cost			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Assets at Cost						0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Depreciation						0	0	0	0	0	0	0	0	0	0	0	0	0
Book Value						0	0	0	0	0	0	0	0	0	0	0	0	0
SOURCES OF FINANCING:		***Funding***																
Federal Grant		**0**																
Other Investor	**n/a**	**0**																
City Debt	**6.25%**	**0**																
		0																

CAPITAL SCHEDULE

Equipment	Total Cost	Lifetime	Year in Service	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
			2007															
			-2	-1	0	1	2	3	4	5	6	7	8	9	10	15	20	25
		25	1		0	-	-	-	-	-	-	-	-	-	-	-	-	0
Total	**0**				0	0	0	0	0	0	0	0	0	0	0	0	0	0

DEPRECIATION SCHEDULE

Equipment	Total Cost	Lifetime	Service Starts	Service Ends		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
0	**0**	25	1	25		0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cost	**0**		*check*		**Annual Depreciation**	0	0	0	0	0	0	0	0	0	0	0	0	0
					Cumulative Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0

SENSITIVITY ON CAPITAL **0%**

ENERGY COST PROJECTION - REAL 2009 $

PRICING FOR YEARS			2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2029	2034
			0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**20**	**25**
Fuel Oil																				
	sensitivity																			
Commodity price/MWh	**0.0%**		**84.21**	106.10	111.11	112.10	114.15	114.17	114.19	114.21	114.24	114.26	114.28	114.30	114.30	114.30	114.30	114.30	114.30	114.30
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Oil Cost $/MWh			84.21	106.10	111.11	112.10	114.15	114.17	114.19	114.21	114.24	114.26	114.28	114.30	114.30	114.30	114.30	114.30	114.30	114.30
$/GJ			23.41	29.50	30.89	31.16	31.73	31.74	31.75	31.75	31.76	31.76	31.77	31.77	31.77	31.77	31.77	31.77	31.77	31.77
Electricity																				
	sensitivity																			
Commodity price/MWh	**0.0%**		**94.75**	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Cost $/MWh			94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75
$/GJ			26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34
Biomass																				
	sensitivity																			
Commodity price/MWh	**0.0%**		**51.29**	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass Cost $/MWh			51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29
$/GJ			14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26
Carbon Offsets	*sensitivity*	2010 value																		
Carbon offset/tonne	**0.0%**	**14.00**		14.00	14.74	15.51	16.33	17.18	18.09	19.04	20.04	21.09	22.20	23.37	24.59	25.89	27.25	28.68	37.05	47.87

WHITEHORSE DISTRICT ENERGY SYSTEM - PRE-FEASIBILITY STUDY
"DISTRICT ENERGY SYSTEM (DES)"

Note: All monetary figures are in real 2009 $

Capital

Initial Capital Cost	$	18,395,443
Total Capital Cost	$	21,477,217

Rate Projections ($/MWh)

	2010	2014	2019	2024	2029	2034
Fuel Oil	$103.79	$111.68	$111.79	$111.81	$111.81	$111.81
Electricity	$94.75	$94.75	$94.75	$94.75	$94.75	$94.75
Biomass	$51.29	$51.29	$51.29	$51.29	$51.29	$51.29
DES Energy Charge	$151.57	$163.10	$163.25	$163.28	$163.28	$163.28
Carbon Offsets ($/tonne)	$14.00	$17.18	$22.20	$28.68	$37.05	$47.87
Model Growth	yes					
Monetize Carbon Offsets	yes					
Premium for Energy Sales	10%					

DES/BAU total heating cost ratio, year 25 **106.0%**

Cashflow & Key Metrics Projections

Payback Period, years	**12**	**IRR, year 25**	**7.3%**
Year Cashflow Turns +ve	**4**	**Year Cum. Cashflow Turns +ve**	**17**
Max Cumulative Deficit	**-$1,311,000**	**Year NPV Turns +ve**	**13**

	2010	2014	2019	2024	2029	2034
Project Year	1	5	10	15	20	25
Revenue	$ 1,812,000	$ 4,026,000	$ 4,227,000	$ 4,441,000	$ 4,677,000	$ 4,941,000
Expenses	$ 1,365,000	$ 2,298,000	$ 2,386,000	$ 2,475,000	$ 2,563,000	$ 2,651,000
Debt Service	$ 1,150,000	$ 1,150,000	$ 1,193,000	$ 1,237,000	$ 1,311,000	$ 1,355,000
Sinking Fund	$ 505,000	$ 505,000	$ 524,000	$ 543,000	$ 575,000	$ 595,000
Cashflow	-$ 1,207,000	$ 74,000	$ 124,000	$ 188,000	$ 227,000	$ 340,000
Cum. Cashflow	-$ 1,207,000	-$ 1,185,000	-$ 799,000	-$ 123,000	$ 704,000	$ 2,037,000
NPV	-$ 1,232,000	-$ 1,260,000	-$ 544,000	$ 563,000	$ 1,770,000	$ 3,054,000
ROIC	-0.9%	6.1%	6.3%	6.6%	6.8%	7.3%
Expenses, $/m2	$ 28.16	$ 23.06	$ 23.06	$ 23.06	$ 23.06	$ 23.06
GHG Emissions - tonnes	5,302	1,355	1,407	1,459	1,511	1,563
GHG Reduction - tonnes	4,020	8,263	8,580	8,897	9,214	9,531

N.B. Cashflow is after debt service and sinking fund contributions.
*ROIC or Return on Invested Capital = EBIT * (1 - tax rate) / (interest bearing debt + equity)*
GHG reduction is in comparision with GHG emissions for the BAU scenario

INPUT ASSUMPTIONS
red - input parameter
blue - input parameter copied from elsewhere
black - calculated value

Parameter	Value
Present Year (all $ in real $ for this year unless otherwise noted)	2009
Operations Commence - Year	2010
Inflation Rate	2%
Escalation Factor - Inflation	1.02
Fuel Oil	
wholesale price - 2009 $/MWh	82.37
commercial price - 2009 $/MWh	84.21
escalation factor post 2014-20	1.000
escalation factor post 2020	1.000
% of energy consumption	15%
GST on fuel oil	0.0%
sensitivity on fuel oil rate	0.0%
GHGs tonnes/MWh	0.3110
premium for energy sales	10%
Electricity	
commercial price - 2009 $/MWh	94.75
escalation factor	1.00
energy consumption at buildout (MWh)	1,033
GST on electricity	0.0%
sensitivity on electricity rate	0.0%
GHGs tonnes/MWh	0.0300
Biomass	
commercial price 2009 $/MWh	51.29
escalation factor	1.000
% of energy consumption	85.0%
GST on biomass	0.0%
sensitivity on biomass rate	0.0%
GHGs tonnes/MWh	0.0000
Carbon Offsets	
Carbon offset/tonne - 2010	$14
Carbon offset escalation factor	1.0526
Sensitivity Factor - Carbon Offset	0%
Monetize Carbon Reduction (yes/no)	yes
Insurance, $/$1000 insured	$1.50
Fuel Oil Boiler Efficiency	77%

DES Efficiency	82%
CoWh Cost of Borrowing - nominal	8.25%
CoWh Cost of Borrowing - real	6.25%
Loan term	25
Discount Rate - real	6.25%
Sinking Fund Rate - nominal	5.0%
Sinking Fund Rate - real	3.0%
Sensitivity Factor for Capital	0.0%
Model growth (yes/no)	yes
% of growth government	40.0%
% of growth commercial	60.0%
O&M costs - 2009	$400,000
Financing from federal grant	$0
Financing from other investor	$0
Other investor coupon - nominal	n/a
Other investor coupon - real	n/a
Other investor term	n/a

Conversion Factor: GJ => MMbtu	0.9480
Conversion Factor: GJ => MWh	0.2780
Conversion Factor: sf => m2	0.0929

CASHFLOW PROJECTION - $000s

PRO FORMA FOR YEARS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
PROJECT YEARS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
REVENUE														
Heating		1,756	3,692	3,755	3,853	3,884	3,914	3,945	3,975	4,006	4,036	4,186	4,335	4,485
Carbon Offsets		56	119	126	134	142	151	160	169	180	190	255	341	456
Total		1,812	3,811	3,881	3,987	4,026	4,065	4,104	4,145	4,185	4,227	4,441	4,677	4,941
EXPENSES														
Fuel		935	1,799	1,817	1,840	1,854	1,869	1,883	1,897	1,912	1,926	1,997	2,068	2,139
O&M		431	434	437	440	443	448	451	454	457	460	477	495	512
Total		1,365	2,233	2,254	2,280	2,298	2,316	2,334	2,351	2,369	2,386	2,475	2,563	2,651
OPERATING INCOME	0	447	1,578	1,626	1,707	1,728	1,748	1,771	1,793	1,817	1,841	1,967	2,113	2,289
PV OPERATING INCOME	0	421	1,398	1,356	1,339	1,276	1,215	1,158	1,104	1,053	1,004	792	629	503
DEPRECIATION		607	607	607	607	607	630	630	630	630	630	653	693	716
EBIT		-160	972	1,020	1,100	1,121	1,119	1,141	1,164	1,187	1,211	1,314	1,421	1,573
INVESTMENTS	18,395	0	0	0	0	695	0	0	0	0	695	1,195	695	0
PV INVESTMENTS	18,395	0	0	0	0	514	0	0	0	0	379	481	207	0
PROJECT CASHFLOW	-18,395	447	1,578	1,626	1,707	1,032	1,748	1,771	1,793	1,817	1,145	771	1,418	2,289
CUM. CASHFLOW	-18,395	-17,948	-16,370	-14,744	-13,037	-12,004	-10,256	-8,485	-6,692	-4,875	-3,730	4,648	14,213	25,293
TERMINAL VALUE		16,743	15,220	13,819	12,531	11,859	10,724	9,681	8,724	7,846	7,420	4,647	2,608	1,140
PROJECT NPV	-18,395	-1,232	-1,356	-1,401	-1,351	-1,260	-1,180	-1,064	-917	-743	-544	563	1,770	3,054
CASHFLOW + YR 25 TERMINAL VALUE	-18,395	447	1,578	1,626	1,707	1,032	1,748	1,771	1,793	1,817	1,145	771	1,418	3,429
IRR, YEAR 25	7.3%													
ROIC		-0.9%	5.3%	5.5%	6.0%	6.1%	5.9%	6.0%	6.1%	6.2%	6.3%	6.6%	6.8%	7.3%
DEBT SERVICE PAYMENTS	0	1,150	1,150	1,150	1,150	1,150	1,193	1,193	1,193	1,193	1,193	1,237	1,311	1,355
SINKING FUND CONTRIBUTIONS		505	505	505	505	505	524	524	524	524	524	543	575	595
TAXES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CF AFTER DEBT PMTS & SF	0	-1,207	-76	-28	52	74	32	54	77	100	124	188	227	340
CUM CF AFTER DEBT & SF	0	-1,207	-1,283	-1,311	-1,258	-1,185	-1,153	-1,099	-1,023	-923	-799	-123	704	2,037

REVENUE PROJECTION - real 2009$

REVENUE FOR YEARS		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
Markets															
Area (m2)			96,988	97,753	98,518	99,283	100,047	100,812	101,577	102,342	103,107	103,871	107,695	111,519	115,343
Demand (MWh)															
Demand (m2-years)			48,494	97,371	98,136	98,900	99,665	100,430	101,195	101,959	102,724	103,489	107,313	111,137	114,961
Demand (kWh/m2)	**238.91**		11,586	23,263	23,446	23,629	23,811	23,994	24,177	24,359	24,542	24,725	25,638	26,552	27,466
Pricing		*premium*													
rate parity factor	**1.30**														
DES customers	$/MWh	**10%**	151.57	158.72	160.14	163.07	163.10	163.13	163.16	163.19	163.22	163.25	163.28	163.28	163.28
Customer Revenues															
Heating Revenue $/year			$1,756,103	$3,692,362	$3,754,573	$3,853,128	$3,883,659	$3,914,194	$3,944,734	$3,975,277	$4,005,823	$4,036,374	$4,186,264	$4,335,433	$4,484,603
Customer Costs $/m2			$36.21	$37.92	$38.26	$38.96	$38.97	$38.97	$38.98	$38.99	$39.00	$39.00	$39.01	$39.01	$39.01
Carbon Offset Revenues															
GHGs for BAU - tonnes			9,322	9,396	9,470	9,543	9,617	9,691	9,765	9,839	9,912	9,986	10,355	10,724	11,093
GHGs for this scenario - tonnes			5,302	1,323	1,334	1,344	1,355	1,365	1,375	1,386	1,396	1,407	1,459	1,511	1,563
GHG reduction - tonnes			4,020	8,072	8,136	8,199	8,263	8,326	8,389	8,453	8,516	8,580	8,897	9,214	9,531
Carbon Offset Revenues $/year		**yes**	$56,285	$118,954	$126,190	$133,857	$141,982	$150,591	$159,714	$169,379	$179,618	$190,467	$255,159	$341,390	$456,222
Total Revenues															
Total System Revenues - $/year			$1,812,388	$3,811,316	$3,880,763	$3,986,985	$4,025,641	$4,064,786	$4,104,447	$4,144,655	$4,185,442	$4,226,841	$4,441,422	$4,676,823	$4,940,825

EXPENSE PROJECTION - $2009

EXPENSES FOR YEARS		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2024	2029	2034
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
Area Served															
Annual growth (m2)		**765**	765	765	765	765	765	765	765	765	765	765	765	765	765
Cumulative Growth (m2)		**0**	765	1,530	2,294	3,059	3,824	4,589	5,353	6,118	6,883	7,648	11,472	15,296	19,119
Total Area (m2)		**96,224**	96,988	97,753	98,518	99,283	100,047	100,812	101,577	102,342	103,107	103,871	107,695	111,519	115,343
Annual Fuel Consumption (MWh)															
Demand (m2-years)			48,494	97,371	98,136	98,900	99,665	100,430	101,195	101,959	102,724	103,489	107,313	111,137	114,961
Demand (kWh/m2)	**291.36**														
Demand (MWh)	**%**	28,035	14,129	28,370	28,592	28,815	29,038	29,261	29,484	29,707	29,929	30,152	31,266	32,380	33,495
Fuel Oil	**15%**	4,205	2,119	4,255	4,289	4,322	4,356	4,389	4,423	4,456	4,489	4,523	4,690	4,857	5,024
Biomass	**85%**	23,830	12,010	24,114	24,304	24,493	24,682	24,872	25,061	25,251	25,440	25,629	26,576	27,523	28,470
Electricity (kWh/m2)	**10.74**	1,033	1,041	1,049	1,058	1,066	1,074	1,082	1,090	1,099	1,107	1,115	1,156	1,197	1,238
total		29,068	15,170	29,419	29,650	29,881	30,112	30,343	30,574	30,805	31,036	31,267	32,422	33,578	34,733
Annual Fuel Costs															
Fuel Oil		346,408	219,968	462,502	470,295	482,640	486,464	490,289	494,114	497,940	501,766	505,593	524,368	543,053	561,738
Biomass		1,222,362	616,039	1,236,935	1,246,650	1,256,366	1,266,081	1,275,796	1,285,511	1,295,227	1,304,942	1,314,657	1,363,233	1,411,809	1,460,386
Electricity		97,877	98,655	99,433	100,211	100,988	101,766	102,544	103,322	104,100	104,878	105,656	109,546	113,435	117,325
Sub-Total Fuel Costs $/yr		$1,666,647	$934,661	$1,798,870	$1,817,156	$1,839,994	$1,854,311	$1,868,629	$1,882,947	$1,897,266	$1,911,586	$1,925,906	$1,997,147	$2,068,297	$2,139,448
O&M Costs	**$/m2**														
O&M Costs	4.1570	400,000	403,179	406,358	409,538	412,717	415,896	419,075	422,254	425,433	428,613	431,792	447,688	463,583	479,479
Insurance			27,593	27,593	27,593	27,593	27,593	28,636	28,636	28,636	28,636	28,636	29,679	31,473	32,516
Sub-Total O&M $/yr		$400,000	$430,772	$433,952	$437,131	$440,310	$443,489	$447,711	$450,891	$454,070	$457,249	$460,428	$477,367	$495,056	$511,995
Other															
Sub-Total Other Costs/yr		0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total System Expenses		$2,066,647	$1,365,434	$2,232,821	$2,254,286	$2,280,303	$2,297,800	$2,316,340	$2,333,838	$2,351,336	$2,368,835	$2,386,334	$2,474,514	$2,563,353	$2,651,443
	$/m2		$28.16	$22.93	$22.97	$23.06	$23.06	$23.06	$23.06	$23.06	$23.06	$23.06	$23.06	$23.06	$23.06

GHG Emissions														
DES														
Fuel Oil		659	1,323	1,334	1,344	1,355	1,365	1,375	1,386	1,396	1,407	1,459	1,511	1,563
Biomass		0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity														
		659	1,323	1,334	1,344	1,355	1,365	1,375	1,386	1,396	1,407	1,459	1,511	1,563
BAU pre-cutover														
demand (m2-years)		48,112	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil - MWh	**310.28**	14,928	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil - GHGs, tonnes		4,643	0	0	0	0	0	0	0	0	0	0	0	0
Total Emissions		5,302	1,323	1,334	1,344	1,355	1,365	1,375	1,386	1,396	1,407	1,459	1,511	1,563

PROJECT CAPITAL AND FINANCING

OUTLAYS FOR YEARS			**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2024**	**2029**	**2034**
Year of First Outlay			-2	-1	0	1	2	3	4	5	6	7	8	9	10	15	20	25
PROJECT CAPITAL:																		
Total Capital Cost		**18,395,443**			**18,395,443**	**0**	**0**	**0**	**0**	**695,443**	**0**	**0**	**0**	**0**	**695,443**	**1,195,443**	**695,443**	**0**
Cum Total Capital Cost			0	0	18,395,443	18,395,443	18,395,443	18,395,443	18,395,443	19,090,887	19,090,887	19,090,887	19,090,887	19,090,887	19,786,330	20,981,773	21,677,217	21,677,217
Assets at Cost						18,395,443	18,395,443	18,395,443	18,395,443	18,395,443	19,090,887	19,090,887	19,090,887	19,090,887	19,090,887	19,786,330	20,981,773	21,677,217
Cumulative Depreciation						606,515	1,213,030	1,819,544	2,426,059	3,032,574	3,662,270	4,291,966	4,921,663	5,551,359	6,181,055	9,445,443	12,909,072	16,488,608
Book Value						17,788,929	17,182,414	16,575,899	15,969,384	15,362,869	15,428,617	14,798,920	14,169,224	13,539,528	12,909,832	10,340,887	8,072,701	5,188,608
SOURCES OF FINANCING:		***Funding***																
Federal Grant		**0**																
Other Investor	**n/a**	**0**																
City Debt	**6.25%**	**18,395,443**																
		18,395,443																

CAPITAL SCHEDULE

			2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2024**	**2029**	**2034**
			-2	-1	0	1	2	3	4	5	6	7	8	9	10	15	20	25
Equipment	**Total Cost**	**Lifetime**	**Year in Service**															
DES plant & inbuilding equipment	**17,500,000**	30	1		17,500,000	-	-	-	-	-	-	-	-	-	-	-	-	-
Land	**200,000**	75	1		200,000	-	-	-	-	-	-	-	-	-	-	-	-	-
Upgrade for growth years 1-5	**695,443**	30	1		695,443	-	-	-	-	-	-	-	-	-	-	-	-	-
Upgrade for growth years 6-10	**695,443**	30	6		-	-	-	-	-	695,443	-	-	-	-	-	-	-	-
Upgrade for growth years 11-15	**695,443**	30	11		-	-	-	-	-	-	-	-	-	-	695,443	-	-	-
Upgrade for growth years 16-20	**695,443**	30	16		-	-	-	-	-	-	-	-	-	-	-	695,443	-	-
Major Replacement	**500,000**	30	16		-	-	-	-	-	-	-	-	-	-	-	500,000	-	-
Upgrade for growth years 21-25	**695,443**	30	21		-	-	-	-	-	-	-	-	-	-	-	-	695,443	-
Total	**21,677,217**				18,395,443	0	0	0	0	695,443	0	0	0	0	695,443	1,195,443	695,443	0

DEPRECIATION SCHEDULE

Equipment	**Total Cost**	**Lifetime**	**Service Starts**	**Service Ends**														
DES plant & inbuilding equipment	**17,500,000**	30	1	30		583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333	583,333
Upgrade for growth years 1-5	**695,443**	30	1	30		23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181
Upgrade for growth years 6-10	**695,443**	30	6	35		0	0	0	0	0	23,181	23,181	23,181	23,181	23,181	23,181	23,181	23,181
Upgrade for growth years 11-15	**695,443**	30	11	40		0	0	0	0	0	0	0	0	0	0	23,181	23,181	23,181
Upgrade for growth years 16-20	**695,443**	30	16	45		0	0	0	0	0	0	0	0	0	0	0	23,181	23,181
Major Replacement	**500,000**	30	16	45		0	0	0	0	0	0	0	0	0	0	0	16,667	16,667
Upgrade for growth years 21-25	**695,443**	30	21	50		0	0	0	0	0	0	0	0	0	0	0	0	23,181
Total Cost	**21,477,217**				**Annual Depreciation**	606,515	606,515	606,515	606,515	606,515	629,696	629,696	629,696	629,696	629,696	652,878	692,726	715,907
					Cumulative Depreciation	606,515	1,213,030	1,819,544	2,426,059	3,032,574	3,662,270	4,291,966	4,921,663	5,551,359	6,181,055	9,445,443	12,909,072	16,488,608

SENSITIVITY ON CAPITAL **0%**

ENERGY COST PROJECTION - REAL 2009 $

PRICING FOR YEARS			**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2024**	**2029**	**2034**
			0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**
Fuel Oil																
Wholesale	*sensitivity*															
Commodity price/MWh	**0.0%**		**82.37**	103.79	108.68	109.65	111.66	111.68	111.71	111.73	111.75	111.77	111.79	111.81	111.81	111.81
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Oil Cost	$/MWh		82.37	103.79	108.68	109.65	111.66	111.68	111.71	111.73	111.75	111.77	111.79	111.81	111.81	111.81
	$/GJ		22.90	28.85	30.21	30.48	31.04	31.05	31.05	31.06	31.07	31.07	31.08	31.08	31.08	31.08
Commercial	*sensitivity*															
Commodity price/MWh	**0.0%**		**84.21**	106.10	111.11	112.10	114.15	114.17	114.19	114.21	114.24	114.26	114.28	114.30	114.30	114.30
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Oil Cost	$/MWh		84.21	106.10	111.11	112.10	114.15	114.17	114.19	114.21	114.24	114.26	114.28	114.30	114.30	114.30
	$/GJ		23.41	29.50	30.89	31.16	31.73	31.74	31.75	31.75	31.76	31.76	31.77	31.77	31.77	31.77
Electricity																
	sensitivity															
Commodity price/MWh	**0.0%**		**94.75**	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Cost	$/MWh		94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75	94.75
	$/GJ		26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34	26.34
Biomass																
	sensitivity															
Commodity price/MWh	**0.0%**		**51.29**	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29
GST	**0.00%**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass Cost	$/MWh		51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29	51.29
	$/GJ		14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26	14.26
Carbon Offsets	*sensitivity*	2010 value														
Carbon offset/tonne	**0.0%**	**14.00**		14.00	14.74	15.51	16.33	17.18	18.09	19.04	20.04	21.09	22.20	28.68	37.05	47.87