Feasibility Study For a Community Energy System In The Emerald Hills Development Area For The County of Strathcona

Project Report

FINAL

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1 EXECUTIVE SUMMARY

FVB Energy Inc. has prepared this report investigating the concept, costs, and business case for a Community Energy System in the Emerald Hills Area of Sherwood Park, in Strathcona County, Alberta.

A key goal for the County was to find a long-term, local, and sustainable primary fuel source for the system – an "alternative" fuel to fossil fuel.

As part of the study, the Alberta Research Council performed a preliminary investigation into alternative fuel options and found that the most attractive option was to use residential municipal solid wastes (MSW) and local industrial/commercial and institutional wastes (ICI). These types of fuels are used frequently in Asia and Europe to fuel community energy systems, and have been used in Canada for over 20 years. Charlottetown, PEI, has had their community energy system using MSW as fuel since 1983.

The concept developed for this Northeast Community Energy System includes for both a heating and cooling service delivered to multiple customers from a central Energy Centre located just north of Highway 16 and west of Clover Bar Road.

The Energy Centre would consist of a "waste to energy" (W2E) module, which would use the local MSW and ICI fuel to produce heating energy in the form of hot water and chillers to produce chilled water. A set of natural gas fired backup boilers are provided for the necessary redundancy in the heating system.

The hot and chilled water would be piped to customers including the proposed hospital complex, and the majority of the proposed Emerald Hills Urban Village. Additional capacity is provided for future buildings in the area, e.g. schools.

The estimated customer loads are summarized below.

SCENARIO 1 (Baseline)	Heating	Cooling
Floor Area Serviced	250,000 m2	250,000 m2
Peak Demand	17 MW[1]	3,000 Tons
Annual Energy	27,800 MWh	2,132,000 TH

FVB has prepared a business case for delivering the service to the customers, as summarized in the table below.

[1] MW – megawatts, MWh – megawatt hours (heating), TH – tonhours (cooling)

Full Build Out	Heating	Cooling	Combined
Customer Revenue	$2,448,000	$1,343,500	$3,791,500
Operating Expense	$1,919,000	$454,500	$2,373,500
Operating Income	$529,000	$889,000	$1,418,000
Other Net Revenue	$3,231,000	$5,000	$3,236,000
Total Income	$3,760,000	$894,000	$4,653,000
Capital Investment (2007)	$41,224,000	$13,964,000	$55,188,000
Payback	14 yrs	19 yrs	15 yrs
Return on Investment	**8.8%**	**3.7%**	**7.8%**
GHG Reduction (est.)	~34,800 T/yr	~200 T/yr	~35,000 T/yr

The proposed concept would deliver a positive rate of return of 7.8%. It would also generate greenhouse gas reductions of on the order of 35,000 tonnes per year.

The heating service alone provides the most attractive returns. In the Alberta climate, centralized cooling service is challenging due to the limited annual energy consumption.

The project would consume 36,000 tonnes per year of waste currently going to landfill, and displace ~140,000 GJ per year of natural gas that would otherwise be needed by customers to produce heat energy. It would also redirect the future transfer of waste from Riley to the nearby Energy Centre saving transport costs and displacing diesel usage.

The $55.2 million capital investment includes ~$29 million for the W2E module, which could be contracted to a suitable firm offering a complete design/build package using best available technologies.

Without the W2E module, i.e. using natural gas as the primary fuel for the heating service, the project return would drop to 5% and the GHG emission reductions would drop to ~1,000 tonnes per year.

FVB could foresee the project starting out based on natural gas while the planning and approvals for the W2E module is progressed to a point it can be implemented. In this way, the early buildings in the development could be connected in the required timeline.

Because of the favorable results that a CES could provide to Strathcona County in this area of their community, it is recommended that the following key steps be taken.

- Establishing the financial arrangements for the project
  - Evaluate partnership alternatives
  - Evaluate impacts of "up-front" customer connection charges to lower capital required – lowers annual rates to customers.
  - Investigate the grants and loans available from the Green Municipal Investment Fund (GMIF) and other federal and provincial programs.
- Regarding the service to customers:
  - Initiate marketing the service to initial customers
  - Develop proposals for the hospital and Christenson Developments
  - Prepare for temporary energy supplies for "early" customers
- Regarding W2E:
  - Confirm quantity, quality and heating value of residential MSW and ICI streams in the County.
  - Negotiate fuel supplies with ICI providers.
  - Obtain further detail from W2E suppliers, as needed.
  - Develop a communications strategy regarding W2E.
  - Further investigate Alberta Environment approvals for "alternative fuels"
- Develop a detailed implementation schedule, along with key dates and milestones for critical tasks.
- Reconfirm financial feasibility of project based on ownership structure and updated information.
- Understand in detail all regulatory requirements.
- Proceed to design and implementation.

2 INTRODUCTION

2.1 *Acknowledgements*

FVB Energy Inc. acknowledges the cooperation and assistance provided by Strathcona County Utilities personnel including Norm Swonek, Jeff Hutton, Kim Zachow to name a few, plus assistance from numerous developers and stakeholders in the project. In addition, the assistance of the Alberta Research Council (ARC) was essential.

2.2 *General*

Community Energy Systems (CES) supply heat to multiple buildings from central sources. The CES infrastructure is the "platform" of an energy delivery system that uses hot water and/or chilled water as the energy medium. The primary energy source that generates the hot water/chilled water can come from practically any source including renewable fuels, cogeneration, or nearby waste-heat sources. CES connect communities and their buildings to a host of energy, environmental and economic benefits. An opportunity for a community energy system exists in the Emerald Hills area of Strathcona County.

Strathcona County is an urban focal point in central Alberta. As with any modern urban center, local government understands that financial commitments are required to facilitate development and growth. One area that is required to support growth is the ability to meet ongoing and new energy demands. It is worthwhile to consider carefully how best to provide this energy. In particular, it is important to minimize the total life cycle cost and not simply the initial investment.

Furthermore, it is highly desirable for any building owner and tenant to secure a degree of stability in its energy budgets, which is likely to become increasingly challenging. Some form of integration and/or rationalization with a central energy facility serving the energy loads may well serve these objectives.

As used in this report, the term "community energy" denotes either community heating or community cooling or both together.

2.3 *Study Scope*

FVB Energy Inc. was retained by Strathcona County Utilities (County) to investigate the business case for a Community Energy System in and around the proposed Emerald Hills Urban Village Development (EHUV).

The study's overall objectives include:

- Understanding the business case for a community energy system in the Northeast portion of Sherwood Park that would serve the heating and cooling needs of the new proposed hospital, the proposed Emerald Hills Urban Village, and possibly surrounding developments
- Identifying at a high level a fuel resource that is sustainable, local, and can ensure the community energy service will be reliable, stable and cost competitive over the long term
- Establish the community energy system concept as a key strategy for Strathcona County to sustainably meet the needs of it's residents

It is further understood that power generation via steam based cogeneration is not under consideration at this time (nor part of this study).

Following completion of this proposed work, the Utilties would be in a position to market the service to the key "anchor" customers and refine the business case. This marketing step typically involves the development of term sheets and face-to-face negotiations leading to long-term Energy Sales Agreements with each customer (beyond the scope of this study).

2.4 History of Community Energy

The concept of Community Energy (formerly referred to as district heating or district cooling) is not new; history points to the Romans as the earliest users. Piped heating systems were first used by the Romans to heat dwellings as well as baths. In 1880, CES became well established in the northeastern United States. Within a decade it had spread to a number of cities across the United States using steam as the energy transfer medium.

The establishment of many small electric utility companies in the United States to serve the growing demand for electric power gave birth to CES. The exhaust steam produced and normally vented to the atmosphere could be sold to CES consumers. These systems were the earliest successful combined heat and power schemes.

In Canada, the first heating CES was established in 1880 in London, Ontario, and the second system in 1924 to serve a small section of the City of Winnipeg's commercial core. Other Canadian cities served today by steam CES include Toronto, Montreal, Ottawa and Vancouver.

The development of hot water CES was primarily a European concept. Hot water systems are less costly and more efficient than steam systems. This has led to the construction of large CES in Northern and Eastern Europe, China and

Korea. All CES constructed during the last two decades in North America have used hot water. These have included systems in St. Paul, Minnesota, Jamestown, New York and several in Canada.

The first two CES in Canada to use the European concept of hot water were at Le Breton Flats in Ottawa (1981) and at Charlottetown, PEI (1987). A third system was completed in 1992 at Ouje Bougoumou, a Cree village in Northern Quebec. This project uses a boiler fuelled by a combination of wood waste and oil. The City of Revelstoke implemented a hot water CES in 2005 that uses locally available forest residues as the primary fuel source. Two other commercial Canadian hot water CES commenced service in the fall of 1994 in Cornwall, Ontario, and in January of 2003 in Hamilton, Ontario, both using natural gas cogeneration systems. Of course, the County can look to their experience of their first hot water CES project at Centre in the Park.

CES that deliver cooling were developed in the United States in the 1970's and have since spread to Europe and the Middle East. A CES with heating and cooling commenced commercial operation during the fall of 1997 in Windsor, Ontario, using ice for cold thermal storage. Other recently constructed CES with heating and cooling are in Sudbury, Ontario and in Markham, Ontario. District cooling is viable in hot humid climates for a good portion of the year, hence systems have developed primarily in eastern Canada. In western Canada, the climate is less suitable for district cooling and the significant infrastructure required.

In North America, the most common application of CES is in university, military, government and large industrial campuses. There are many thousand such systems, some of which are larger than most of the utility owned systems. Therefore, the technology is mature and well developed.

All of the CES developed in North America recently have started as relatively small systems, and have grown gradually over the years, as proposed in the current study.

3 MARKET FOR COMMUNITY ENERGY

3.1 General

Several industry trends point to a growing Community Energy market. Utility companies that left the Community Energy business are now returning to it. The interest in Community Energy from the electric utility sector is growing rapidly; also from the gas industry, but not as rapidly. When asked about their newfound interest in Community Energy, many utility companies answer by saying that they know that if they do not do it someone else will. They feel that Community Energy would happen and they want to do it. They want to be able to protect their revenue stream from their customers by offering a new, higher valued service. Energy service companies, equipment suppliers, Independent Power Producers (IPP), electric, gas, and oil companies are all in the business of looking for new ways to connect with energy users and their communities. Investment bankers and other financial institutions are paying more attention to CES than ever before because of opportunities to create deals.

3.2 The Service

Strathcona County would offer a Community Energy service to the community in and around EHUV including the proposed adjacent hospital development.

Community heating would be delivered in the form of hot water (Maximum Temperature = 95 °C) from a centralized facility to the various buildings. The buildings would use the hot water to provide for their space heating and domestic hot water needs. Community cooling would be delivered in the form of chilled water (Minimum Temperature = 4 °C) from the same centralized facility to the various buildings. The buildings would use the chilled water to provide for their air conditioning needs.

Currently, the targeted buildings use large natural gas fired boiler plants, located within their buildings, to provide their heating and domestic hot water needs and large electrically driven chiller plants, located within their buildings, and cooling towers, located on their roofs, to meet their cooling needs. These boiler and chiller plants are a large capital investment for the building owner and have to be completely replaced over time. In addition, these boiler and chiller plants require annual operation and maintenance and have dedicated manpower assigned to them. Further, these internal plants require fuel procurement, which can be time consuming and risky. A Community Energy service eliminates the need for these large boiler and chiller plants within the buildings, the annual operation and maintenance costs associated with them, and the labour and management effort assigned to them.

The targeted buildings would be offered Community heating and Community cooling. The majority of the buildings would want both as the majority of the buildings contain all three major elements - boilers, chillers and cooling towers. Their operating staff usually operates and maintains all three items. If they eliminate their boiler plants by taking the Community heating service then they still have to operate and maintain their chiller plants and cooling towers. If they eliminate their chiller plants and cooling towers by taking the Community cooling service, they still have to operate and maintain their boiler plants. By receiving both Community heating and cooling, building owners can eliminate all such activity as it relates to the production of heating and cooling.

A Community Energy service is based on the concept of adding value to the basic elements of production, which are natural gas and electricity. Without a Community Energy service, individual building owners buy the ingredients separately and produce heating and cooling. A Community Energy service moves the customer from concerns and purchases of individual ingredients to the delivery of a completed service. It moves the customer from a product and price position to a service and value position. There is a major movement in the economy that is putting more and more emphasis on customer service and satisfaction. Community Energy is a higher quality service designed to produce the higher levels of satisfaction only achievable by making life easier for its users. Offering a cheaper energy product cannot produce this kind of satisfaction. In addition, the out-sourcing of building management and operations' tasks is a growing trend. Community Energy service is the most complete way to out-source heating and cooling.

For the County, a key goal is to implement a system based on using a local and sustainable primary fuel source (non fossil fuel) to offset natural gas by over 80%. FVB, as part of this study, will be investigating what the primary fuel options are.

If a non fossil fuel is not practical, the use of natural gas fired cogeneration would be another way to improve overall fuel use and efficiencies. A cogenerator produces electric power and with the installation of heat recovery equipment can provide the base heating needs of the CES. There are many examples of CES employing natural gas fired cogeneration systems in Canada. For the County, this would only be considered if no other primary fuel source was practical.

3.3 Entry and Growth Strategy

FVB has reviewed the suitability of the buildings in the EHUV area of Strathcona County for connection to a CES.

The following summarizes the general characteristics of buildings that are most likely to connect to a CES:

- Larger office buildings, multi-unit residential buildings (MURB's) public buildings, schools and hospitals.
- Buildings that currently utilize centralized hydronic-heating systems.
- Buildings that are budgeting for the replacement of their existing boiler plants over the next five years.
- New Buildings that are planned for construction within the next five years.

Based on the EHUV Master Plan provided by the developer, FVB has prepared a preliminary CES system layout located in Appendix 1.

The EHUV project area is primarily high-density residential with some office and commercial developments. The core or targeted area for the CES is the higher density developments making up a large portion of the EHUV area. The far south portion of the EHUV is primarily low-density residential development and this is not part of the base evaluation. FVB will identify the incremental costs and benefits for heating service for this portion separately. Cooling service was never contemplated for this area.

A CES is normally developed over several years. It is important to start a CES with the simplest and lowest risk approach.

The EHUV CES is envisioned to be developed over a multi-year period in concert with the development of the EHUV and surrounding area. The first building connections are slated for the heating season of 2008 (Phase 0), with the remaining phases following based on the developer's build-out schedule.

In Phase 0, a temporary heating plant would be installed in a suitable location relative to the Phase 0 buildings (CASA and MURB MR-4), as the Central Energy Centre will not be ready for the fall of 2008.

Phase 1 would see the establishment of the natural gas fired boiler (peaking/backup) and chiller modules of the Central Energy Centre. The location of the Energy Centre is planned for property on the north side of Highway 16, directly north of the proposed hospital site. The W2E Module of the Energy Centre is anticipated to be ready in late 2010, according to the preliminary schedule.

In total 16 new buildings have been identified and targeted as core customers to the heating and cooling service, plus 3 of which are unidentified to date and listed as "future" connections, e.g. possible schools or commercial development to the west of EHUV. The future connections represent about 20% increased load over the identified buildings to date.

3.4 Competition

In reality, the CES competes directly with each building owner's ability to produce its own space heating and domestic hot water. Because of this uniqueness, it is often more appropriate to identify existing businesses in Strathcona County that would perceive the CES to having a negative impact on them.

Natural Gas Utility - Currently the majority of the targeted buildings use natural gas fired boiler plants to meet their heating needs. The CES would eliminate the use of natural gas (except for example kitchen use, etc.) in buildings that purchase the service. The general limitation of a natural gas company is that they are not in a position to provide a finished product to compete against CES. The only way they could compete would be to cut price. Fortunately, for the CES, natural gas is only one of the components of the overall product. A CES delivers the final product, while the natural gas company only supplies fuel. Hence, a CES is completely compatible with new technologies, new and alternative fuel sources, and hence can become an integral part of a sustainable energy vision.

HVAC Consultants and Contractors - Initially the majority of heating, ventilation and control (HVAC) consultants and contractors would feel that the CES would have a negative impact on their business. By removing the need for boilers and chillers, the CES would eliminate some of the service contracts that the building owners have with these HVAC companies. It would be important for the County to meet with these groups to point out the positive impacts that the CES would have on their businesses, especially in the area of controls and building retrofits.

3.5 Benefits

3.5.1 CES Owner/Operator

By developing a CES in this area the County would:

1. Earn a positive rate of return on its investment (see Section 9 for financial results).

2. Diversify its portfolio of services to include value added energy services, i.e. customer heating and cooling.
3. Establish the central infrastructure or "platform" whereby future input energy sources can be utilized, e.g. waste-heat recovery, hydrogen, and renewable/alternate fuels.
4. Reduce the overall emissions generated in the project area by reducing fossil fuel use, while generating greenhouse gas emissions reductions.
5. Demonstrate leadership in energy efficiency and enhance its corporate citizenship in Strathcona County and for society in general.

3.5.2 CES Customers

By connecting to the CES the building owners will see advantages over producing heating and cooling on-site including:

- Reliable, stable, and cost competitive energy service. A CES enables the potential to use primary fuel sources that are local, renewable, and sustainable. A key goal of the County is to implement an alternative fuel to displace fossil fuels.
- Operation and maintenance costs are minimized and associated risks eliminated. Maintenance contracts and labour assigned to boilers, chillers, and cooling towers can be reassigned to the core business or eliminated altogether.
- Investment in boilers, chillers and cooling towers is eliminated. No longer do building owners have to incorporate boiler stacks and cooling towers into their designs.
- Increased building space as boilers, chillers and cooling towers are removed. This space can be used for more profitable purposes.
- Reduction of environmental risk. By producing heating and cooling on-site building owners are exposing themselves to a certain amount of environmental risk. This risk comes from a number of sources that a Community Energy service can eliminate:
    - On-site storage and use of water treatment chemicals.
    - On-site storage and use of CFC-based refrigerants.
    - Stack emissions from the boiler plant (CO_2 and NO_X).
- Increased reliability and flexibility. Community Energy Systems have a better reliability record than individual heating and cooling systems. CES are designed to a much higher standard than what typical building

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owners could afford to design their individual building systems to (industrial versus commercial). Building owners are currently limited to using natural gas and electricity as a primary component to their heating and cooling production. If these energy sources see significant increases in price, building owners have no choice but to absorb the related costs. CE systems have the flexibility to use other energy sources that are more economical (e.g. waste heat from industrial processes, municipally generated wastes as fuel, or power generation via cogeneration facilities).

- Focus on core business. Currently building owners and managers spend time dealing with heating and cooling issues in their buildings. A significant amount of time is spent on labor related issues and in budget meetings dealing with natural gas and electrical costs or in some cases setting aside funds to replace or retrofit boilers, chillers and cooling towers. A Community heating and cooling service allows the building owners and managers to forget about fuels, boilers, chillers and cooling towers and focus more directly on the core business

3.5.3 The Community of Strathcona County

A CES can offer significant benefits that are difficult to quantify to other groups who are not direct customers of the service. Besides the property or building owners, Strathcona County and society as a whole also could benefit from a CES.

A CES helps reduce capital costs for new or renovated buildings because no boilers are required. A CES helps attract and retain businesses by providing heating/cooling which is economical and stable in price. A CES increases energy security and cost stability because they increase flexibility to use a variety of energy sources, including renewable resources.

A CES development provides jobs and increases opportunities to use local energy and human resources. System development is very labour intensive, requiring labourers, welders, heavy equipment operators and other types of workers. A study prepared for the U.S. Department of Housing and Urban Development (HUD) estimated that 23,400 job-years would be created per $1 billion in CES construction. About 60 percent of the costs of a CES development is labour, and in a large urban area, about 50 percent of the equipment is typically purchased from local equipment suppliers. The result is that about 85 percent of the CES capital investment -- labour and equipment -- is retained within the local economy.

By using local human and energy resources, CES provide added growth as these expenditures multiply through the local, regional and national economies.

Further, if the ultimate goal of implementing local, renewable, and sustainable fuels is achieved, dollars previously invested in purchasing natural gas from multi-national companies will now be invested in the local economy through fuel processing, delivery, and associated infrastructure.

3.5.4 Society

The development of a CES is a response to the need to provide energy into the future in a manner that is consistent with the need to protect our environment. The production of heating and cooling (and possibly electricity) from a centralized facility allows for significant improvements in energy conservation. Energy conservation and the wise use of fuel sources are the most cost effective ways available to us to reduce atmospheric emissions, global warming, and the release of ozone depleting gases. Not only can the quality of life be maintained without a significant increase in the cost of energy, but also the initiative is in line with meeting international protocols. The need for a positive reduction of air emissions is even more pressing now with the growing public awareness and concern with global warming and pollution.

The underlying principles adopted for CES are to provide a cost effective, reliable, efficient and environmentally friendly service which not only benefits the customer, but also the public at large through lower greenhouse gas emissions and other air pollutants in the production of energy.

4 BUILDING OWNER'S STATUS QUO SELF-GENERATION COSTS

4.1 General

The most important element in any Community Energy business is the revenue stream. The revenue stream is the product of the volume and the selling price of the various products being sold by the Community Energy system. The Community Energy system proposed would sell both ***hot water and chilled water service***.

Hot Water – The value of the hot water being sold is based on what it costs the building owners to produce heating and domestic hot water with their existing equipment. This is referred to as the Status Quo Heating Self-Generation Costs. These costs have been estimated and are based on FVB's experience marketing Community Heating to various building owners across North America.

Chilled Water – The value of the chilled water being sold is based on what it costs the building owners to produce cooling with their existing equipment. This is referred to as the Status Quo Cooling Self-Generation Costs. These costs have been estimated and are based on FVB's experience marketing Community Cooling to various building owners across North America.

4.2 Status Quo Heating & Cooling Self-Generation Costs

The cost for building owners to produce heating and cooling on-site does not vary significantly from one region of the country to the other. The only components that do vary are commodity prices like Electricity, Natural Gas and Water. These commodity prices are easily determined and we have utilized the existing commodity prices for Strathcona County.

The revenue stream for centralized heating and cooling has been based on a model that looks at the targeted customers and calculates their status quo costs on an individual basis. The revenue stream is then set by the status quo costs – either at 100% if there are no savings offered or a lesser percentage if savings offered.

Based on FVB's evaluation of each planned building, it's load, expected installed capacity, redundancy needs, etc., an estimate of the heating and cooling self-generation cost was produced.

An overall average (blended) heating and cooling self-generation cost of approximately $88 per MWh and $0.63 per ton-hour, respectively, were estimated for the financial analysis. The table below summarizes the blended self-generation costs.

Table 1: Heating and Cooling Self-Generation Cost Estimates

Self-Gen Costs	Heating	Cooling
Fuel Purchase	$47.60/MWh	$0.10/TH
Equipment	$26.80/MWh	$0.38/TH
Ongoing O&M	$13.60/MWh	$0.15/TH
Totals	**$88/MWh**	**$0.63/TH**

The assumed delivered commodity prices used were $8.74/GJ and $0.105/KWh for natural gas and electricity, respectively. The Alberta natural gas rebate program is still in effect but was not taken into consideration, as the program was extended to qualified district energy systems. If the CES supplies gas based energy, the CES owner will get a rebate to pass on to customers. If the CES supplies alternate fuel based energy, customers will qualify for the same rebate as if they remained on natural gas.

The project revenues have been set at 100% of the self-generation cost values, providing a **0% savings** to the average customer. A sensitivity analysis has been performed on a 5% and 10% savings.

Summary self-generation cost sheets for four customers are included in Appendix 2. These sheets are presented for information only and are typically of insufficient detail to use for customer proposals/negotiations.

During the marketing phase, typically the next step following the study, individual proposals are developed for presentation to the building owner, whereby a rate structure would be developed for each building customer. Typically, the rate structures for both heating and cooling of existing buildings have both a capacity and energy charge associated with it. The capacity charge generally moves with the consumer's price index (CPI) and the energy charge generally moves with the price of the primary fuel used (in the case of hot water) or electricity (in the case of chilled water). Hence, revenues are protected against inflation and commodity prices.

The actual rate structures for each building will be based on the self-generation costs developed, and will be presented to each customer in a formal proposal (not part of this study).

In summary, the marketing phase would typically consist of the following main steps:

1. Develop individual "Building Connection Term Sheets" to establish and agree to the building load, energy and self-generation costs.

2. Develop individual "Energy Service Proposals" to establish the individual rate structure and commercial terms for the Community Energy service.
3. Develop individual "Energy Service Agreements" to finalize the long-term Community Energy service relationship.

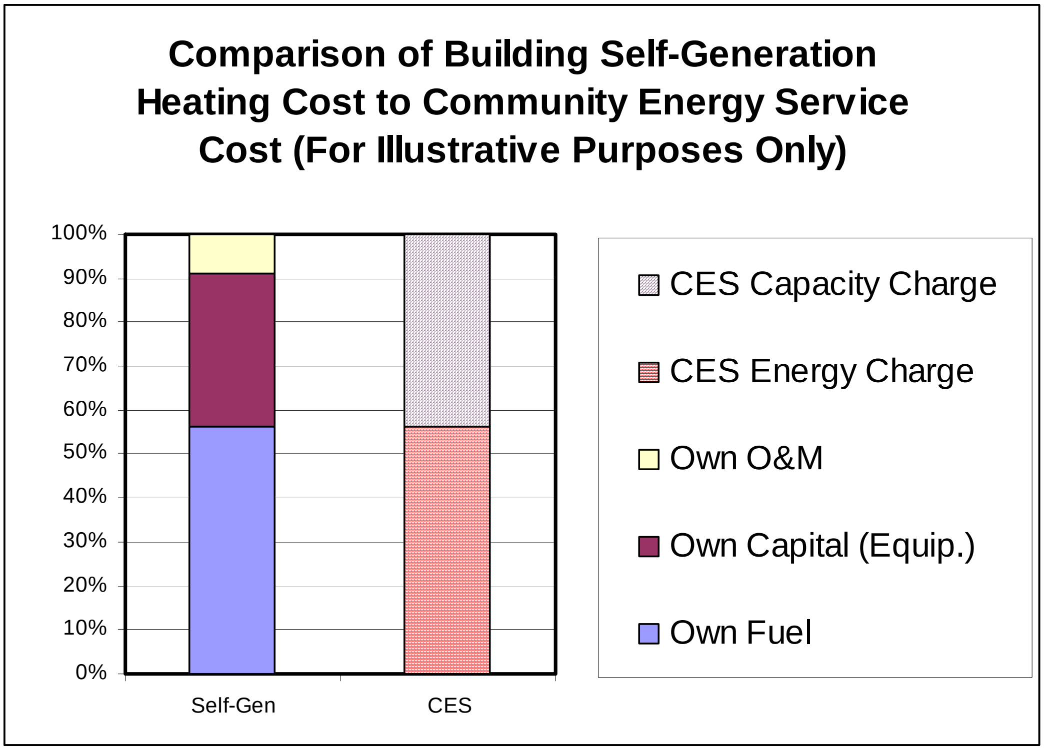
The above steps, in some cases e.g. where there is common ownership and particularly for County owned buildings, may be consolidated for multiple buildings.

The status quo costs for new developments are typically different than for the existing buildings. Since the buildings will be brand new, they will be able to avoid more capital in heating and cooling plants than existing buildings.

Private residential condominium developments can present unique challenges to CES projects during the marketing of the service.

Residential condominium customers are typically only "exposed" to the fuel portion of their overall cost to provide heating or cooling. As discussed previously, the end product of heating and cooling is obtained by converting the fuel into useable (and valued) heating or cooling service. A boiler or furnace does the conversion. The cost of this conversion is the cost to purchase, operate and maintain (O&M) the equipment. In many cases, the residential end-user may not be aware or exposed to this cost, e.g. it may be "hidden" in the condominium fees, charged "upfront", or in some combination. The challenge for a centralized Community Energy service is to ensure the end-user understands their full life-cycle cost to provide their existing level of comfort, and demonstrate how the CE can provide a competitive and better option. The figure below illustrates how the owners should view their own self-generated heating cost.

Figure 1: Illustrative Self-Gen vs. CES Building Cost



In the above illustration, the CES Energy Charge is set equal to the fuel cost typically "seen" by the end-user. The CES Capacity Charge then equals the "hidden" cost to convert the fuel. The CES Energy Charge can then be passed directly on to the end-user while the CES Capacity Charge can be included in the condominium fees, charged upfront (or in some combination of the two) as a fixed charge.

5 ENERGY LOADS

5.1 General

Each buildings' demand and energy requirements are determined. After which the overall system is evaluated in terms of diversification.

For existing buildings, weather conditions, actual annual gas, and electricity consumption for the studied buildings are taken into account and compared with actual performance data from other similar Community heating and cooling systems. The combination of actual performance data, local climatic conditions and actual utility data are used as inputs into our estimating procedures.

Forecasting energy demands for existing buildings relies more on historical data while for new buildings, the proposed design standards become more important.

For EHUV buildings, information gathered from developers at the February 2007 Workshop plus subsequent information gathered from stakeholders provided the basis for the estimated building loads.

Two load scenarios were developed, as follows:

- Scenario 1 is intended to reflect a "most likely" (baseline) arch type with a customer load equivalent to a Model National Energy Code less 25% (minimum Required for LEED Certification).
- Scenario 2 is intended to reflect an "improved" arch type with a customer load equivalent to a Model National Energy Code less 50%.

These Scenarios do not include the southern portion of the EHUV development as the base case. Incremental costs are provided for the heating service only to show the relative high cost to connect this low density area. Cooling service to this area was never contemplated.

5.2 Building Peak Demands

A particular building's peak demand is a very important calculation. The Community heating and cooling system has to be designed to provide enough capacity to deliver each building's peak thermal needs during peak days. To establish an accurate estimate of each building's peak demand requirements three different methods can be used. Obviously the more information that is available regarding each building's systems, the more accurately its peak requirements can be calculated. The three ways to calculate peak demand are:

- Use watts per square meter (load density) estimate based on climatic conditions and experienced values for similar building types. Also available is computer based models, which have to used with caution.
- If available, determine a building's current installed boiler and chiller capacity and how much of it is utilized during peak conditions.
- If available, utilize existing electrical & gas consumption data and equivalent utilization hours.

Combinations of all three methods were utilized to determine the peak demand.

5.3 Load Diversification Factor

A CES would normally have a lower thermal peak demand than the sum of the individual buildings' thermal peaks that are being served. This is mainly because individual buildings reach their respective thermal peaks at different times during the day due to distinct building construction, orientation, location, and building operation. The term to describe the combination of these phenomena is called load diversification. The mix of buildings normally contained within a CES allows for a certain load diversification in sizing the production plant and distribution system.

For the Northeast CES, the diversity for the heating system is estimated to be 85% of the total connected load. The EHUV CES has a high degree of residential customers and hence can be expected to have less diversity than a typical CES in Canada.

The cooling system diversity is estimated to be 90% of the total connected cooling load for all phases.

Load diversification allows the central energy plant and the distribution system mains to be sized for the potentially smaller diversified load as compared to the total connected load. Final plant sizing is influenced by other factors in addition to the load diversification estimate. Our experience shows that sizing according to diversified peaks is sufficient in meeting all buildings' peak needs.

5.4 Building Annual Energy Usage

Another step in the evaluation of the heating and cooling loads for a building or a complex of buildings is to determine the energy utilization over the year and develop the load duration curves. The load duration curves graphically display the relationship between the system demand and the duration time that the demand exists.

Next, the utilization hours are developed. Equivalent utilization hours represent the period of time the system would sustain full load to generate the equivalent amount of energy that is generated over the course of a year. The term is commonly used to compare different heating or cooling alternatives. The utilization hours that have been developed for the proposed CES, from the load duration curves, are one of the critical inputs into determining the actual heating and cooling energy consumption.

The system heating utilization hours for the existing buildings identified were assigned values based on FVB's extensive experience from other Community energy projects. The heating utilization hours range between 1500 and 2200 hours depending on the type of building and its occupancy and usage.

The system cooling utilization hours for the existing buildings identified were assigned values based on FVB's extensive experience from other Community energy projects. The cooling utilization hours range between 500 and 1200 hours. The equivalent utilization hours are used to estimate the building peak cooling loads.

The hospital would be at the high end of the utilization hours range.

The energy usage for new buildings within EHUV is based on assigned full load hours and load densities for different types of buildings from FVB's experience connecting buildings to CES. The resulting energy densities correspond to current design standards (e.g. ASHRAE Standard 90.1 and Model National Energy Code for Buildings) and standard building practices.

5.5 Building Thermal Demand and Energy Summary

The customer load under Scenario 1 is summarized below.

Table 2: Scenario 1 Customer Load Estimate

SCENARIO 1 (Baseline)	Heating	Cooling
Floor Area Serviced	250,000 m2	250,000 m2
Peak Demand	17 MW	3,000 Tons
Annual Energy	27,800 MWh	2,132,000 TH

The incremental load resulting from connecting the southern portion of EHUV to the heating service is 2 MW demand and 3,560 MWh of annual energy.

The customer load under Scenario 2 is summarized below.

Table 3: Scenario 2 Customer Load Estimate

SCENARIO 2 (Improved)	Heating	Cooling
Floor Area Serviced	250,000 m2	250,000 m2
Customer Demand	14 MW	2,100 Tons
Annual Energy	19,600 MWh	1,308,000 TH

The incremental load resulting from connecting the southern portion of EHUV to the heating service is 1.6 MW demand and 2,500 MWh.

Please refer to Appendix 3, for a list of buildings along with their specific peak demands and annual energy estimates.

The heat energy for all studied buildings is normalized for the annual degree-days according to data from Environment Canada.

The estimated seasonal efficiency for each of the existing building boilers is on average 66%, based on a higher heating value of fuel. The seasonal boiler efficiency is defined as the overall efficiency of the boiler over the entire heating season. Boiler efficiency varies as the loading of the boiler varies. According to FVB's extensive experience from converting buildings from individual boiler operation to district heating, the range is between 55 – 75% (HHV), depending on the type and age of the boilers and their operating schedules. This is also consistent with historical boiler efficiency data presented at past International District Energy (IDEA) conferences.

The estimated seasonal coefficient of performance (COP) for the individual building chillers, including auxiliaries, is 3.5 on average (used for determining cooling self-generation costs).

Load duration curves as well as monthly load profiles for the overall system are provided in Appendix 4.

5.6 Building Load Phasing

The anticipated phasing for the customer connections to the CES is entirely dependent on the schedule of construction by the developers. Based on feedback from the developers, FVB has prepared an estimate of the load growth for Scenario 1, provided in the figures below.

Phase 0 corresponds to year 2008 with subsequent phases following year by year.

Figure 2: Heating Load Gowth

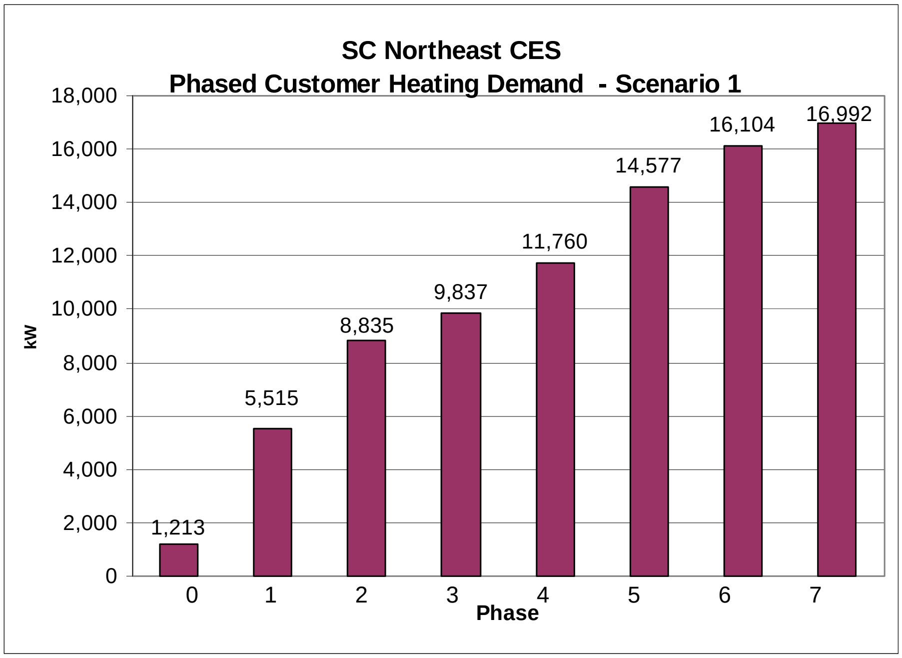
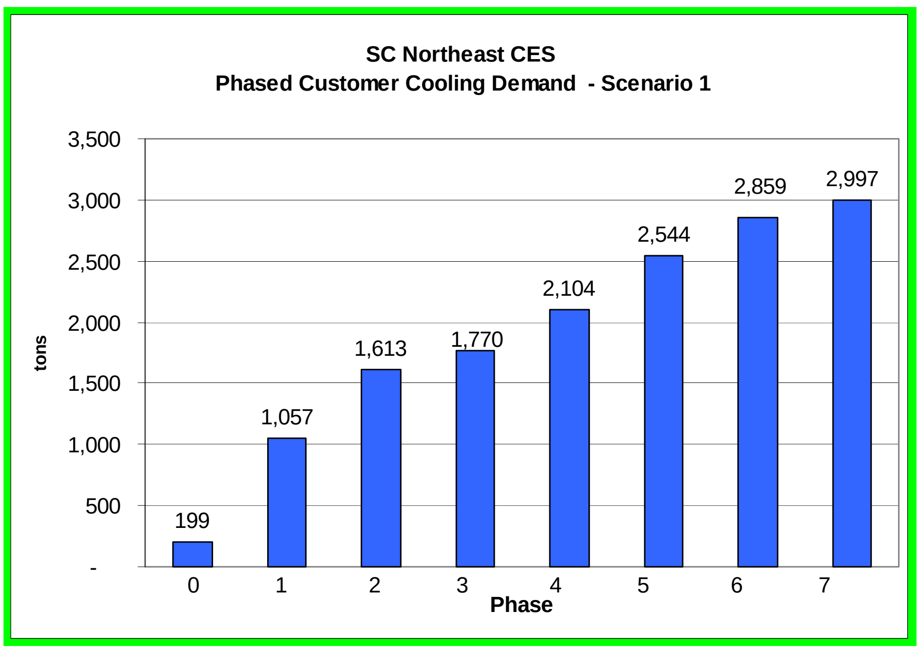


Figure 3: Cooling Load Growth



6 COMMUNITY ENERGY SYSTEM DESCRIPTION

6.1 System Components

A CES has three components:

- Building Interfaces (also called Energy Transfer Stations).
- Distribution System (i.e. pipes connecting buildings to Energy Centers).
- Energy Centers (also called Production Plants).

6.2 Energy Transfer Stations (ETS)

6.2.1 General

The Energy Transfer Station (ETS) is the interface between the CES and the building heating and cooling systems. An ETS consists of heat exchangers, controls, energy meters, valves, and associated equipment and piping.

An ETS can be provided for each building or alternatively provided for a group of buildings, typically where common ownership is in place, e.g. a lot or parcel with multiple buildings. For the Northeast CES, one ETS is provided for each lot, as indicated on the EHUV Master Plan.

There are contemplated a total of 16 ETSs for "targeted" lots plus 3 allocated for future loads.

The energy meter on each ETS continuously meters the building thermal load. The energy meter is made up of a flow meter, two temperature sensors (supply and return) and an energy calculator. This equipment is located on the primary side of the energy transfer station and has the ability to measure the 15 minute peak cooling and heating demand of the building as well as the annual energy consumption over the year.

The selected meters could be connected to the controller for future remote readout capability (from the central energy center control system). The meters specified for this project meet existing Canadian (CSA C900) and international standards (OIML R75 and EN1434) for thermal energy metering.

6.2.2 Building Connections – Heating

The heating ETS for the customers will be designed so that each building can be "indirectly" connected to the main distribution system. This means that each building's internal heating and domestic hot water systems (secondary side) are isolated from the CES distribution system (primary side) by means of a brazed plate heat exchanger(s). The basic ETS would consist of the isolating valves, heat exchanger, actuated control valves, a digital controller, and an energy meter. The controller is used to sense the heat load demanded by the building and satisfies the heating demand by modulating the two-way control valves located on the primary side return of the ETS. This modulating action allows either more or less heat to be made available for transfer to the building's internal heating system.

The CES will supply up to 100°C (212°F) to each building ETS and return 60°C (140°F) hot water during peak periods at a maximum operating pressure of 1,100 kPa (~160psig). The building's internal heating system would draw heat from the ETS and supply water to its internal heating systems at a temperature of 70-80°C (158-176°F) and returning a blended maximum of 55°C (131°F) during peak operating conditions.

The temperatures of the district heating distribution system (primary) will follow a setback schedule (or curve) based on the outdoor ambient temperature. Two key points on the schedule are summarized in the table below.

Table 4: Heating System Temperatures

HEATING	Coldest Winter Days	Summer Time
Supply	Max. 100°C	Max. 70°C
Return	60°C	55°C

The design temperature difference for heating is 40°C (assumes indirect connections).

Community Energy Systems throughout North America are typically designed to deliver 90 to 120°C hot water to targeted customers. This supply temperature is a reality of the heating system designs of the buildings served and existing building systems cannot be changed without major retrofit. Where CES can be applied to solely new buildings, and where these buildings are designed to accept lower temperature supply, then the CES can lower its overall supply and return temperatures. The lower temperature scheme provides the opportunity to consider other forms of lower grade primary energy supply.

6.2.3 Building Connections – Cooling

For the purposes of this study, "indirect" connections have been used for the cooling ETS, however, at the design stage it is recommended to consider "direct" connections, i.e. the building would be connected to the distribution system directly, without a heat exchanger separating the primary from the secondary. Since most of the proposed buildings for cooling connections are low-rise buildings, no problems with static pressure are anticipated. Direct connections provide a cost and space savings and improve the overall system efficiency. Water treatment becomes centralized providing uniform water quality throughout. The existing buildings should be further investigated at the design stage to ensure no possible concerns with a direct connection. If pressure or water treatment concerns are discovered, these buildings will be connected indirectly (via heat exchanger).

During peak operating conditions the Community cooling system (primary side) would supply 4°C (39F) to the ETS and return 14°C (57F) chilled water, at a maximum operating pressure of 1035 kPag, (150 psig). To achieve this temperature increase in the system, the building's internal cooling (secondary side) system should be modified, if required, so that it can utilize a 5.7°C (42F) supply from the ETS and return a minimum of 16°C (61F) during peak operating conditions.

The temperatures of the district cooling distribution system (primary) will follow a setback schedule (or curve) based on the outdoor ambient temperature. Two key points on the schedule are summarized in the table below.

Table 5: Cooling System Temperatures

COOLING	Hottest Summer Day	Non-peak Times
Supply	Min. 4°C	Min. 8°C
Return (indirect connected)	14°C	12°C
Return (direct connected)	16°C	14°C

The design temperature difference for cooling is 10°C for indirect connected customers and 12°C for direct connected customers.

6.2.4 Building Conversion Requirements

As all customer connections will be new buildings, no conversion requirements are necessary. However, it does assume all building mechanical systems are compatible for connection to the CES for the temperatures provided above.

Coordination with building developers will be essential during the design and implementation of the project.

Generalized ETS schematics for the Hospital and for a typical MURB are provided in Appendix 5.

6.3 Distribution Piping System (DPS)

6.3.1 General

The distribution network is the physical link between energy sinks (customers) and sources (plants). The system proposed would consist of a below ground direct buried hot water and chilled water distribution network with supply and return piping in a closed circuit (4-pipe system). Both the heating and cooling piping would generally be installed in the same trench in a parallel configuration.

Where feasible, routing the DPS through interior spaces, typically underground parking structures, will be planned.

FVB has prepared a preliminary distribution-piping concept including: routing, sizing, and material selection to provide Community heating and cooling services to the targeted buildings.

6.3.2 Distribution Network Pipe Routing & Sizing

The objective of the pipe routing and sizing is to minimize capital investment, as typically 25 to 30 percent of the total capital investment in CES is attributed to the distribution-piping network. For the Northeast CES, due to the relatively high load density, limited distribution network and implementation of the W2E module, the portion of the distribution piping investment is only 16 percent of the total CES capital. Without the W2E module it is 32%.

The proposed distribution piping system is based on the main Energy Center being located at the proposed location north of Highway 16, as per direction from the County. The proposed route moves southward to the west of the proposed hospital and then south into the Emerald Hills Urban Village development. The routing within the development has been based on the EHUV Master Plan as provided by the developer.

Much scrutiny of the development plans around the proposed project area and plant site is required before determining final route plans. This will have to be done in close cooperation with the developers, County authorities, and local utility providers.

The pipe sizing for the selected route has been governed by the following four key factors:

- The heating and cooling water supply and return temperature differentials, referred to as ΔT (delta T).
- Maximum allowable fluid velocity.
- Distribution network pressure at the design load conditions.
- Differential pressure requirements to service the most remote customer.

In the case of heating, distribution pipe sizes are based on ΔT of 40°C (72°F) with an allowed flow velocity of up to 2.5 meters per second (8.2 ft/s).

The result of the analysis determined that the maximum size of pipe would be 250 mm (10") nominal diameter for heating and 350 mm (14") for cooling.

The total trench length of pipes to connect the targeted customers is estimated at just under 3,000 trench meters, as summarized in the following table:

Table 6: Distribution Piping System – Scenario 1

	Heating	Cooling
Trench Length	2,965 m	2,965 m
Average Diameter	144 mm	206 mm

To connect the south end of the EHUV development for heating service, an extra 2,270 trench meters of buried pipe at an average diameter of 69 mm is required.

The distribution piping system for Scenario 2 loads is assumed to be the same, as it is assumed that the available capacity would be used in the future for additional load growth.

The installation of the distribution system is assumed to be by excavated trench methods, with both heating and cooling pipes in a "side by side" configuration. A typical cross-section is provided on the layout provided in Appendix #1. Generally, we have assumed an average depth of bury to the top of the pipes of 1200 mm cover. The minimum depth of bury can be as little as 600 mm in low traffic areas. This may vary in reality depending on County burial depth requirements and the location of other utility services.

A single communication conduit (HCPE or PVC) will be installed along with the distribution piping to allow for communication between each building ETS and

Plant controls. If desired, the County could install an additional conduit for its own internal use.

6.3.3 Distribution Piping Material

From the technical point of view, considering the size and capacity of the proposed Community Energy distribution systems, all welded steel piping systems for both heating and cooling are recommended. The piping material can accommodate the required working pressures and flow velocities and provides a watertight solution. Guarantees of uninterrupted supplies can be provided to potential customers with greater confidence than with other materials (e.g. mechanical jointed systems like PVC or ductile iron).

For the heating service, Medium Temperature Hot Water (MTHW) System, European st37.0, DIN 2458 (EN253 Standard) thin walled steel pipe, insulated with PUR insulation, HDPE outer jacket and a built in leak detection system is recommended.

For the cooling service, epoxy coated steel pipe is recommended. The piping used for cooling would be un-insulated since the thermal heat gains/losses from/to the surrounding soil would be expected to be insignificant given the low ground temperatures typical for northern climate zones. There could be some potential for excessive temperature degradation in the smaller (6" and smaller) cooling supply lines during the cooling season, hence at the design stage consideration will be given to insulating these smaller lines.

Once the project moves forward to the execution stage, project specification documents should be developed such that more than one manufacturer's piping system may be considered. It is also possible to use all welded high density polyethylene (HDPE) for cooling, which has benefits as far as heat losses/gains at smaller diameters. Final selection would be made at the design stage.

6.4 Production

6.4.1 General

Production of hot water for the heating system and chilled water for the cooling system will be centralized in a Central Energy Centre.

The primary sources of fuel are to be evaluated as part of this study. The Central Energy Centre concept enables the County to implement fuel switching to ensure price stability, price competitiveness, and meet objectives related to use of local, renewable and sustainable fuels.

Natural gas will be used as a backup and peaking fuel for the hot water production, and grid electricity will be used for chilled water production.

The County has commissioned FVB to evaluate local, sustainable, and non-fossil fuel based sources as the primary energy source for the CES. Natural gas would be used as the peaking and backup fuel supply to the system.

For heating, the following options were evaluated as primary energy sources:

- Solid wood residue fuels (e.g. forestry residues),
- Solid agricultural residue fuels (e.g. cereal straw and dedicated energy crops),
- Municipal solid wastes, including local residential wastes (MSW), and wastes from the industrial, commercial and institutional sectors (ICI).

FVB subcontracted the Alberta Research Council (ARC) to conduct a "Resource Assessment" of the local region to evaluate the above options at a preliminary level and identify the best option by which to base the business case for the CES.

6.4.2 Resource Assessment (Summary of ARC Findings)

The full ARC report is included as a separate insert to this report (Attachment #1).

ARC looked at the region surrounding Strathcona County to determine what the best primary fuel source would be relative to the following criteria:

- Greenhouse gas emission benefits
- Availability and reliability (including storage issues)
- Supply infrastructure and administration
- Proven use as a fuel for energy production
- Delivered cost to the project
- Emissions and disposal costs
- Impacts on plant maintenance
- Impacts on local traffic
- Public acceptability
- Social impacts

The main findings of the Resource Assessment are summarized, as follows:

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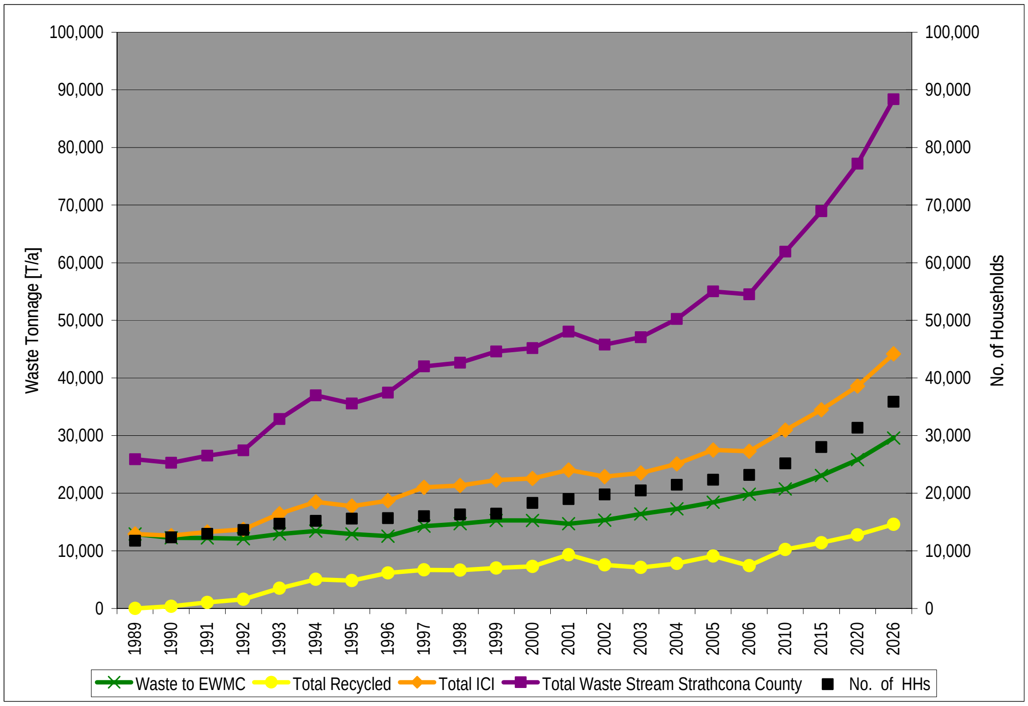
- MSW and ICI offer the greatest Greenhouse gas emission offset credits. They also offer a significant net reduction in greenhouse gas production relative to reduced transport.
- MSW and ICI fuel resource streams offer the greatest predictability and supply reliability as a fuel, followed by straw.
- MSW and ICI provide the greatest opportunity to offset existing costs for waste disposal (MSW) and to charge tipping fees to outside waste generators (ICI), hence this primary fuel source is a net revenue generator.
- Woody residues from forestry operations is very limited in supply, with insufficient amounts relative to the expected need. Densified woody residues (pellets) are very costly and local markets are not well developed.
- Strathcona County has the greatest control over the MSW fuel source in terms of logistics management, cost structure and potentially over quality of fuel.
- Straw is widely available in the region but its supply represents a hard cost to the County and carries with it a logistics management burden.

The following figure represents the actual and forecasted residential MSW and ICI fractions for the County.

Figure 4: Strathcona County Waste Volumes (Source ARC)



In 2006, the County sent just under 20,000 tonnes of residential waste to the Edmonton Waste Management Centre.

The fuel resource availability is summarized in the following table.

Table 7: Resource Assessment Summary

	Volumes Available 2006 Tonnes/year	Expected Price $/Tonne
Woody residues	Not readily available	$60
MSW and ICI residues	20,000 T/y (MSW) 23,000 T/y (ICI)	-$50 to -$100 (a savings or fee)
Straw residues	17,000 T/y in Strathcona County 160,000 T/y in neighbouring counties	$30 to $60

ARC found that these volumes will increase as population and number of households increase. On an annual basis, the volumes are steady for each month. The clear "organic" fraction, such as yard waste, brush and curbside grass and leaves, which is the largest component that varies through the year is not included in the above totals.

A schematic on the MSW and ICI waste streams is provided in Appendix 6 (Source ARC).

The County has relative control over the MSW volumes generated but would have to secure ICI waste via contracts, if these volumes were needed.

Each of the fuel options have been proven as primary fuel supplies in community energy projects around the world. In Canada, biomass to energy is most prevalent, but there are a number of MSW or "waste to energy" (W2E) projects with long histories in Canada, including the Charlottetown PEI district heating system which has been using MSW as a fuel since 1983, the Burnaby W2E project, and the Algonquin Peel W2E project.

Identified concerns and environmental issues related to using MSW for energy production (W2E projects) is addressed in Section 9 and Appendix 14 of this report.

Given the preliminary assessment completed by ARC, the MSW and ICI residues are the recommended primary fuel source for this project and are being used in the CES business case analysis.

6.4.3 Central Energy Center

6.4.3.1 General

The production of hot water for heating service and chilled water for cooling service is planned to come from the installation of three distinct modules, including:

1. Gas Peaking/Backup Module – this module is fired by natural gas and serves as the winter peaking and backup supply for the hot water production.
2. W2E Module – this module is planned to be fired by MSW/ICI and will be the primary source of hot water production for the system. Also known as "waste-to-energy" (W2E).
3. Chilled Water Module – this module will produce the chilled water via electrical centrifugal chillers for the cooling service.

A preliminary block schematic and site layout is provided in Appendix 7.

The development of a central energy centre will follow the build-up of load to be served. As such, it is anticipated the Gas Module and Chilled Water module will be the first components installed.

Due to the expected extended timeline of approvals for the W2E Module, this module will be implemented subsequent to the Gas and Chilled Water Modules.

The Gas and Chilled Water Modules would be housed in a single level enclosed building of steel frame, block wall construction and brick facing or metal clad building, which is suitable for this type of service. The plant building will be approximately 28mx28m with a height of 7.4m. A flue gas emission stack(s) is required and will be approximately 18m above ground.

A stand-alone fit for purpose building is allowed for in the plant costing. Special architectural features are not included. Acquisition of land is not included in the plant costing.

The central Energy Centre will incorporate sufficient capacity to meet the redundancy requirements of the customers. The installed capacity for Scenario 1 is summarized in the following table.

Table 8: Energy Centre Installed Capacity (Full Build-out)

	Heating	Cooling
Peak Demand (div.)	14.5 MW	2,700 Tons
Units Installed	1 x 1 MW Condensing Blr 2 x 7 MW Gas HW Blr 1 x 8.5 MW W2E Blr	2 x 1,350 Ton Chillers 1 x 300 Ton Ambient HEX
Total Installed Capacity	**23.5 MW**	**2,700 Tons (at peak)**
Redundant Capacity	15 MW	1,350 Tons

The above configurations provide for a single fully redundant boiler, equal to the output capacity of the single largest unit installed. This allows the CES to guarantee service for heating in order to safeguard the public during unplanned outages in winter.

A new natural gas service would be needed to provide fuel to all of the natural gas consumers in the plant.

New water and sewer lines would be installed to service the new plant.

Depending on the final site location, a new or upgraded electrical service would need to be installed.

6.4.3.2 Gas Peaking/Backup Module (Hot Water)

The natural gas fired peaking/backup module (GPBM) would produce the required heat energy from two sources:

1. Condensing Boiler.
2. Main hot water boilers.

The hot water design temperatures are 100 °C supply and 60 °C return.

Multiple boilers are provided to ensure sufficient redundant capacity should one boiler fail, and to ensure a high efficiency of operation. A condensing boiler is provided to serve the low summer loads expected. The condensing boiler will be base loaded year round.

The main hot water boilers would be a forced draft water tube style boiler supplied complete with stand alone digital control, low NOx fully modulating burner system complete with exhaust gas analysis. The boilers would only be provided with natural gas fueled burners.

The hot water is circulated from the plant to the building customers subscribing to the heating service. Two distribution pumps located in the plant are used to circulate the hot water throughout the distribution network. Both of the pumps would be capable of variable speed operation. Both units would be sized for 100% of the total capacity.

As the boilers do not generate steam, the water treatment requirements would be limited to water softening, and chemical treatment for corrosion and water quality management.

An energy meter would be used to measure the amount of heat energy exported from the plant.

Control of the boilers, distribution pumps, and associated hot water plant systems would be provided by a single plant microprocessor based control system.

Piping headers and layouts will be designed for future expansion of heating production equipment, including boilers and/or an Alternate Energy Module.

6.4.3.3 Chilled Water Module

The chilled water system would produce the required chilled water cooling energy from packaged mechanical centrifugal chiller.

The chilled water design temperatures are 4°C supply and 14°C return.

Two chillers are installed to provide 50% redundancy to the system should a single chiller failure occur.

The mechanical centrifugal chillers would utilize either R-134a or R-123 as the refrigerant.

Evaporative cooling towers are utilized to provide condenser cooling water to each chiller. The cooling towers would be located on the ground.

An "ambient" cooling heat exchanger of ~300 Tons is included. This system would operate in shoulder seasons when the outdoor air temperature is sufficiently low and there is still cooling demand. The cooling return water (14°C) is essentially cooled to the required temperature via the cooling towers without running the chillers.

The chilled water is circulated from the Energy Centre to the building customers subscribing to the cooling service. Two distribution pumps located in the plant are used to circulate the chilled water throughout the distribution network. The pumps would be sized for 100% of capacity and be capable of variable speed operation.

Water treatment would be required for the chilled water circulated to the cooling customers as well as for the open loop cooling tower water system.

An energy meter located in the return line of the chilled water piping system would measure the amount of cooling energy exported from the plant.

The overall control of the chillers would be accomplished through the common central plant control system.

6.4.3.4 Alternate Energy Module

FVB has investigated methods to convert the recommended primary fuel source (MSW and ICI waste) into usable thermal energy for the CES, also known as a "Waste-to-Energy" facility (W2E).

The methods investigated include

- Mass Burn Technology, including the following types
    - Grate Combustion
    - "Starved Air" Technology
    - Rotary Kiln Technology
    - Refuse Derived Fuel
- Gasification Technology

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- Plasma Arc Technology

The Mass Burn technologies are considered mature commercial technologies, particularly Grate Combustion, while the latter two are considered developmental technologies.

FVB solicited feedback from industry stakeholders to identify suitable technologies and proven suppliers, and appropriate criteria by which to evaluate.

FVB prepared a "request for information" (RFI) to solicit information from potential suppliers. The RFI is included in Appendix 8.

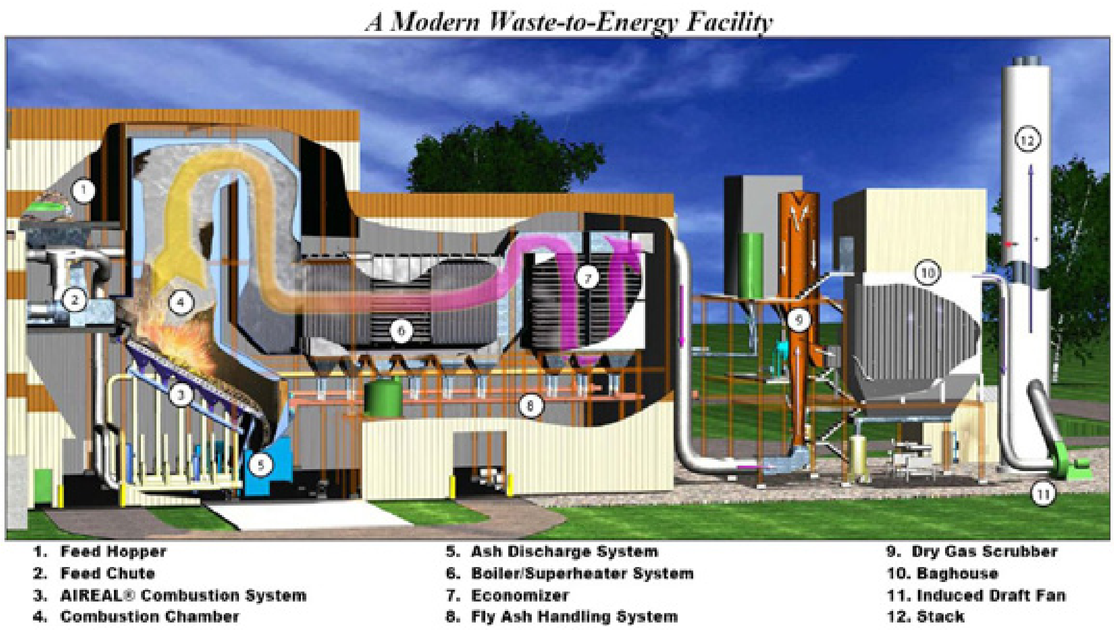
Based on information received and investigations with industry stakeholders, FVB prepared a summary table outlining our findings for a preferred technology and supplier. The summary table is included in Appendix 9.

The W2E module size is dictated by the base heating load of the system at full build out, plus the size availability from suppliers. A challenge for this project is that the size required, on the order of 5-8 MW thermal, is not readily available from suppliers. A more common small size for W2E modules is 8.5-10 MW thermal output or a nominal feed rate of 100 tonnes per day (TPD).

At this time, FVB recommends a Mass Burn Technology using "maximum available control technology" for emissions cleanup. This technology is well-proven, simple in respect of fuel preparation, of small footprint, meets all applicable air emissions requirements/guidelines, has many suppliers, can be implemented at the size scale desired, and is relatively cost competitive.

A representative picture of a W2E concept is provided in the figure below.

Figure 5: Modern Waste to Energy Facility (Source Barlow Projects Inc.)



The W2E Module will consume 100 tonnes per day (100 TPD) on average, producing approximately 8.5 MW of thermal energy in the form of hot water.

The total expected annual fuel requirement is on the order of 36,000 tonnes, if baseloaded. ARC found that the County currently has approximately 20,000 tonnes of MSW and up to 23,000 tonnes of ICI waste available annually for use in a W2E facility. ARC also indicated that these volumes would increase based on forecasted population increases.

This concept relies on straight truck dumping of fuel into the fuel pit with minimal fuel preparation and separating required. As such, it is imperative that oversized, non-combustible, and toxic materials are removed from the fuel at the source of collection. This should be part of an overall Waste Management program within the County to maximize recovery and minimize waste going to the landfill. The fuel operator will be responsible for ensuring proper fuel mix to the combustors.

The resulting amount of truck traffic will depend on the truck size used by the County for collection and hauling. At 5 tonnes per truck, there will be approximately 20 trucks per day coming into the W2E facility. During a 8 hour shift or time period, this represents 2.5 trucks per hour (one every 24 minutes).

The predicted availability of this module is estimated at 90+%. The module will be baseloaded at all times to consume waste. During the summer, heat generated will be greater than heating demand and thus will either be rejected, or in the future it is possible to use this heat for an absorption chiller (to offset electricity).

6.4.3.5 Redundancy for Hospital

Heating service redundancy for the proposed hospital is to be provided via a "fuel oil" fired boiler located at the hospital ETS. The boiler will be sized at 67% of the hospital peak heating demand. This boiler will be owned and operated by the County as part of the ETS.

Inputs for this boiler, such as combustion air, ventilation, electricity, water, and fuel oil will be provided by the Hospital.

Cooling service redundancy for the proposed hospital is to be provided via the central Energy Centre chillers. Two chillers at 50% of the system peak demand is provided, or 2 at 1,350 Tons. The hospital demand in emergency situation is estimated at 50% of the peak hospital demand, or ~350 Tons. Hence, sufficient capacity exists to meet the hospital needs.

6.4.4 Module Contributions to Annual Energy

Based on the estimated peak heating and cooling loads and yearly energy requirements, heat balances were performed to determine the amount of energy supplied by each of the production modules. The results of these calculations are summarized in the table below.

Table 9: Fully Developed System Heat Balance

Production Unit	Annual Energy	% of Annual Energy (%)
Heating:		
Gas Peaking/Backup Module	2,780 MWh	10% maximum
W2E Module	25,020 MWh	85% minimum
Total	27,800 MWh	
Cooling:		
Centrifugal Chillers	1,706,000 TH	80%
"Ambient" Cooling HEX	426,500 TH	20%
Total	2,132,500 TH	

The Alternative Energy Module sizing and thus the contribution to the annual energy need should be optimized during the design stage.

At the same time, a decision should be made as to the viability of using "excess" heat generated from the W2E Module in the summer for absorption cooling. This has the potential to supply half the cooling energy of the centrifugal chillers and thus reducing electricity need significantly.

In addition, it may be viable to use a steam boiler with this module instead of a hot water boiler, which would provide the opportunity to generate power for both internal needs and possibly export. This would be reviewed in detail at the preliminary design stage.

6.4.5 Energy Centre Registration & Staffing

The Energy Centre is a combination of a heating plant and a chilled water plant. Alberta has regulation governing these plants.

The plant will require registration with the Alberta Boiler Safety Association (ABSA) in order to obtain the required provincial approvals to operate to produce thermal energy.

Under the Alberta Safety Codes Act, the regulations affecting the Energy Centre registration and staffing include:

- ABSA Pressure Equipment Safety Regulation (AR 49/2006)
- ABSA Power Engineers Regulation (AR 85/2003)

For the W2E module additional regulations are likely to apply under the Environment Protection and Enhancement Act including:

- Activities Designation Regulation (AR 276/2003 consolidated up to AR 113/2007)
- Waste Control Regulation (AR 192/96 including AR 87/2007)
- Substance Release Regulation (AR 124/93 consolidated up to AR 114/2006)

FVB's interpretation of the staffing requirements for the proposed energy center based on the Alberta Power Engineers Act (Alberta Regulation 85/2003), is that the plant would require a Class 4 operator to act as Chief Engineer and that General Supervision Status would apply. This level of supervision requires that the plant's equipment be inspected a minimum of two times per 24 hr period, with at least 7 hrs elapsed time between the two inspections.

Further, according to the regulation, general supervision may be suspended for up to 96 hours provided that the period is only on weekends and or statutory holidays, the plant is in good working order, and the buildings served by the plant are unoccupied.

However, due to the complexity of the W2E module and amount of equipment required, FVB has currently allowed for 9.5 full time staff, in its financial model for the operation of the plant, which is consistent with similar W2E systems in Canada and Scandanavia. Formal confirmation of this assumption is required.

As part of the plant registration process with ABSA and Alberta Environment, the required number of operating staff and operator qualifications will be formally identified, as a condition of receiving the plant operating permit.

6.4.6 Energy Center – Location

Based on direction provided by the County, FVB performed a preliminary review of the potential sites for the Energy Centre. The two potential sites provided were;

- Directly to the west of the proposed hospital property,
- Directly north of the proposed hospital property and across Highway 16.

The County felt that if the W2E Module was a real possibility then the Energy Centre had to be somewhat distant from both the EHUV and the hospital. The site north of Highway 16 was considered as the best option and forms the basis for the capital cost estimates.

Refer to the layout in Appendix 1 to see the proposed Energy Centre site location and the preliminary site plan in Appendix 7.

The anticipated footprint of the Energy Centre is 1,250 m2. The site footprint is estimated at 13,000 m2 (3.25 acres).

7 COST ESTIMATES – CAPITAL AND ANNUAL OPERATING

7.1 General

FVB has prepared the following preliminary cost estimates based on the concept described in the previous sections.

Cost estimates are provided for both Scenario 1 system loads (baseline case) and for Scenario 2 system loads (improved case).

All costs are provided in 2007 Canadian Dollars.

FVB considers the level of accuracy for these estimates at +20%/-10% on a total project basis given the estimate is based on a concept only (no design).

7.2 Summary of Capital Cost Estimates

The capital cost estimates include the cost of equipment and installation, a standalone plant building, engineering, construction support services, overheads, and owner's contingency.

The estimated capital cost to implement the CES as contemplated is estimated at **$55,188,000**.

Without the W2E Module, the CES capital cost is estimated at $27,093,000, of which $13,129,000 is for the heating service and $13,964,000 is for the cooling service.

The capital cost includes $2,616,000 in contingency funds not including contingency within the W2E module supplier estimate.

The capital cost estimate under Scenario 1 is summarized in the table below.

Table 10: Scenario 1 Capital Cost Estimate

SCENARIO 1 (Baseline)	Heating	Cooling	Total
Energy Transfer Stations	$2,999,000	$1,831,000	$4,830,000
Distribution Piping System	$3,670,000	$5,116,000	$8,786,000
Energy Centre – HW/CW Modules	$5,604,000	$7,017,000	$12,621,000
Energy Centre –	$28,951,000		$28,951,000

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W2E Module			
Totals	**$41,224,000**	**$13,964,000**	**$55,188,000**

Detail of all the capital costing can be found in Appendix 10.

The incremental cost to connect the southern portion of EHUV to the heating service only is estimated at $3,920,000 for the DPS and ETS, plus an incremental $750,000 at the Energy Centre to add capacity. This incremental capital adds an estimated $300,000 in incremental income, resulting in >15 year payback.

The capital cost under Scenario 2 is summarized in the table below.

Table 11: Scenario 2 Capital Cost Estimate

SCENARIO 2 (Improved)	Heating	Cooling	Total
Energy Transfer Stations	$2,213,000	$1,254,000	$3,467,000
Distribution Piping System	$3,303,000	$4,604,000	$7,907,000
Energy Centre – Gas Module	$5,446,000	$6,030,000	$11,476,000
Energy Centre – W2E Module	$28,951,000		$28,951,000
Totals	**$39,913,000**	**$11,888,000**	**$51,801,000**

The estimated capital cost for full build-out for Scenario 2 is slightly less than that for Scenario 1, primarily due to the same size for the W2E Module.

Without the W2E Module, the CES capital cost is estimated at $23,203,000 or 86% of Scenario 1.

7.3 Capital Cost Assumptions

7.3.1 General

- Costs are based on concept only, not on design.
- All costs are Q2 2007 Canadian Dollars

- GST is not included
- Land purchase costs are not included
- Costs for Environmental investigation/remediation not included
- Fees for Environmental permits and regulatory fees not included
- Fees for permits, right-of-ways, easements not included
- Engineering fees assume a single design contract
- 10% Contingency is included in all estimates, unless otherwise stated explicitly
- No allowance provide for owner's development costs including studies, salaries, legal costs, administrative expenses, etc.

The cost of GST has not been included in the estimates of capital for the project. The amount of any GST paid by a CE developer with a commercial GST registration may be netted against any GST collected from customers for service revenues. This would result in a net zero payment of GST on the capital costs. Experience on recent projects in Ontario has shown that all GST paid on capital costs can be exempted and/or recovered.

7.3.2 Energy Transfer Stations

- Costs included for primary side heating and cooling only
- Assumes one ETS per parcel or lot, i.e., multiple buildings within the lot will be responsible for picking HW/CW up from the ETS
- Assumes one energy meter on the primary side of the ETS only – secondary side metering is by others
- Heating and cooling service is "indirect" connected via heat exchangers
- Generally assumes 1 heat exchanger for each of space heating, space cooling, and domestic hot water
- Assumes DHW storage capacity provided on secondary side of ETS (by others)
- At the hospital only, a fuel oil boiler at 67% of peak heating demand will be installed for emergency backup on the primary side of the ETS
- Generally, assumes sufficient space in basement room and within 10 m from outside wall.
- Pricing reflects a combined commercial control system (TA Canada).

- Peak supply temperatures assumed at 100°C for heating and 4°C for cooling.

7.3.3 Distribution Piping

- Assumes four-pipe system for heating and cooling, where noted, in an open-cut trench to a burial depth of maximum 1200mm to top of pipe.
- Heating pipes are pre-insulated steel pipe (EN253)
- Cooling pipes are uninsulated jacketed steel pipe (ASME)
- Assumes directional drilling of each pipe with steel casing under Hwy 16 (each borehole is 170 meters long)
- Assumes reinstatement for open-cut trenches to “as-is” conditions, which for most of the area is to “construction grade” finish.
- Nominal shoring only.
- Costs include material supply, mech. installation and all civil works.
- Price to include for supply and return lines.
- Mechanical and civil costs include allowance for mobilization, specialist subcontractors, bonding and insurance.

7.3.4 Energy Center

The Energy Centre capital costs were developed by utilizing unit costing for the major pieces of equipment. The unit costing is developed from past project costing for similar sized installations. The balance of plant systems cost is then factored from the equipment costs produced.

For the W2E Module, suitable suppliers were contacted to provide specific information and budget level quotes. One response was received at the time of this report and is thus used as the basis for the cost estimates for this module. The supplier response was for a complete “design-build-commission” module, but did not include for the building.

Generally, cost allowances have been made for:

- Provision of general utility services from the property line to the Energy Centre building including water, sewer, natural gas, and electricity.
- Provision in the Gas Peaking/Backup Hot Water module for a small condensing boiler for summer baseload operation, particularly for the early years of operation and prior to implementation of the W2E Module.

- Provision in W2E Module for lifting crane, heat rejection heat exchanger, and unmanned truck weigh scale.
- Provision for Ambient Cooling heat exchanger in Chilled Water module.
- Provision for a small amount of "site improvements", e.g. landscaping once construction is complete.
- Provision for the Energy Centre building consisting of basic steel frame with block wall construction and standard brick facing. No allowance has been made for extensive architectural input. The building cost assumes the following:
    - Gas Peaking/Backup and Chilled Water Modules (one single building)
        - 780 m2 footprint
        - 6.5 m clear height
        - $2,550/m2 building cost allowed ($235/ft2)
    - W2E Module (second building)
        - 470 m2 footprint
        - 20 m height above ground level and 4 m basement below ground level.
        - $3,680/m2 building cost allowed ($340/ft2)
- FVB recognizes the County will attempt to achieve a LEED designation on the Energy Centre, and as such made a general allowance of 10% increase on the building for this effort.

Land costs including for acquisition, easements, or rights-of-way for the Energy Centre site have not been included in the capital cost estimates.

7.4 Summary of Annual Operating Costs

The annual operating cost for the CES has been estimated. For the Gas Peaking/Backup Module and the Chilled Water Module, annual costs are based on previous experience with similar sized projects.

For the W2E Module, annual operating cost estimates are based on supplier information and based on FVB's experience from Charlottetown (PEI) and Scandanavia.

For the Northeast CES, the expected annual operating costs are summarized in the table below.

Table 12: Annual Operating Cost Estimate

SCENARIO 1 (Baseline)	Heating ($/yr)	Cooling ($/yr)
Gas Peaking/Backup Module	$211,000	
Chilled Water Module		$370,000
W2E Module	$1,546,000	
ETS/DPS	$76,000	$77,000
Overall Admin/Mngmt	$86,000	$8,000
Totals	**$1,919,000**	**$455,000**
	$2,374,000	

The W2E Module is the prominent operating cost as would be expected. Without the W2E module, the total system annual operating cost is expected to be $1,923,000, a large portion of which is to purchase natural gas (~60%).

Details of the operating costs are provided in Appendix 11.

Some of the key operating cost assumptions are summarized in the table below.

Table 13: Operating Cost Assumptions

Item	Value
Commodity Prices	Natural Gas: $7.50/GJ market price $8.74/GJ to customers $8.18/GJ to Energy Centre Electricity: $80/MWh blended market price $102/MWh delivered to Energy Centre

	Blended Water and Sewer = $1.15/m3
Staff Needs	Gas HW Module = 1 FTE CW Module = 0.5 FTE W2E Module = 8 FTE plus 1 supervisor
Staff Costs	Class 4 operator rate assumed for average FTE cost at $63,600/yr fully burdened Admin/Mngmt Cost at 15% of total Staff Cost.
Consumables	Natural Gas Use ~ 11,000 GJ/yr Electricity Use ~ 2,300 Mwh/y Water Use ~ 2,000 m3/yr
Equipment Maintenance	Gas HW Module = $3.26/MWh(th) CW Module = $0.012/TH W2E Module = $5.00/MWh(th)
Ash	20% by weight of input $50/tonne to dispose 3% recyclable as recovered steel sold at $60/tonne
Tipping Fee	36,000 tonnes/yr MSW consumed Tipping Fee at $63.78/Tonne (as per County)

No allowance has been provided for annual property tax costs.

8 FINANCIAL ANALYSIS

8.1 General

The summary financial results and associated discussion is presented in this section.

The following financial results are presented:

1. Baseline or Scenario 1 Loads
    a. With W2E Module implemented
    b. Without W2E Module implemented
2. Modified or Scenario 2 Loads

The results are presented in terms of an "unleveraged" return or Return on Investment (ROI). In this case, the project is fully financed internally and no assumptions regarding financing and related costs are included.

Leveraged rates of return or return on equity (ROE) are also presented solely to examine the relative impact on debt financing. ROE is based on certain financial assumptions made by FVB, which must be confirmed by the County.

Next, a sensitivity analysis is presented on key variables.

Detailed proforma analyses for Scenario 1 and 2 are provided in Appendix 12.

8.2 Scenario 1 Results

The financial analysis for the Northeast CES with Scenario 1 loads and with the W2E Module implemented is summarized in the table below.

Table 14: Scenario 1 Result (with W2E Module)

Full Build Out	Heating	Cooling	Combined
Customer Revenue	$2,448,000	$1,343,500	$3,791,500
Operating Expense	$1,919,000	$454,500	$2,373,500
Operating Income	$529,000	$889,000	$1,418,000
Other Net Revenue	$3,231,000	$5,000	$3,236,000
Total Income	$3,760,000	$894,000	$4,653,000
Capital Investment (2007)	$41,224,000	$13,964,000	$55,188,000
Payback	14 yrs	19 yrs	15 yrs
Return on Investment	**8.8%**	**3.7%**	**7.8%**
Est. GHG Reduction	~34,800 T/yr	~200 T/yr	~35,000 T/yr

The results show that the project provides a positive rate of return on investment (ROI) of 7.5%, and generates significant greenhouse gas emission reductions of ~35,000 Tonnes per year.

As anticipated, the heating service alone provides the best result whereas the cooling service is relatively poor due to the low annual energy use.

The customer revenues assume a 0% savings from the customers' own cost to generate both heating and cooling energy (self-generation costs). Some key self-generation cost assumptions include:

- Delivered natural gas cost at $8.74 per GJ (Note, rebates, if still available, are now available in Alberta to CES operators for flow through to customers, so rebates are not a barrier.)
- Delivered electricity cost at $102 per MWh(e)
- Boiler capacity installed is generally two boilers each at 67% of peak demand
- Chiller capacity installed is generally two chillers each at 50% of peak demand

The "other" revenues are significant at 46% of total revenues and are a direct result of investing in the W2E module. The other revenues include:

- Tipping revenue of $2,297,000 for the receipt of 36,020 tonnes MSW at a tipping fee of $63.78 per tonne. These are currently real costs to the County paid to haulers and landfill owners, which would now be invested in the project infrastructure.
- Recyclables (metal) revenue of $64,800 for 1,080 tonnes at $60.00 per tonne.
- Greenhouse Gas Emission (GHG) Reductions generated on the order of 35,000 Tonnes per year CO2eq and sold at average price of $25.00 per tonne. Essentially all of this reduction is generated by the W2E Module primarily by displacing fossil fuels used for heating and transport of MSW, and by displacing MSW going to landfill. The GHG offset factor used is 0.965 kg per tonne, and is relative to a "non gas recovery" landfill. The County waste is planned to go to the Riley landfill, which is a non gas recovery landfill.

The GHG revenue is significant at an estimated $870,000 per year. The value is considered reasonable given the following:

- The W2E Module is anticipated to be installed 2-4 years out when markets for GHG emission reductions will be more certain. Currently markets are considered uncertain.
- Governments (federal and provincial) are actively working on GHG emission reduction programs that include some form of minimum pricing per tonne. In Alberta, as of July 1 2007 the price is $15/tonne.
- A recent report commissioned by Environment Canada and performed by The National Round Table on the Environment and Economy (NRTEE) concluded that for the federal government to meet it's GHG emission reduction targets outlined in it's Clean Air Regulatory Agenda the price per tonne of GHG emission reductions will need to start out (immediately) at $30-60 per tonne and will need to rise to over $150 per tonne by 2020 and over $300 per tonne by 2050. There currently exists much uncertainty to how this market will develop but what appears quite certain is that action is happening and that prices are being set.

In addition, in the operating cost calculations are included "ash disposal" for over 6,000 tonnes per year at $50 per tonne. There is a real possibility that a large portion of this ash could be used as "zero cost" aggregate for low risk applications in landfills, road construction, etc. There are W2E facilities that have approval for ash utilization in this regard. If the County were to obtain approval, then this $300,000 cost item could be reduced dramatically or eliminated altogether.

The sensitivity analysis presented below will address the impact of these items.

The Scenario 1 results without the W2E Module are presented in the table below.

Table 15: Scenario 1 Result (without the W2E Module)

Full Build Out	Heating	Cooling	Combined
Customer Revenue	$2,448,000	$1,343,500	$3,791,500
Operating Expense	$1,469,000	$454,500	$1,923,500
Operating Income	$979,000	$889,000	$1,868,000
Other Income	$19,000	$5,000	$24,000
Total Income	$998,000	$894,000	$1,892,000
Capital Investment (2007)	$13,129,000	$13,964,000	$27,093,000
Phased Payback	17 yrs	19 yrs	18 yrs
Return on Investment	**5.8%**	**3.7%**	**5%**
Est. GHG Reduction	~800 T/yr	~200 T/yr	~1,000 T/yr

Based on the Scenario 1 results, the W2E Module due to it's ability to displace significant natural gas used for heating and displace MSW going to landfill improves the ROI of the project and generates significant more GHG emission reductions. However, to obtain these benefits a significant increase in capital expenditure is required.

8.3 Scenario 2 Results

The Scenario 2 results with the W2E Module implemented is provided below for comparison.

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Table 16: Scenario 2 Result (with W2E Module)

Full Build Out	Combined Heating and Cooling
Customer Revenue	$2,934,000
Operating Expense	$2,297,000
Operating Income	$636,500
Other Income	$3,176,000
Total Income	$3,812,500
Capital Investment (2007)	$51,801,000
Phased Payback	16 yrs
Return on Investment	**6.6%**
Est. GHG Reduction	~32,000 T/yr

The results show that should the identified customers achieve the ability to require less energy, through better design or otherwise, the project proforma is negatively impacted. The project ROI decreases from 7.8% to 6.6%, and the project annual income decreases from $4.65 million to $3.81 million (18% decrease).

8.4 Leveraged Results (Preliminary)

FVB has prepared the following summary of the potential of the project to be "leveraged" through long-term debt financing.

FVB has assumed 80% financing over 20 years at a project interest rate of 5%.

The table below summarizes the results.

Table 17: Leveraged Results (ROE)

	ROI	ROE
Scenario 1:		
Combined Results with W2E	7.8%	13.0%
Combined Results without W2E	5.0%	5.3%
Scenario 2:		
Combined Results with W2E	6.6%	9.7%

The "leveraged" return or return on equity (ROE) is favourable provided the ROI is greater than the rate of interest on the debt. Hence, Scenario 1 with the W2E Module can be leveraged to provide a greater return on the project. The ROE analysis is presented by FVB for information only and the County should confirm financial assumptions internally.

8.5 Financial Sensitivity Analysis

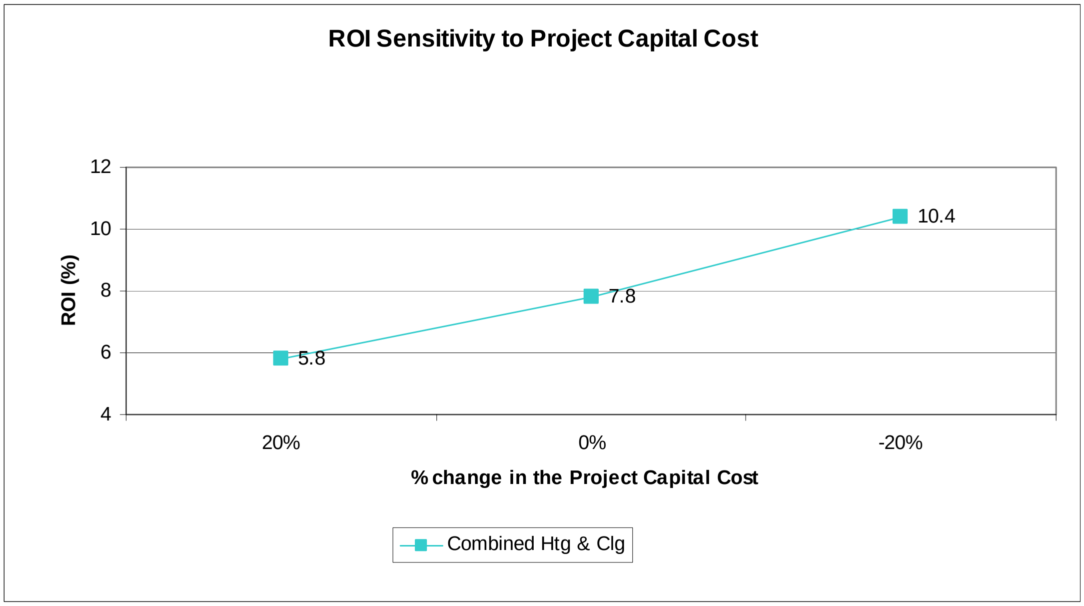
8.5.1 Sensitivity to Capital

A sensitivity analysis on the project return on investment was performed on the capital cost estimates.

The results were evaluated for 20% over and 20% under the estimated capital costs.

The figure below outlines the results for Scenario 1 with the W2E Module.

Figure 6: Sensitivity to Capital



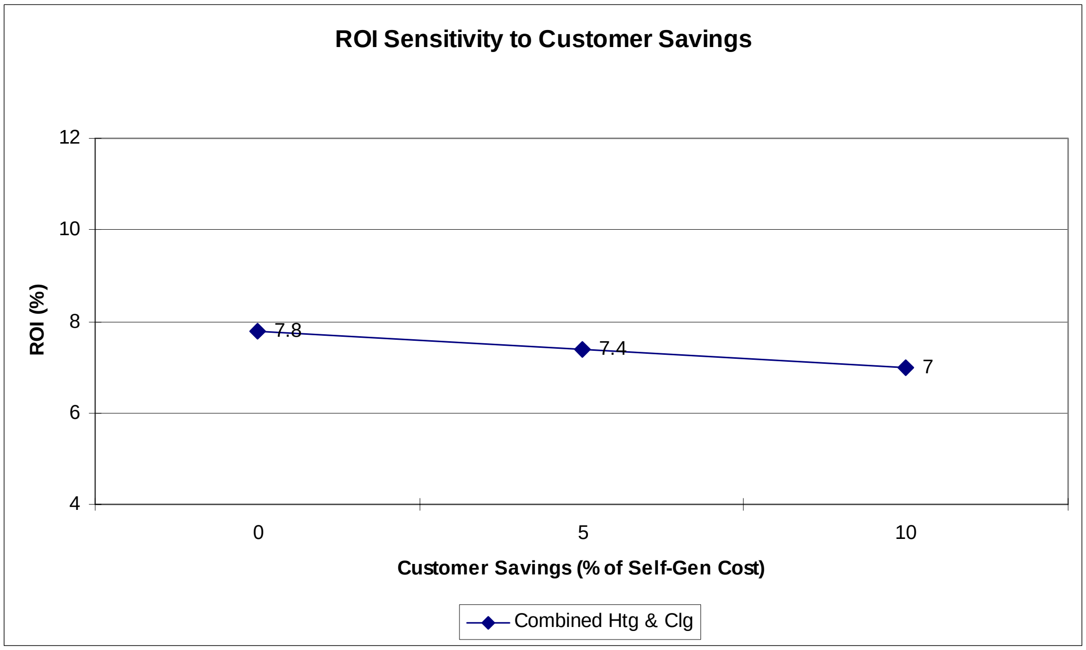
The combined heating and cooling system with the W2E Module achieves an ROI remaining above the 5% level even at an increase of 20% in capital cost.

8.5.2 Sensitivity to Customer Savings

The revenue for CES projects is the key cash flow stream and is made up of heating and chilled water sales. Heating and chilled water sales are a direct result of the calculated building self-generation cost and the allocated customer savings. The base analysis assumes 0% customer savings.

The figure below shows how the ROI is affected by changes in the customer savings offered.

Figure 7: Sensitivity to Customer Savings



Some conclusions from the figure include:

- The project ROI is negatively impacted by increased savings offered to customers.
- The project is not very sensitive to savings offered.

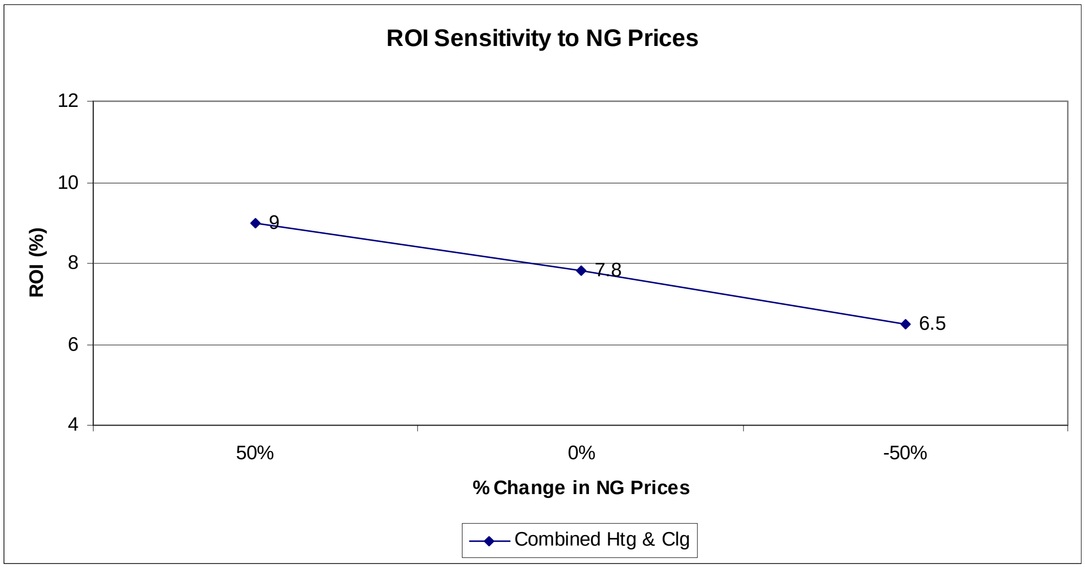
Savings offered to potential customers is typically a negotiating variable when marketing the service, and in this case will not dramatically affect project returns.

8.5.3 Sensitivity to Natural Gas Prices

The figure below shows how the ROI is affected by changes in the market for natural gas prices.

The results were evaluated for 50% over and 50% under the base natural gas market price ($7.50/GJ).

Figure 8: Sensitivity to Natural Gas Prices



Higher natural gas prices help the project due to the customer reliance on natural gas to provide their own "alternative" heating, and the ability of the W2E Module to displace much of the natural gas at the central Energy Centre.

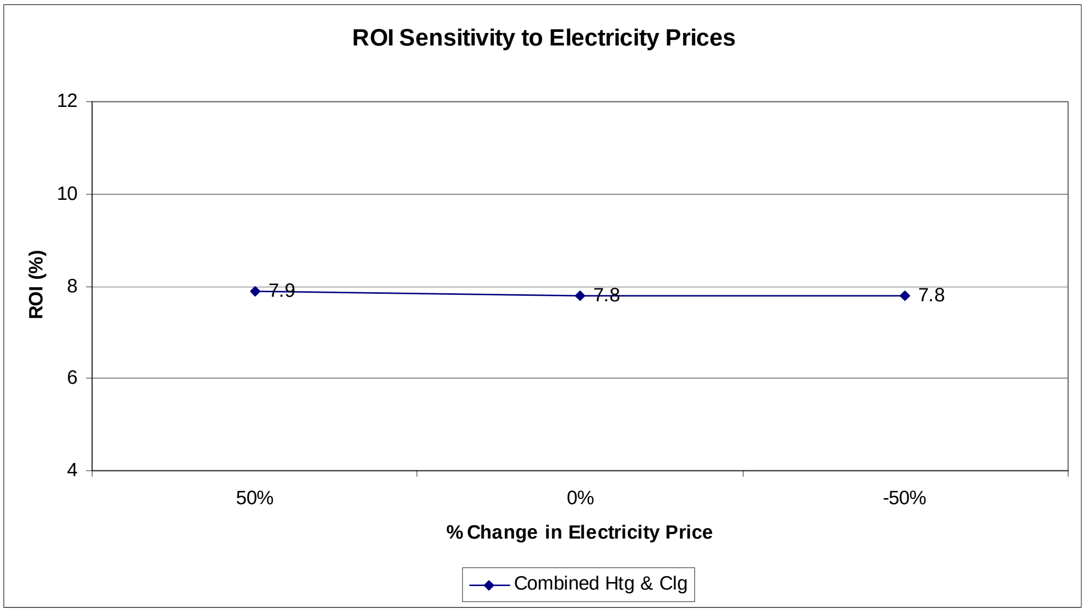
Conversely, lower long-term natural gas prices negatively affect the project return due to the lower revenues and hence less margin to payoff the investment.

8.5.4 Sensitivity to Electricity Prices

The figure below shows how the ROI is affected by changes in the market for electricity prices.

The results were evaluated for 50% over and 50% under the base electricity market price ($80/MWh).

Figure 9: Sensitivity to Electricity Prices



The project is not highly sensitive to electricity prices as it primarily effects the cooling service, and the difference in electricity use from the status quo to the district cooling service is relatively small. For the cooling service only, the effect of 50% increase in electricity price is to improve the cooling service ROI from 3.7% to 4.1%.

8.6 "What If" Analysis

FVB has prepared the following narrative on selected "what if" scenarios. Note, the base project returns are 8.8% for heating, 3.7% for cooling, and 7.8% for the combined service.

What if the project connected the southern portion of EHUV to the heating service?

As discussed earlier, investing to connect the low-density portion of EHUV is challenging from an economic perspective. The incremental cost to connect the southern portion of EHUV to the heating service only is estimated at $3,920,000 for the DPS and ETS, plus an incremental $750,000 at the Energy Centre to add capacity. This incremental capital adds an estimated $300,000 in incremental income, resulting in >15 year payback.

FVB considers this portion a higher capital risk due to the number of connections required.

What if some of the load did not develop as expected (or the overall market penetration of the service was less)?

If the ultimate load connected ended up being 75% that of expected, the ROI for the heating service would decrease to 7% and the overall heating and cooling service combined would decrease to 5.9%.

What if landfill tipping fees and transport costs increased to $100 per tonne?

The ROI for the heating service would increase to 12.4% and the overall heating and cooling service combined would increase to 10.7%.

What if ash disposal costs were eliminated?

The ROI for the heating service would increase to 9.5% and the overall heating and cooling service combined would increase to 8.4%.

What if GHG emission reduction prices do not develop, i.e., there was no revenue stream?

The ROI for the heating service would decrease to 5.9% and the overall heating and cooling service combined would decrease to 5.6%.

What if a 25% capital grant was secured?

The ROI for the heating service would increase to 15% and the overall heating and cooling service combined would increase to 12.9%.

What if the cooling service was restricted to the main hospital only?

As discussed previously, the cooling service as contemplated requires a significant investment (~$14 million) and is detrimental to the economics of the heating service. If the service was restricted to the hospital only, it would be prudent to locate the chiller(s) at the hospital ETS with the proposed backup boiler. The incremental cost to include the chillers (2x350 Tons) would be on the order of $2.5 million to $3.0 million, depending on the services available from the hospital. The estimated cooling self-generation cost for the main hospital is ~$380,000 per year. So, if the hospital provides a location to expand the ETS to include two chillers then the option would be viable and reduce overall capital requirements for the project. How the other customers respond to not having the cooling service will be an issue.

What if the W2E module did not proceed and natural gas fired cogeneration was required?

Natural gas fired cogeneration is a means of improving the efficiency of a natural gas based community energy system, if low cost alternative fuel is not available. For the Northeast CES with a base heating load on the order of 5 MW thermal, a cogeneration capacity on the order of 5 MW(e) would be required. Two 2.5 MW(e) engines would be a concept to consider. The cost would be on the order of $11 million to $13 million. A cogeneration plant would generate on the order of $2 million per year of incremental income at a market heat rate of minimum 10 GJ/MWh. This is definitely a long-term option if the W2E module does not proceed.

9 REGULATORY AND ENVIRONMENTAL ISSUES – PRELIMINARY REVIEW

9.1 Permits and Approvals

Expected approvals required to construct and operate the proposed Community Energy System are as outlined below.

For the Energy Centre (Gas and Chilled Water Modules):

- Strathcona County development permit
- Strathcona County building permit
- Alberta Boiler Safety approval to construct
- Alberta Boiler Safety Plant registration
- Utility services permits – natural gas, electricity, water, sewer

FVB does not anticipate issues with approvals for this module(s), based on previous experience.

For the W2E Module:

- Alberta Environment (AE) environmental approval
- Strathcona County development permit
- Strathcona County building permit
- Alberta Boiler Safety approval to construct
- Alberta Boiler Safety Plant registration
- Utility services permits – natural gas, electricity, water, sewer (if required)

The approvals for a W2E facility are not certain at this time. Discussions with Alberta Environment indicate they are seeing an increase in interest in the concept and they are currently developing a protocol to address "alternative fuels".

For the Distribution System:

- ABSA pipeline design registration as required
- Property easement and crossing approvals as required.

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9.2 General Environmental Issues

The environmental impact of the CES is primarily focused on the benefits of using less fossil fuels to generate the required thermal energy. These benefits are typically associated with air emissions, but other benefits can accrue, e.g. solid waste reductions and/or synergies with other local issues, e.g. landfill usage. For the purpose of this study, environmental impacts of the CES project are focused on air emissions only.

Air emissions resulting from human activities, particularly the burning of fossil fuels, are substantially increasing the atmospheric concentrations of several important environmental stressors[2], summarized as follows:

- Greenhouse gases (GHG), especially carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
- Acid Deposition Precursors (ADP), especially sulphur dioxide (SO_2) and nitrogen oxides (NO_x) – air pollutants that affect whole ecosystems.
- Ground-level Ozone Precursors (GLOP), especially volatile organic compounds (VOC) and nitrogen oxides (NO_x) – air pollutants that affect human health and vegetation.

Typically, centralized heating and cooling plants reduce net emissions of these stressors in the following main ways:

- By improving the net efficiency to deliver the heating and cooling medium resulting in less fossil fuels combusted.
- By utilizing advanced technology, which becomes more cost effective when dealing with one centralized system versus many small systems located in individual buildings. The result is fewer emissions per unit of fuel burned, i.e. a lower emission factor.
- By utilizing alternative primary fuels, e.g. locally available waste fuels that would normally cause other environmental stressors. The result is a net decrease in the amount of fossil fuel consumed to deliver the same energy service.

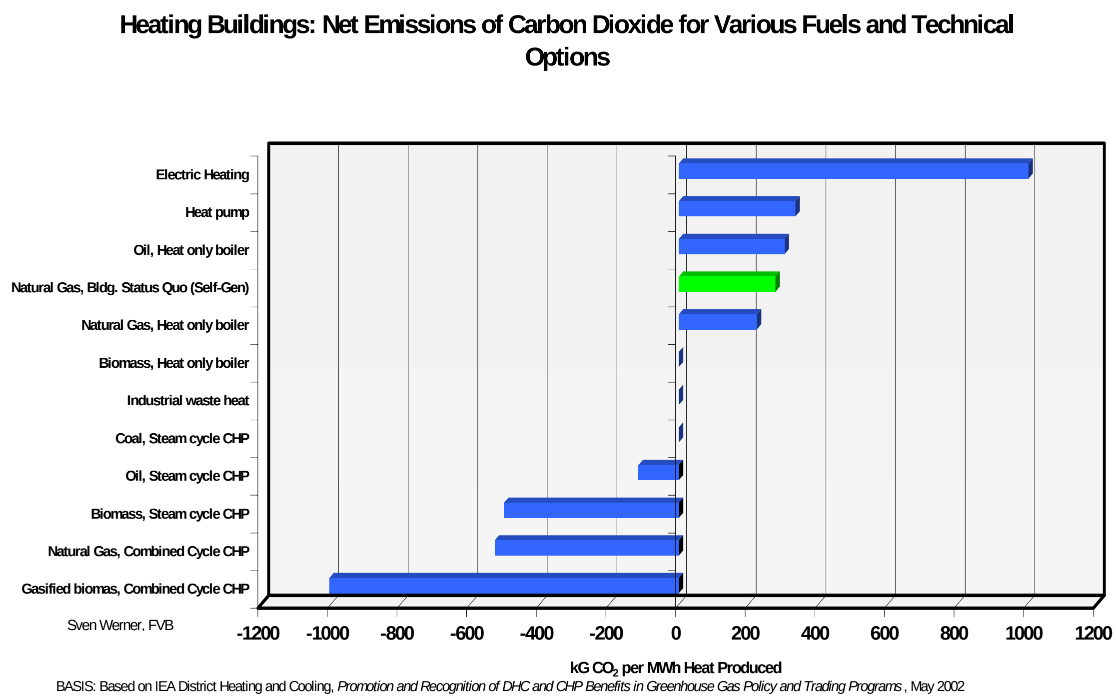
Under the Kyoto Agreement, Canada is committed to a significant reduction in greenhouse gas emissions from a "business as usual" scenario. As one of the Provinces that emits the greatest amount of greenhouses gases, Alberta is expected to come under pressure to take mitigating action. The proposed

[2] Environment Canada website, http://www.ec.gc.ca/air/introduction_e.html, December 18, 2003.

Community Energy project would be one of the most effective ways in which the Client could contribute to this objective.

For illustration purposes, the figure below shows how different fuels and technology systems affect CO_2 (main component of GHG) emissions.

Figure 10 : CO_2 Reduction Options

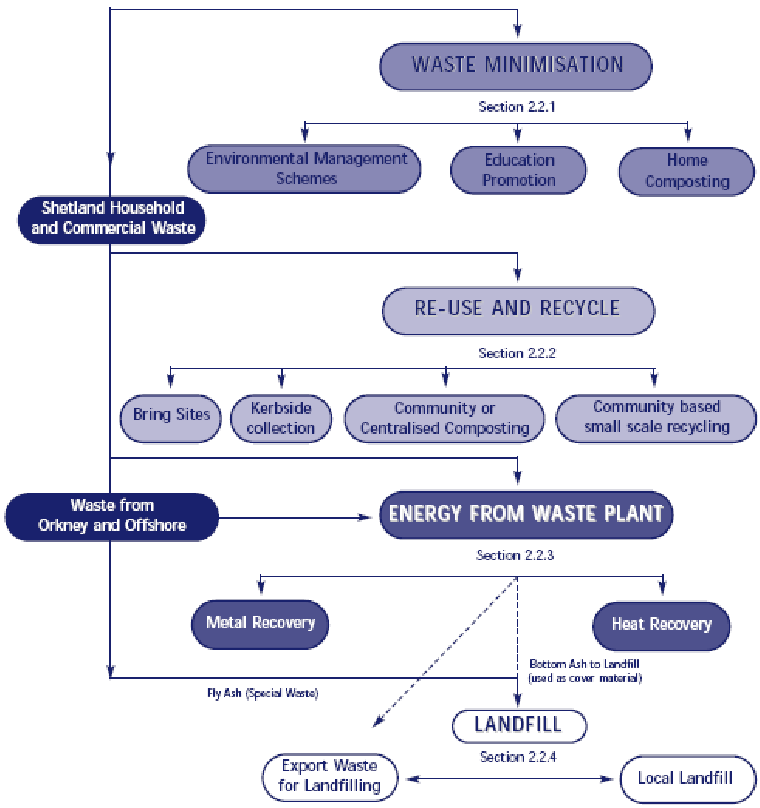


The figure shows how the "status quo" of building boilers matches up against centralized natural gas heating boilers, waste-heat recovery, and CHP. Note how heat pumps (typically used with geothermal), which use a significant amount of electricity can actually increase CO_2 emissions.

9.3 Waste to Energy Issues

Waste to Energy (W2E) facilities are best implemented as part of an overall waste management program. Only after concrete efforts in re-use and recycling into products is it prudent to extract energy out of the remaining waste.

Figure 11: Integration of W2E into a Waste Management System in Shetland, U.K. (Source ARC Report)



W2E facilities do impose environmental burdens and these must be addressed.

There are a number of key issues with respect to W2E and FVB has attempted to summarize these in the following narrative. More detailed explanation and references can be found in Appendix 14.

The following are the key issues discussed:

- Public Perception
- Toxic Pollutants
- Impact on Recycling
- Greenhouse Gas Emissions

9.3.1 Public Perception

- Is highly influenced by the worst examples of irresponsible pollution from waste combustion plants before widespread legal and policy reforms during the late 1980's and 1990's.
- The risks of W2E are involuntarily imposed, and are concentrated in a small area of the population (though it serves the population as a whole).
- Lack of clear philosophy for waste management, and no consistent political buy-in to the waste management hierarchy.
- Industrial facilities are unwelcome and sometimes distrusted in areas outside of industrial parks.
- Confusion due to the complexity of data, the variability of the data (and inconsistency in presenting it), general distrust of "scientific proof", and biased reporting (including the lack of coverage of landfill pollution and abatement practices in W2E, and "loaded phrases" to characterize waste management)
- Odour, noise, and traffic congestion will be a nuisance.
- Release of harmful toxins will make people sick, or give them diseases like cancer and/or birth defects.
- Desire to preserve our environment for future generations (and the perception that W2E is a threat to it)
- Belief that 100% recycling is technically possible and economically feasible (either now, or in the near future).
- W2E is more expensive than other waste management practices and cannot be sustained without creating a "hungry monster" for recycled materials that "sweeten the stock" (make the fuel combust with more energy)

Appendix 14 provides comments intended to correct the perception with realistic data, or provide guidance in addressing public concern with the practice of W2E.

The following bullet points address various arguments made against adopting W2E as a waste management practice. The factual content of the arguments is addressed in detail in Appendix 14. Comments are made here to briefly address the key points.

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9.3.2 Impact on Recycling

- The materials in MSW that contribute the most combustion energy are the kind of materials we ought to be recycling.
    - This is not an impediment to the successful implementation of W2E, as has been proven in Europe where countries with the highest rates of W2E have the highest rates of recycling, and conversely those with the highest landfilling have the lowest recycling.
- Segregation of MSW (i.e. source separation, or collection and separation at a central facility) reduces the viability of W2E because it decreases the combustion energy of the fuel.
    - Generally, source separation will increase the combustion energy of fuel by removing glass, metal and biogenic materials that don't easily combust.
- W2E competes with recycling and composting for material.
    - Recycling is not a competing source for waste. W2E is the next step in waste management after diverting materials for recycling and composting/digestion.
- We can soon recycle or compost all of our MSW, thereby discarding zero waste to W2E or landfill.
    - This is not realistic for the foreseeable lifetime of a W2E facility.
- We can harvest or mine recyclable materials from landfills (now and in the future) but we can't with W2E
    - This is true. This also ignores the fact that we can generate energy right now with W2E. However, there are also costs and emissions to account for in mining practices. It is not clear how effective this will be and what the environmental impact of disturbing old landfill waste will be. This is a tradeoff to consider between the technologies.
- Recycling generates less pollution and consumes less net energy (over the lifecycle of the material) than combustion or landfill.
    - This is true. Recycling and composting or digestion of appropriate materials is certainly a higher priority than W2E or landfill. All levels of government policy should be coordinated to this effect.

- Recycling with landfill is the most economically conservative choice. W2E is cost prohibitive.
  - Recycling works in conjunction with both W2E and landfill. It is cheaper to landfill wastes in Canada (in general, though there are exceptions). However, this is entirely subject to government policy. W2E is not cost prohibitive. There are many examples of facilities that generate a profit even without subsidies.

9.3.3 Greenhouse Gas Emissions

- W2E generates less energy per unit mass and emits more GHGs per unit mass than other forms of energy generation using fossil fuels.
  - This is true. It is also an irrelevant argument for implementing W2E, since fossil fuels are offset by the energy from W2E. If the waste were not combusted, it would still pollute in landfills and fossil fuels would need to be combusted. The latter scenario produces more overall emissions than when W2E is used.
- Recycling emits less GHG per unit mass than W2E.
  - This is true. Recycling and composting/digestion of materials should be a higher priority for diverting materials to reduce GHG emissions. However, the practical issues of available technologies and markets means that W2E still has a role to play in reducing GHGs.
- Landfilling (tipping) emits less GHG per unit mass than W2E.
  - This is not true. When considering the lifecycle emissions for all activities associated with landfill or W2E, there are more emissions per ton of waste when landfilling. The amount depends on the type of landfill. For Riley (the County alternative), where gas collection is not implemented there would be higher GHG emissions.
- Buried plastics are a suitable form of carbon sequestration.
  - This is a difficult argument to accept. Plastics are derived from fossil fuels. Only renewable materials should be considered forms of carbon sequestration. Plastics are also a source of toxic pollution when left in a landfill.
- Emissions from W2E will be a major source of GHGs.

  - This is only the case if we ignore all the associated activities that are necessary in waste management. Overall, W2E is considered a GHG sink, not a source. Even gross GHG emissions from a W2E plant are much less than other anthropogenic ("man-made") sources.

9.3.4 Toxic Pollutants

- W2E generates less energy per unit mass and emits more toxic pollutants per unit mass than other forms of energy generation using fossil fuels.
  - Energy generation is not an appropriate comparison. W2E uses waste energy that would otherwise not be capture. Therefore the matter of toxic emissions is irrelevant as a matter of comparison. The only concern should be the gross emissions and if the level of toxins will be harmful. There is no evidence that W2E will cause harm (though data is limited and more research is called for).
- Recycling and composting are non-polluting.
  - This is not true. There are emissions associated with each activity, however the relative contribution compared to W2E or landfill is less. This is another reason to consider these a higher priority in waste management, though only one aspect of the overall solution to reducing pollution, which should also include the BACT for W2E and landfill.
- Landfills emit fewer toxic pollutants than W2E.
  - Landfills emit different toxic pollutants than W2E. The quantifiable difference to the effect on health is negligible.
- Toxic pollutants from W2E pose a health risk to the population in general and especially to the population near the plant.
  - While the data is limited, this does not appear to be true. Levels of toxins from W2E in the neighborhood of the plant are hardly discernable compared with the background levels already present in the environment.
- W2E technology is not compatible with the pronouncement by the Canadian Council of Ministers of the Environment to virtually eliminate emissions of dioxins and furans .

  - The Ministers tabled a report specifically targeting the W2E sector to meet these "virtually eliminated" targets. Alberta Environment has an implementation plan titled Canada-wide Standards for Dioxins and Furans – Alberta Implementation Plan: Emissions from Waste Incinerators and Coastal Pulp and Paper Boilers (Burning Salt Laden Wood). The report is available from Queen's Printer online.
- W2E is a dangerous source of dioxins and furans.
  - W2E does emit dioxins and furans. The proposed plant emits fewer dioxins and furans than a barrel used to burn yard waste. Levels of dioxins and furans from W2E in the neighborhood of the plant are hardly discernable compared with the background levels already present in the environment.

9.3.5 Conclusions

W2E has a role to play in minimizing pollution directly by diverting materials from landfills and by offsetting fossil fuel combustion. It is one technology in an array of policies and technologies that need to be in place to begin to reduce the quantity of discarded waste.

The specific health effects of W2E are not easy to quantify and even less so when comparing emissions to landfills. However, even conservative estimates do not indicate that W2E is a threat to public health. For instance, a study of a W2E plant located in urban Brooklyn, NY indicated no adverse health effects compared with background pollution from all other sources.

However, if public concern is not abated, a study of the proposal for Strathcona County is necessary to determine the specific risks in this case. Public awareness of local sources of pollution and the perception of harm are the most significant factors against application of W2E.

For a more detailed discussion, including supporting figures, tables and references, refer to Appendix 14.

10 PRELIMINARY IMPLEMENTATION SCHEDULE

The project is anticipated to be developed in concert with the EHUV development and the hospital development. The initial customer is contemplated to require energy service by fall 2008 (as per developer) with full build-out currently estimated by 2015.

A preliminary implementation schedule for the Northeast CES project is provided in Appendix 13.

Generally, implementation involves the following key steps:

1. Customer Marketing
2. Business Ownership Structure and Financing
3. Decision to Proceed (target January 1, 2008)
4. Engineering and Procurement for Phase 0 (Q1 2008)
5. Construction (Q2-Q3 2008)

Each phase of the project is contemplated to have procurement completed during the winter and construction starting in spring. It is anticipated each phase will have separate construction contracts.

11

BUSINESS STRUCTURE OPTIONS

As a first step, Strathcona County should decide what type of ownership and delivery model they would like to pursue. There are a number of options. One extreme is to have a third party Develop/Own/Operate the CES. The other extreme is to have Strathcona County Develop/Own/Operate the CES. In between are a number of different options that provide their own advantages and disadvantages.

Given the capital required of $55 million for the overall heating and cooling project with a W2E module, it may be necessary for Strathcona County to seek out a partner.

The following discussion is some possibilities for the County to consider.

Strathcona County Goes Out for an RFP to Locate a Third Party

A Third Party would be willing to take over the development, ownership and operation of the proposed Community Energy System (CES). The Third Party would enter in to an Energy Services Agreement (ESA) to provide Hot Water (and perhaps chilled water) to each individual building customer. The Third Party would decide how to provide these services in the future to serve both the existing facilities as well as any future buildings. In this type of arrangement, Strathcona County would not be involved in these types of decisions and would become strictly a customer. The ESA would typically guarantee a certain cost for these energy services and their future escalation/reduction would be tied to fuel price increases/decreases. Since the primary fuel for the thermal energy source is a local renewable fuel that would alternatively be combusted as waste, rather than a commodity such as natural gas, thermal price increases can be limited to an agreed index, e.g. CPI.

The advantage to this type of arrangement is that Strathcona County would not have to secure capital and pay for the upfront development costs for the CES. The ESA if negotiated properly could also guarantee that Strathcona County building owners receive competitive rates for its energy services. In addition, the Third party would typically assume all of the risk associated with owning and operating the CES.

The disadvantage is that the Third Party will require quite a high rate of return (15% to 20%) and will be a taxable entity. This means that a significant part of the economic advantage that a CES could deliver would not be realized by Strathcona County because the Third Party would need to retain dollars to create a return for itself and pay taxes. This could also result in the system not getting started if some of the targeted buildings decide not to connect and the after-tax ROE drops below 15%.

Another disadvantage is that the County would lose control over how the CES is developed and what loads it would ultimately service. The private sector constantly changes its business model especially in the energy sector (i.e. look at the changes at Transalta, Epcor, and Enmax in the last three years alone). It is quite common for private sector companies to decide that they want to be in the district energy business and a couple of years later decide that they do not want to be in this business. Municipalities on the other hand have a longer-term horizon and since the ESA's with building owners are quite long (20 years), Strathcona County will ultimately be left the job of running the CES if the private sector company decides to get out.

Recently, some former utility companies with extensive regulated operations in Alberta, have expressed interest in the ownership and operation of CES projects.

Strathcona County Goes Out for an RFP to Partner with a Third Party

In this scenario, Strathcona County would have to allocate capital funds to partner with the Third Party. Strathcona County would be increasing their level of risk but at the same time increase their financial benefits. A large portion of the risk would be mitigated by the fact that the targeted building owners (which include the County) would be purchasing all of the systems output. The Third Party, however, would still require a rate of return and pay taxes on its portion of the investment. The County would have some control over how energy services were provided because of their equity position.

This is currently how Sudbury District Energy operates. The Community of Sudbury not only wanted a third party to own/operate the entire system but also wanted to share in the profits and have some level of control. Sudbury and the Third Party are equal partners in this system. The Third Party are a key equipment supplier to the project.

This could possibly work for the W2E module, provided the supplier was interested.

Strathcona County Goes Out For An RFP to Design/Build the CES

In this scenario, the County would have to allocate capital funds to own the CES. Strathcona County would be increasing their level of risk but at the same time increase the financial benefits. A large portion of the risk would be mitigated by the fact that the targeted building owners (which include the County) would be purchasing all of the systems output.

It is very likely the W2E module would be a Design/Build contract. This would minimize technical risk.

This is currently how a number of CES with cooling are developed in major US cities. The design/build approach helps mitigate the risk associated with construction. There is a premium, however, to be paid for this risk mitigation. Some US systems found the design/build approach to be too expensive and opted for the traditional engineer, procure and construct approach.

Strathcona County Does Not Go Out For An RFP & Pursues Project Internally

In this scenario, Strathcona County would have to allocate capital funds and resources to build, own and operate the CES. Strathcona County would be increasing their level of risk but at the same time increase the financial benefits. A large portion of the risk would be mitigated by the fact that the targeted building owners (which include the County) would be purchasing all of the systems output.

This is currently how Hamilton Community Energy, Markham District Energy and Cornwall District Energy operate. Hamilton & Markham & Cornwall tendered all of the major equipment and the construction contract. Of note however, is that in Ontario it is common to have a municipal utility that can readily take on this role. In Alberta and specifically Strathcona County, no such utility exists and therefore it could be more difficult to execute and manage internally. However, Strathcona County has demonstrated their ability to take on this role successfully in the implementation of the Centre in the Park Community Energy System.

Strathcona County Goes Out For An RFP to Have a Third Party Build/Own/Operate the Hot Water Production Plant

In this scenario, Strathcona County would split the CES into two logical parts. The County would be responsible for the distribution piping and customer connections and the Third Party would be responsible for the hot water production plant. The theory behind this type of arrangement is that the County is normally comfortable with distributing hot water and dealing with the building owners as it is similar in some ways to their existing potable water service. The Third Party on the other hand is normally more comfortable with the production plant and is willing to negotiate an Energy Service Agreement (ESA) to sell the County hot water at the plant gate. Since the Third Party could be headquartered in a different community (like Vancouver, Toronto or Calgary) they will not want to deal with local issues like right of ways or building owners.

The advantage to this type of arrangement is that the Third Party provides some of the capital required for the CES (production plant) and has the expertise to operate it, particularly the W2E module. For example, the supplier of the W2E module could be the Third Party who owns the entire Energy Centre. The disadvantage is that normally the Third Party will demand a higher share of the profit to meet its required rates of return and pay taxes. This means that the County sometimes receives less of the profit (and sometimes none of it) although they have made a capital investment as well.

This is currently how Windsor District Energy operates. The Community of Windsor was not comfortable with owning and operating a production plant and wanted to find a Third Party to do this for them. Windsor runs the distribution and customer connection side through the potable water service as a non-taxable business.

12 CONCLUSIONS AND NEXT STEPS

12.1 Conclusions

The following conclusions have been derived from this study:

- A Community Energy System for both heating and cooling is viable for the EHUV and surrounding area, providing a solid rate of return on investment (ROI=7.8%), while ensuring the community is well positioned for a sustainable future.
- The estimated capital investment required is $55,188,000, which provides for using locally available alternative fuel as the primary fuel source for the system.
- The most attractive primary energy source available that is sustainable, local, and generates GHG emission offsets is Solid Wastes from Municipal, Institutional, Commercial and Industrial sources, i.e. a W2E concept. Municipal Solid Wastes are the preferred fuel choice as the County has control over these streams.
- A W2E module would require on the order of 36,000 tonnes per year of fuel and the County has on the order of 20,000 tonnes per year of MSW available and the local ICI solid waste is on the order of 23,000 tonnes per year. The County would have to contract with ICI providers for ~16,000 tonnes per year of solid waste. The volumes generated are expected to increase as the population in the region increases.
- The W2E module will deliver 8.5 MW of thermal energy representing ~50% of the peak demand. It will be baseloaded and will deliver over 85% of the annual heating energy, displacing 140,000 GJ per year of natural gas.
- The W2E module is estimated to generate on the order of 35,000 tonnes per year of GHG emission reductions, via displaced natural gas, displaced transport of MSW, and reduced landfill emissions. Without the W2E module, the GHG emission reductions are on the order of 1,000 tonnes per year.
- Without the W2E module, the CES still provides a positive return (ROI=5%) although not as high and it does not generate nearly the same GHG emission reductions.
- The cooling service is not as financially attractive (ROI=3.7%) as the heating service (ROI=8.8%) due to the relatively low annual cooling energy and the high cost to provide this service.

- Service to the south end of the EHUV development, i.e. the low density parcels, is not recommended due to the high relative capital cost and complexity to connect and the low revenue potential.
- The project investments will be phased to match the building developments as much as possible. Five phases are proposed for the Northeast CES beginning in 2008 (Phase 0) and ending in 2015 (Phase.
- Phase 0 of the project is to deliver service to the first CDL MURB and to the CASA building of Capital Health. The heating service is expected for the fall 2008, while the cooling service is expected for the summer 2009.

12.2 Next Steps

Because of the favorable results that a CES could provide to Strathcona County in this area of their community, it is recommended that the following key steps be taken.

- Establishing the financial arrangements for the project
    - Evaluate partnership alternatives
    - Evaluate impacts of "up-front" customer connection charges to lower capital required – lowers annual rates to customers.
    - Investigate the grants and loans available from the Green Municipal Investment Fund (GMIF) and other federal and provincial programs.
- Regarding the service to customers:
    - Initiate marketing the service to initial customers
    - Develop proposals for the hospital and Christenson Developments
    - Prepare for temporary energy supplies for "early" customers
- Regarding W2E:
    - Confirm quantity, quality and heating value of residential MSW and ICI streams in the County.
    - Negotiate fuel supplies with ICI providers.
    - Obtain further detail from W2E suppliers, as needed.
    - Develop a communications strategy regarding W2E.
    - Further investigate Alberta Environment approvals for "alternative fuels"

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- Develop a detailed implementation schedule, along with key dates and milestones for critical tasks.
- Reconfirm financial feasibility of project based on ownership structure and updated information.
- Understand in detail all regulatory requirements.
- Proceed to design and implementation.

END

APPENDIX 1: OVERALL SYSTEM MAP AND BUILDING LIST

CES Layout

Trench Cross-Section - Heating and Cooling

APPENDIX 2: CUSTOMER SELF-GENERATION COST PROFILES

APPENDIX 3: CUSTOMER LOAD ESTIMATES

Scenario 1

Scenario 2

APPENDIX 4: LOAD DURATION CURVES AND MONTHLY PROFILES

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APPENDIX 5: ETS SCHEMATICS

APPENDIX 6: MSW AND ICI SCHEMATIC (ARC)

APPENDIX 7: ENERGY CENTRE SCHEMATIC AND SITE LAYOUT

APPENDIX 8: W2E REQUEST FOR INFORMATION PACKAGE

APPENDIX 9: W2E TECHNOLOGY ASSESSMENT SUMMARY

APPENDIX 10: CAPITAL COST SUMMARIES

Scenario 1

Scenario 2

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Scenario 1 Capital Costs

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Scenario 2 Capital Costs

APPENDIX 11: OPERATING COST SUMMARIES

APPENDIX 12: FINANCIAL PROFORMA SUMMARIES

Scenario 1

Scenario 2

Scenario 1 Proforma

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Scenario 2 Proforma

APPENDIX 13: PRELIMINARY PROJECT SCHEDULE

APPENDIX 14: FURTHER DISCUSSION ON W2E

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*** END OF DOCUMENT, ATTACHMENTS TO FOLLOW ***

Resource Assessment for Strathcona County

Report

Prepared by the

Alberta Research Council

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Edmonton, July 2007

1. Introduction

This study is part of a greater feasibility study conducted by FVB Energy for Strathcona County (SC). SC's objectives include:

- Understanding the business case for a community energy system in the Northeast portion of Sherwood Park serving the heating and cooling needs of a new proposed hospital, the proposed Emerald Hills Urban Village, and possibly surrounding developments.

FVB Energy has engaged the Alberta Research Council to assist in identifying sustainable and local fuel resources and in making recommendations about preferred resource supply options. ARC's task was to review and identify the most promising, renewable, and available fuel resources for this project. The following options were considered:

- Solid wood residue fuels including densification options,
- Solid agricultural residues, in this case cereal straw and dedicated energy crops,
- Municipal solid wastes, including residential wastes and wastes from the industrial, commercial and institutional sector (ICI).

Each resource option is confirmed, presented, and assessed for implementation in SC. Criteria for further assessment were developed and each resource option is reviewed against these criteria. The strengths, weaknesses, opportunities and threats of each resource option are then prepared in a SWOT table, which is then followed by an economical resource assessment. For each resource option three case studies for district heating projects are presented. Last but not least a summary including recommendations for the Emerald Hills Urban Village in SC is prepared.

2. Resource Options - Narratives and Concepts

Fuel resource options are presented including their initial assessment as a potential energy source for the Emerald Hills District Heating system.

2.1. Forestry Residues

Historically, wood waste presented a major disposal issue but is now saw mill yard residues are burned on-site for heat and power generation. Logging and harvesting residues still remain largely unutilized but transporting logging residues is economically not feasible and they are left in the forest to decompose gradually or get piled and burned operationally. There are no active forestry operations in and around SC so any viable option utilizing raw forestry residues is unlikely.

Haul distances and high transportation cost suggest that one of the following densification options is needed to allow any considerable amount of forestry feedstocks to be used for heat generation in SC.

2.1.1. Densification Option A: Pelletization

Pelletization is a relatively low cost densification technology that compresses sawmill wastes including planer shavings and sawdust into small, uniform pellets that can be readily transported, stored and distributed to markets worldwide. Wood pellets burn cleanly with very low emissions and very low ash content and at a cost lower than that of conventional heat energy sources including natural gas and heating oil.

Raw wood material costs are less than $10 per MT and capital and operation costs are very low (approximately $30 per MT) resulting in a low cost product that is competitive in export markets including the Netherlands, Sweden and Denmark where energy policies and subsidized biofuel market structures make exporting wood pellets a viable business model for Canadian producers.

Local wood pellet markets continue to grow primarily in the small scale residential markets as packaging and distribution channels are being established, as awareness grows about fuel savings and as combustion technology and as a domestic pellet stove manufacturing and distribution sector becomes established.

As demand for wood pellets grows both domestically and internationally and as inexpensive sawmill waste supply opportunities disappear, it is anticipated that new wood biomass supplies will be exploited soon. Pacific Bioenergy intends utilizing Mountain Pine Beetle (MPB) kill. As this standing beetle killed timber ages, its utility as a feedstock for lumber and pulp production diminishes but still retains value as a biofuel where it can be harvested, ground and pelletized. Additional harvesting and transportation costs make this feedstock more expensive to procure and process (approximately $60 per MT) but there still remains a satisfactory profit margin. It is anticipated that this application will also lead to opportunities processing fire killed timber, and other unmerchantable species or forest stands on impoverished soils.

There are presently 23 pellet manufacturing plants in Canada with more under construction producing over 1 million MTs of pellets annually primarily for export. 750,000 MT of pellets are produced in British Columbia alone. Almost half a million tonnes are shipped annually to European electrical utility plants. British Columbia producers expect to be producing 3 million MT within 5 years.

The option of purchasing wood pellets for the SC facility at a market price is available and will remain so in the coming years. However it could become a quite costly option with the nearest pellet manufacturer located over 200 km away in Slave Lave (Vanderwell Contractors (1971) Ltd.) and because of an upward pressure on wood pellet prices from the European and local residential markets.

2.1.2. Densification Option B: Bio-oil

In the mid-future, other densification options may become viable. Bio-oil is a free-flowing dark brown liquid with a pungent, smoky odour containing several hundred chemicals. It is produced via pyrolytic heating of a prepared biomass feedstock to 450 – 500^{o}C for less than two seconds in a fluidized bed reactor. The material decomposes to a combination of solid char, gas, vapours and aerosols. Rapid quenching and condensation prevents chemical cracking of the components producing a liquid called bio-oil. Bio-oil contains water (20-25%), pyrolitic lignin (25-30%), organic acids (5-12%), hydrocarbons (5-10%), anhydrosugars (5-10%) and other oxygenated compounds (10-25%). Any biomass feedstock can be used such as wood or bark, straw or sludges.

Feedstock preparation involves shredding or grinding and drying the feedstock to < 10% moisture. Wood-derived feedstocks yield 70% bio-oil, 15% char and 15% non-condensable, medium-calorific gas on a mass basis. On a volumetric basis, bio-oil has 55% of the energy content of diesel oil. Pyrolysis conversion consumes 5% of the calorific content of the biomass feedstock. Most applications utilize the char and non-condensable gases as a heat source for drying feedstock. Some small scale mobile bio-oil systems utilize the non-condensable gases for electrical generation. With 55% of the energy density of diesel oil, feed rates must be doubled to maintain equivalent energy output. Poor ignition characteristics of the fuel, has led Canadian government combustion researchers to collaborate with Dynamotive, a bio-oil technology company, in developing a new burner nozzle that improves the atomization and spray characteristics of the fuel, promoting more complete combustion. Over time and at higher temperatures, bio-oil is subject to polymerization resulting in increasing viscosity. Research is ongoing to extend bio-oil viscosity stability to a 12 month storage period. Bio-oil produces no SOx emissions and its higher water content assists in reducing viscosity and NOx emissions, which are generally less than half those produced by diesel oil. On first generation gas turbine combustion systems, CO and particulate emissions have been found to be higher on bio-oil than with diesel.

Dynamotive claims that near-future life-cycle electricity generation costs could be in the 6c/kWh range, for a 30 MW combined cycle installation and a biomass feedstock cost of $5-6/MT. As cheap sources of wood biomass such as sawmill waste become utilized for various biomass to energy processes, bio-oil has the advantage of being able to densify forestry biomass at remote locations for cost efficient transportation energy generation facilities. Bio-oil has a higher energy density than wood pellets resulting in lower shipping costs. Bio-oil utilizes a wider spectrum of heterogenous forestry wastes including slash which includes branches, bark, sawdust, needles and non-merchantable or undersized trees. An undeveloped market for bio-oil and difficulties in shipping bio-oil liquids to distant overseas markets means bio-oil is best suited for local and regional applications. Finnish bio-energy researchers see huge potential for using bio-oil in future retrofits to existing oil and diesel-fired boilers and power plants in the 0.1 – 10 MW range. In their view, the primary technical issue to be overcome is polymerization of stored fuel, but variability in fuel, depending on feedstock, also needs to be addressed to produce fuels with standard combustion characteristics.

2.2. Solid Agricultural Residues

2.2.1. Cereal Straw

The prairies are major potential suppliers of wheat and barley straw. Estimates of potential straw production depend on average grain production and straw to grain ratios. Straw to grain ratios range from 1 to 1.4 for barley, and 1.3 to 3.1 for wheat. Both grain and straw production factors depend on soil type and weather. Some is required for soil conservation and cattle use. NRCan (2004) estimates that an average of 35 million MT per year of wheat and barley straw are produced in the prairie provinces. A limited amount of straw is traded on the market, primarily for industrial use, and animal feed and bedding. The straw price varies widely with supply and demand and location. For example, in 2004 prices ranged from $23 to $47 per MT. NRCan (2004) estimates straw prices ranging from $38 per MT (which would cover collection, loading, transport, and nutrient replacement costs) to approximately $52 per MT once a profit margin is added. Current straw prices as of March 2007 are still within the same $20 to $47 range FOB farm gate.

Our estimate of cereal straw availability in the County of Strathcona is based on a study conducted by Alberta Agriculture (Spiess, 2005). Over the 18-year observation period, total straw production varied from over 41,000 MT to a maximum of almost 63,000 MT (Table 1). With 18-year average net straw density of over 13 MT per sq. km and after subtracting straw needed for soil conservation and cattle an average of over 17,000 net straw MT were estimated to be available for industrial use; annual variation due to weather would account for approximately 10% or $\pm$2,000 MT. In case of straw shortage during unproductive years, adjacent counties produce almost 150,000 MT of surplus straw annually (Table 1). The County of Sturgeon, just north of SC (see Figure 1), is the primary candidate for potential straw imports due to the highest production density at 28 MT/km^2 and greatest amount of annual surplus straw at over 64,000 MT/year.

Table 1. Total straw production and estimated net straw availability (1985-2001). Adapted from Spiess (2005).

County	Total straw production (T/a)		Net straw	
	Minimum	Average	Density (T/km2)	Available (T/a)
Strathcona	41,762	62,719	13.3	17,571
Lamont	119,675	175,324	10.3	25,954
Beaver	161,026	242,877	2.8	10,242
Camrose	165,252	251,739	3.3	12,159
Leduc	84,037	126,096	10.0	27,402
Parkland	23,446	40,164	1.8	5,027
Sturgeon	156,195	227,513	28.6	64,473
Thorhild	34,445	61,239	8.4	17,004

Locally produced cereal straws would cover any long-term need in additional feedstock. Given the large volumes available, the cost of straw would not be overly affected by potentially rapid development of competitive uses, such as bio-composites or other bio-heat opportunities. Cereal straw is inexpensive locally produced biomass, which is both available in a large amount and suitable for generation of heat. Air dried straw has heating value of over 15,000kJ/kg with a moisture content of 10% which is only 13% lower than that of wood. There are simple systems designed for burning whole bales. They are less efficient than gasification but are lower cost and well suited to heating where there is good access to bales but not pellets.

MAP 2 CARTE 2

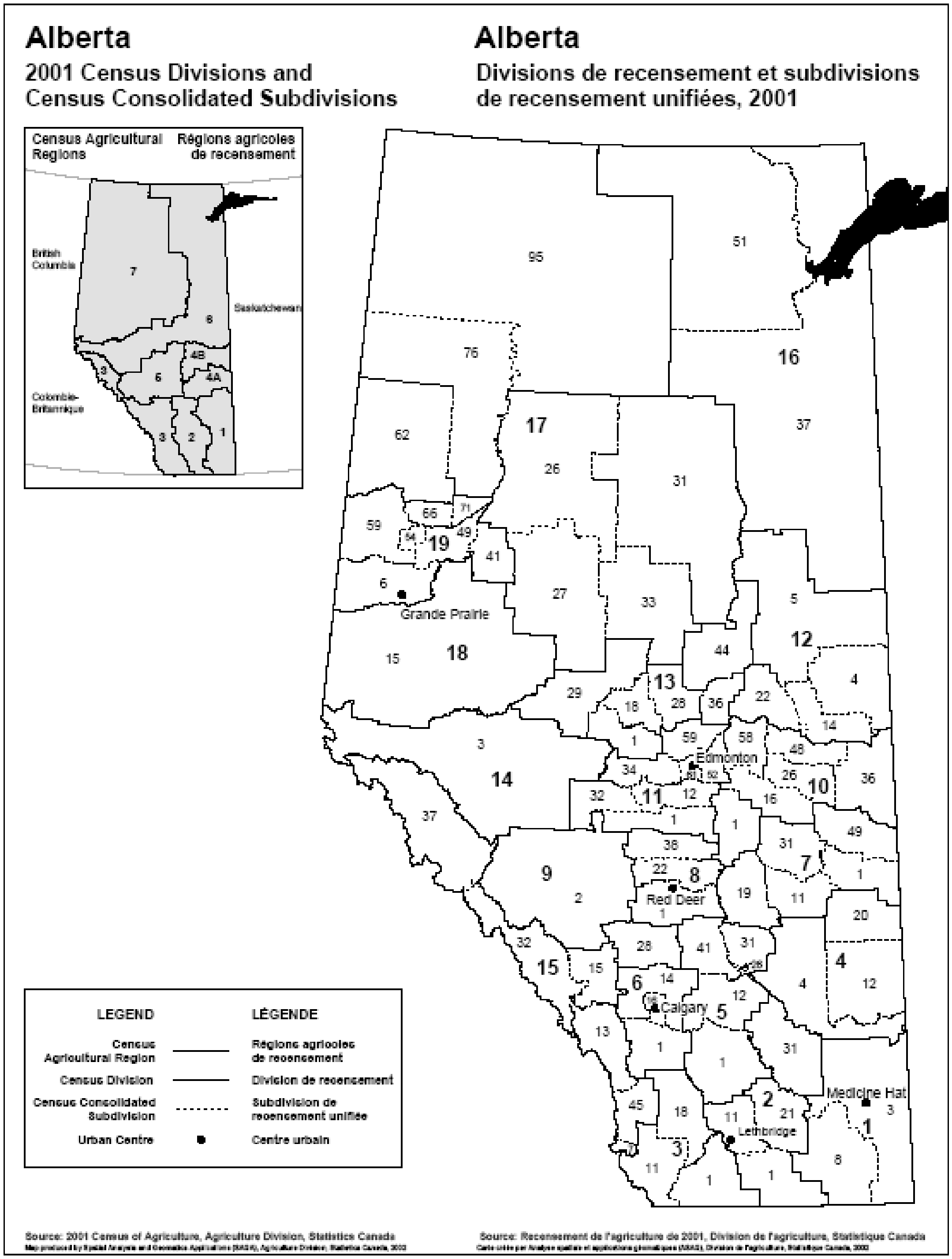


Figure. 1. County Map of Alberta - SC labelled 52. Surrounding straw producing counties: Lamont (58); Beaver (16); Camrose (1); Leduc (12); Parkland (34); Sturgeon (59); Thorhild (36). **Adapted from www.statcan.ca/english/freepub/95F0301XIE/maps/alta2.pdf**

Potential issues associated with using straw as a feedstock for heat generation are:

- Low density – major inconvenience for long-distance hauling, not an issue in this case owing to reliable and available local supply.
- Moisture – should be as low as possible meaning carefully timed removal from the fields as well as a need for storage facility
- 10% ash content - added cost of handling and equipment maintenance although it is suitable for agricultural land application and many local farmers may be willing to spread it on their fields.

2.2.2 Dedicated Energy Crops (DEC)

In the coming years, much of SC's agricultural land base will be in transition to urban use. Farmers may want to use the situation as an opportunity to introduce grasses or short rotation crops (SRC) on affected lands as well as on currently underutilized marginal lands. Seeding perennial grasses is an attractive option resulting in high biomass yields with low financial input and risk. Extensive research on SRC's has been conducted locally by the Canadian Forest Service (Derek Sidders, personal communication), which shows a high biomass output from both hybrid poplars and willows. Increased carbon sequestration under grasses and many SRC's would provide additional source of income to local farmers when carbon credits are introduced in Alberta.

2.3. Solid Municipal Residues

For the review of the resource option "municipal residues" the project team applied a methodology based on a combination of theoretical calculations and available waste generation, population, and literature data. The current total waste generation including single waste stream compounds in SC was determined and based on existing literature data the as-received higher heating values (HHV) for different waste types and waste management scenarios were calculated.

The current residential waste stream consists of waste disposal, recycling activities and composting at the Edmonton Waste Management Center (EWMC) in Clover Bar and a recyclable waste stream, which is handled within SC. Waste generation data and recycling statistics covering the years 1989 to 2006 were provided by SC. Waste from the Industrial, Commercial, and Institutional sector (ICI) was assumed to be equal to the residential waste stream. An overview on ICI waste stream composition was based on information provide by SC representatives and a current waste management model report for the Alberta Capital Region Alliance (ACRA), which was prepared by Dillon Consulting. To model future waste generation for SC an Alberta population growth model was implemented based on information from Alberta Finance ("Alberta Population Projections by Census Divisions, 2004-2026"). Parallel to the ACRA study ARC also used the medium scenario projection numbers.

The main waste generation rates for the past and the future are presented in Figure 2, distinguished into waste currently going to the EWMC, waste currently recycled in SC, total ICI waste stream, and total waste stream generated in SC. In addition the total number of households is shown. A detailed table of all waste streams and generation rates can be found in the Appendix of this report.

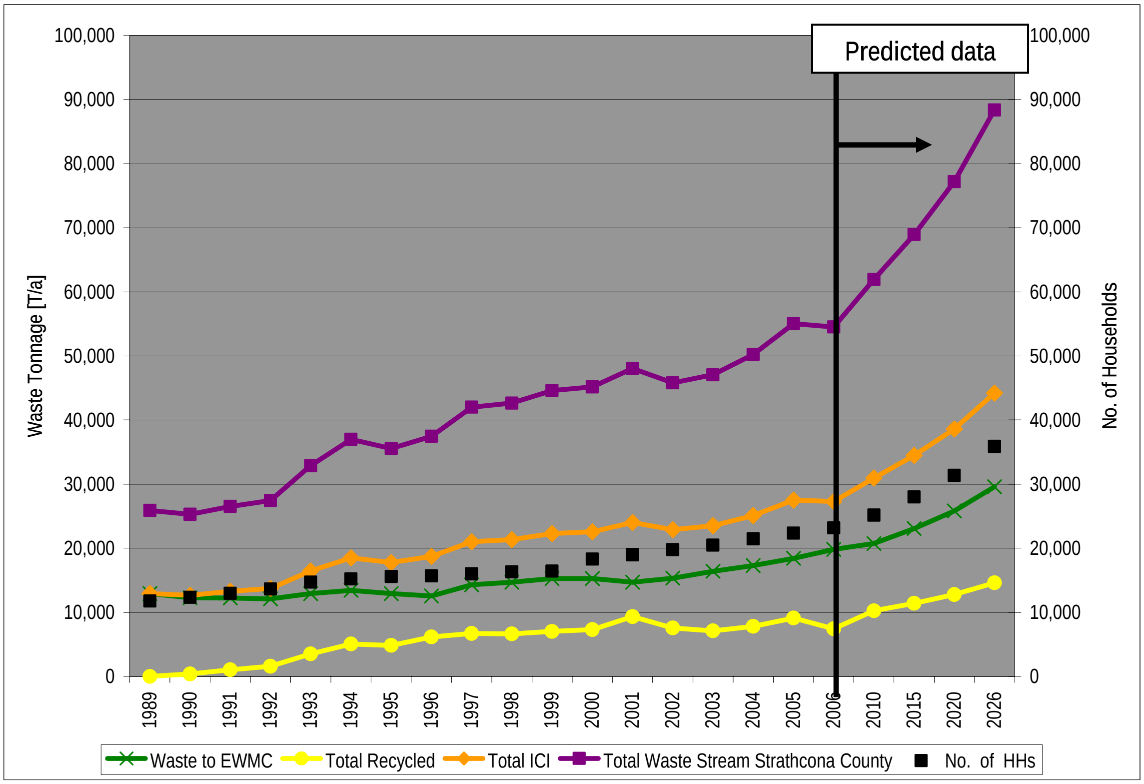


Figure 2. Waste Generation in SC

In 2006 the total amount of waste going to the EWMC, either to the Co-Composter or directly/indirectly to the Clover Bar landfill was 19,823 MT. Total amount of waste recycled was 7,437 MT. Based on the predicted population increase waste generation rates, assuming no major changes in current recycling, treatment and disposal activities will increase to 20,721 MT per year of waste to the EWMC in 2010 and to 25,836 MT per year in the year 2020. In comparison 10,231 and 12,757 MT per year will be recycled in the years 2010 and 2020 respectively. The total amount of waste generated in SC, based on our assumptions, will increase from 54,521 MT per year in 2005 to 61,904 and 77,187 MT per year in 2010 and 2020 respectively.

After determining the waste generation data from each waste stream we reviewed available literature to determine average as-received HHV's, moisture, and ash contents for each waste stream compound. Due to the nature of this study the theoretical calculations are based on literature data only. It should be noted that as-received HHV's, moisture, and ash content may vary regionally and temporally, so that presented data can only provide an initial overview of the nature of the waste generated. Actual boiler or lab calorimeter or chemical analysis of the waste streams will provide a more precise picture.

As-received HHV's based on eight waste generation and treatment scenarios based on 2006 data were calculated. The scenarios, describing the waste streams, which would be processed in the Energy Center at Emerald Hills, are described in Table 2.

Table 2. Waste Generation and Treatment Scenarios

Scenario	Description
I	All residential waste streams currently treated/disposed at the EWMC
II	All residential waste streams currently treated/disposed at the EWMC, excluding residential organics
III	All residential waste streams, excluded residential organics
IV	All residential waste streams
V	All residential waste streams, excluding all residential recycling activities in SC and residential organics
VI	All wastes generated in SC (Residential and ICI)
VII	All wastes generated in SC (Residential and ICI), without current residential recycling activities in SC
VIII	All wastes generated in SC, without current residential recycling activities in SC and organic from residential and ICI waste streams

Table 3 presents the above described scenario with annual tonnage (2006 data) and the calculated average as-received HHV's.

Table 3. Treatment Scenarios, Tonnage and calculated As-Received HHV's

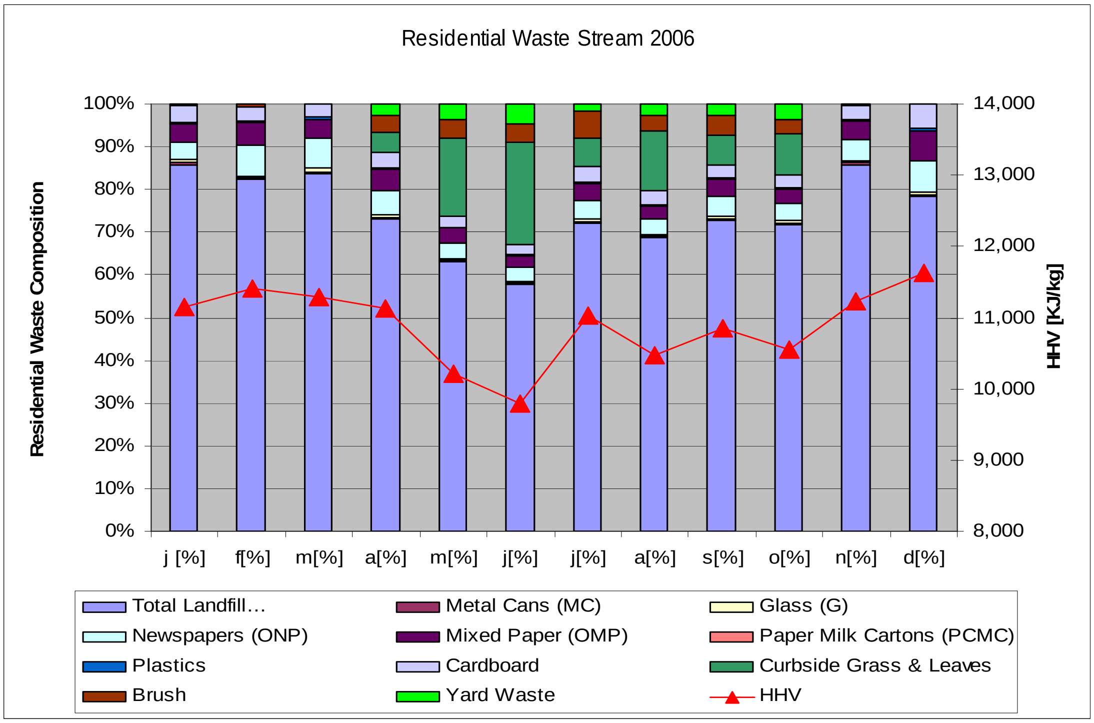
Scenario	2006 Tonnage [T/a]	As-received HHV [KJ/kg]
I	25,285	9,651
II	20,053	10,351
III	23,421	11,275
IV	28,653	10,488
V	19,823	10,467
VI	55,903	11,830
VII	52,535	11,513
VIII	42,021	13,188

Graphical presentation each scenario and the calculated tonnage and HHV's can be found in the appendix of this report.

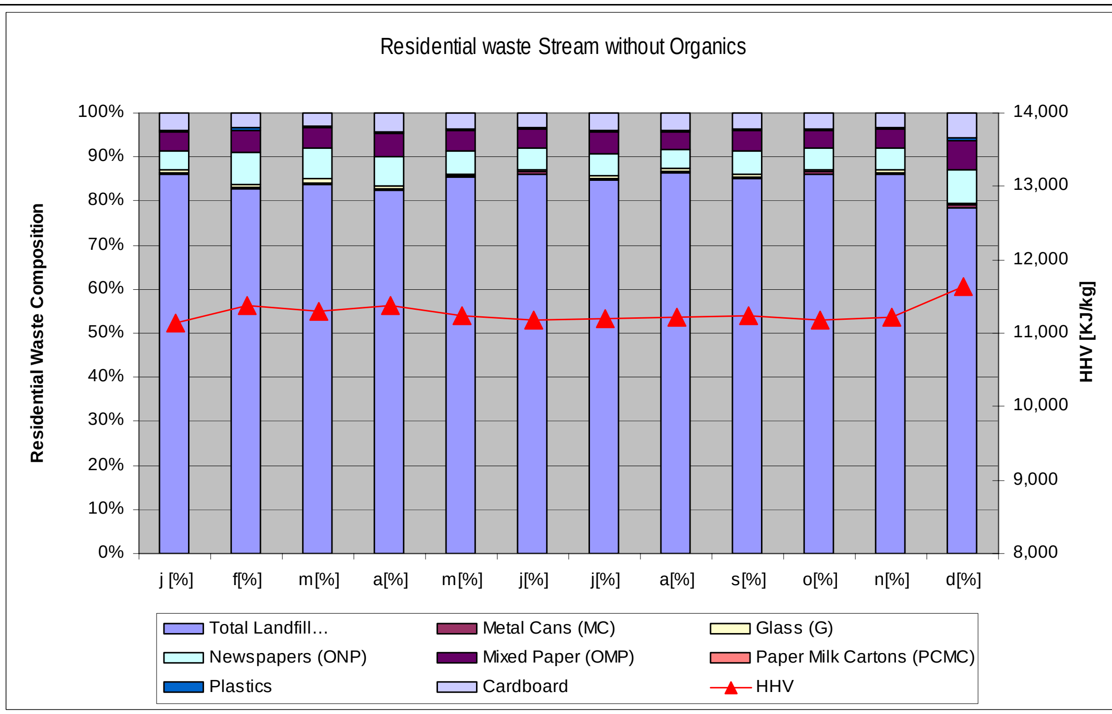
Seasonal variation of as-received HHV's over the year is clearly influenced by change in moisture content and the seasonality of organic waste generation and treatment during the summer months. Changes in the monthly HHV's between the generation and treatment of the residential waste stream with and without organics, at assumed constant moisture content, are presented in Figure 3.

Figure 3. Monthly Residential Waste Composition and HHV Change

Residential Waste Stream 2006 including Organic Fraction



Residential Waste Stream 2006 excluding Organic Fraction



The implementation of the resource option “municipal residues” can be handled smoothly, as no major changes would have to be implemented to the current waste collection and transport operation to the Edmonton Waste Management Center. In view of a possible location of the Energy Center close to the Emerald Hills area, the hauling distance might even be shorter.

Dependent on the final choice of scenario (see Table 2 and 3), its implementation might lead to changes to residential recycling activities, collection and transport. That would involve a possible transport of recycling materials to the Energy Center or a dedicated biological waste treatment plant. An improved clear bag program will help to source separate a major part of the organic fraction from the total waste stream for a possible further biological treatment. As County plans involve a possible biological waste treatment plant, this was implemented in the graphical presentation of the scenarios for the Energy Center. These can be found in the appendix of this study.

3. Criteria Development and Review

In order to compare and evaluate the single resource options described, chosen criteria were generated by the project team. These criteria are greenhouse gas (GHG) emissions, current and future availability and reliability including storage solutions, supplier infrastructure and administration management, proven use, current delivered costs, emissions and disposal of residues, fleet and processing maintenance issues, impact on traffic, public acceptability and social impacts. In Table 4 the three resource options are reviewed against these criteria.

Table 4. Review of Each Resource Option against the Chosen Criteria

Criteria	MSW	Forestry	Agricultural
GHG Emissions	GHG mitigation through diversion of waste from landfills, Generation of GHG credits/off set highly possible, might lead to additional revenues	After portion of wood residuals retained for soil fertility balance for fuel results in carbon neutral GHG balance. Larger transportation carbon footprint due to distant supplies.	After portion of straw retained for soil fertility. Balance for fuel results in carbon neutral GHG balance. Small transportation carbon footprint.
Current Availability/Reliability inclusive Storage	Availability is not an issue for residential waste stream as it is responsibility of SC, residential waste generation in SC is reliable, storage in bunker system possible for days, longer term storage is not a likable option (costs, odours, emissions tec.), existing landfills (Riley and Roseridge) can be possible temporary options for MSW treatment and disposal if plant is down etc.	Raw materials unavailable within SC. Proximate Alberta residuals from forestry plants all spoken for and unavailable. Plant operation subject to market conditions. Wood pellets available. Future bio-oil potential.	Supply available and reliable within SC and surrounding area. Storage at farm gate possible and surge storage needed. Peak demands on straw alone would present extreme logistics volume challenges.
Future Availability/Reliability inclusive Storage	Waste generation in SC will increase due to the current economical growth in Alberta, residential waste generation in SC is reliable, storage is not a likable option (costs, odours, emissions tec.), existing landfills (Riley and Roseridge) can be possible temporary options for MSW treatment and disposal	Continued constraints on solid forestry residuals due to demand, Potential availability of bio-oil may improve.	Potential increasing demand for straw composite materials, biofuel and soil carbon GHG mitigation and carbon credits may constrain supply over longer term. Straw as a future carbon sequestration commodity.
Supplier Infrastructure and Administration Management	No changes are expected as existing private hauling provider can be used, no further administration costs are expected, slight changes might be considered depending on which scenario for the Energy Center is chosen	In the case of wood pellets and bio-oil, higher fuel densities and fewer suppliers simplifies administration and logisitcs management.	Many supply contracts needed or a straw supplier consortium. Major logistics effort needed to coordinate deliveries and inventory management. Concerns about fleet and driver capacity and availability.
Proven Use	Large and small scale waste incineration projects in Europe (Sweden, Denmark, Scotland), including district heating projects	Large scale wood pellet plants in Europe (get examples) Dynamotive biooil demo plants	Large scale straw plant exist in Europe. See case studies.
Current Delivered Cost (Production, Transport and Storage)	Current Collection & Transport costs ($4.65/HH) equals 1.6 Mill.$, Current tipping fees at the EWMC is 1.1 Mill.$, Recycling and Special Programs costs are 250 K$, all numbers 2006.	Estimated at $100/MT. Strong global demand especially in Europe establishing a global price.	March 2007 pricing of $35 to $40/MT. Freight costs of aprox. $15/MT for a delivered cost of $50/MT.
Emissions and Disposal of Residues	Intensive flue gas treatment will be necessary, fly and bottom ashes can be recycled or disposed in landfills in the region.	Less intensive flue emission requirements. Low ash content. Ash can be utilized as a soil amendment.	Less intensive flue emissions. High ash content (10%) presents ash handling and disposal issues. Can be used as soil amendment.
Fleet and Processing Maintenance Issues	No to minor changes, which might be expected due to the scenario chosen for the Energy Center	Low silica and very clean burning with low ash content.	High Silica content presents combustion scaling and maintenance issues. High ash content presents plugging issues.
Impact on Traffic	No to minor changes to the existing system,minor changes are to the scenario chosen for the Energy Center	Medium impact	Very high impact. Peak demands estimated at 26 bales per hour or 624 bales per day = 20 to 30 loads per day and 2 to 3 loads of outgoing ash.
Public Acceptibility	Communication plan needed. Growing public support given favourable records in Europe, technological improvements and greater acceptance.	No issues expected.	Traffic issues. Agricultural support a plus.
Social Impacts	Strong local economic benefit anticipated. Public acceptibility communication plan and consensus req'd.	Favourable. Minimal local raw material supply economic benefit.	Favourable. Strong local agricultural benefit.

4. SWOT Analysis

Based on the review of the single resource options against the chosen criteria in chapter 3, the project team generated a SWOT (Strength, Weaknesses, Opportunities and Threats) for the municipal, agricultural and forestry residue option. The results are presented in Table 5.

Table 5. SWOT Analysis of the Resource Options

Criteria	MSW	Forestry	Agricultural
Strength	Internal supply insulates from changing market prices and dependencies, solves disposal problem and generates renewable energy (tax efficient), delivered raw material economics, available and reliabe, GHG mitigation strategy, net reduction in total traffic, easiest to manage from a storage requirement, use of regional landfill sites, best of supply and management logistics, integrative with other waste management options i.e. organics and recycling activities.	Cleaner air emissions, high energy density, future potential for bio-oil, least process operation maintenance, least ash content, ash readily disposable (requires mgmt.), fewer public acceptability issues	Cleaner air emissions, good energy density (close to forestry residues), available + reliable supply, potential for future renewable energy subsidies, fewer public acceptability issues,
Weaknesses	Emissions treatment costly (dirtiest fuel), major communication and consensus management effort required, small scale plant impact, lower energy density, high raw material cost,	Available but expensive and competitive uses, long supply line, high raw material costs	Future competitive use, logistically challenging and high administration mgmt. burden, high ash content, high silica, maintenance issues
Opportunities	SC has control over supply and costs, expendandable to additional waste stream and waste heat, demonstration plant effect for green technology (funding mechanisms), high sustainable profile, inclusion of waste stream from surrounding counties (integrative and inclusive project), example/template for community engagement re waste management and renewable energy,	Future bio-oil option might be available	Opportunities to engage rural county residents, keeps money local, strengthen and diversifying local rural economy, greater marginal land utilization (right of ways/transition lands), leverage agricultural renewables subsidies into project, straw has homogenizing effect with MSW, availability beyong SC
Threats	Public perception and communication management, danger of overrun costs as demonstration project - more sophisticated technology	Cost, availability and reliability issues	Some future uncertainties on pricing, availability, and carbon credit mechanisms

5. Resource Assessment Analysis

Based upon the peak energy consumption demand of 19230 kw or 1661 GJ per day, assumptions were made as to daily energy demands per month and heating values of various available feedstock sources to calculate the feedstock mix. These assumptions were based upon the Alberta Research Council's own energy demand at its CHP facility in Vegreville in 2005 - 06. Power requirements may over-estimate summer energy demands.

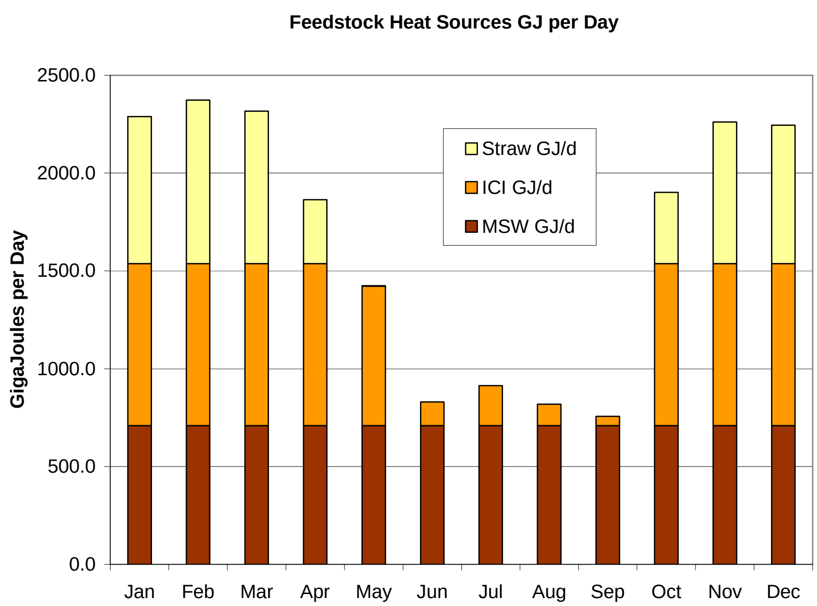


Figure 4. Feedstock Heat Sources GJ per Day

Based on these assumptions, the entire MSW stream can be utilized year round. The entire ICI stream can be utilized for half the year with straw utilized for peak swing demands in winter.

Heating values of the various feedstocks alter feedstock volumes somewhat but the basic supply profile is the same. Approximately 11 GJ/MT was assumed for MSW, 13 GJ/MT was assumed for ICI feedstock and 13 GJ/MT was assumed for straw.

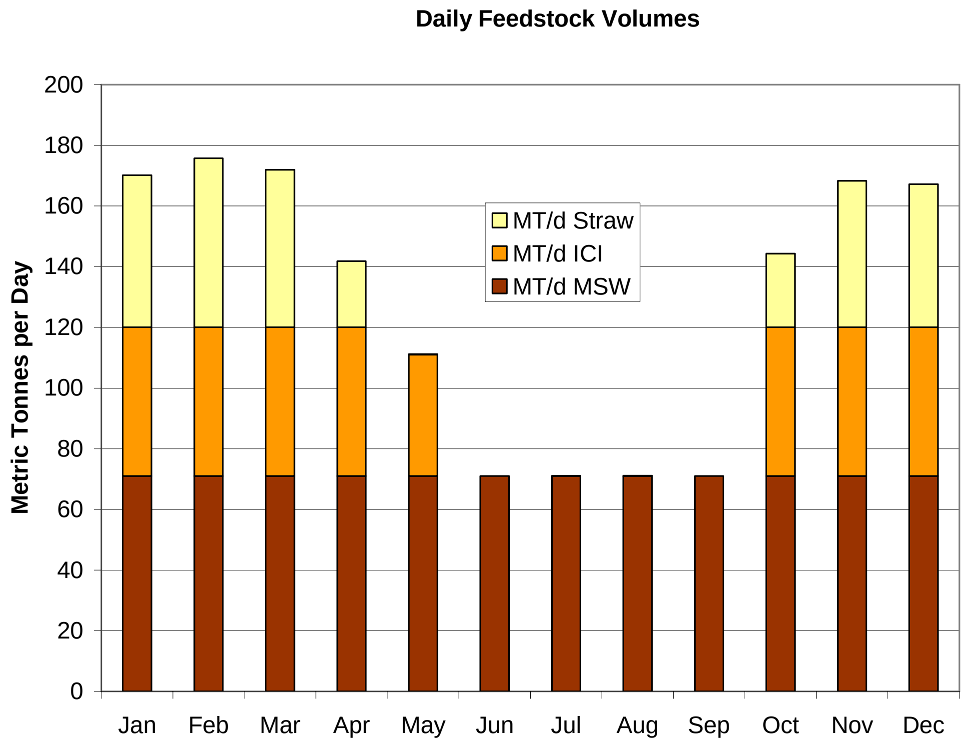


Figure 5. Daily Feedstock Values

Overall, the entire 27,760 MT of MSW would be utilized as well as 11,000 MT of ICI with 9,000 MT of straw utilized in winter months. The advantages of utilizing straw only in the winter months are that the product is going to be drier, farmers will have time available to carry out loading and deliveries and because just over 50% of available straw resources within SC are being utilized, lower transportation costs and a less competitive buyer's market will exist.

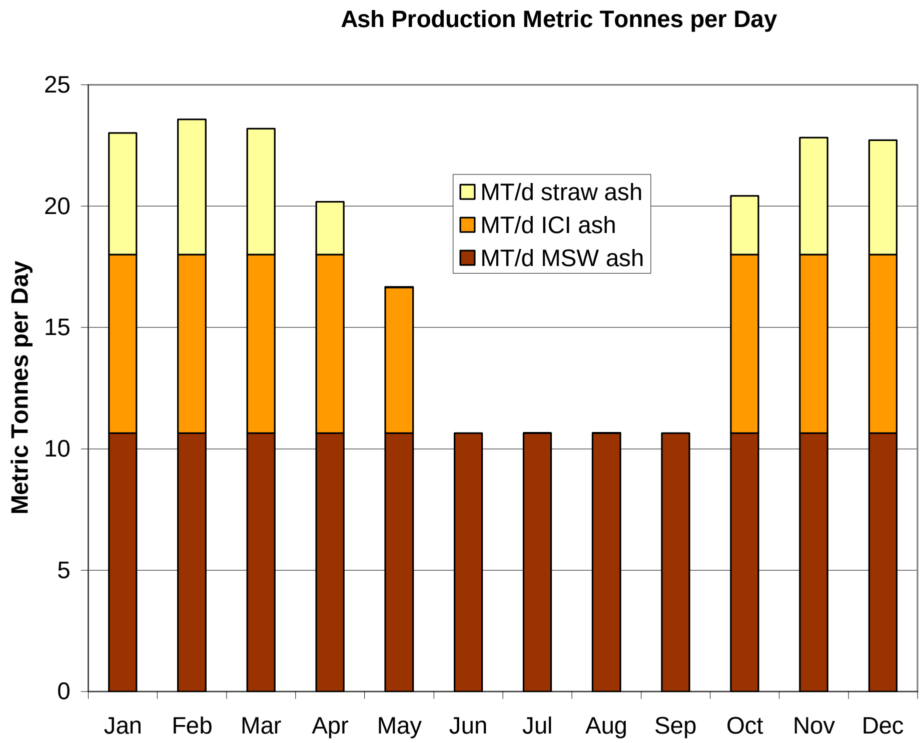


Figure 6. Ash Production from the Feedstock Options

Ash production will vary from 23 MT per day in winter to around 10 MT per day in summer. It is assumed that MSW and ICI ash will be hauled to Riley whereas straw ash can be utilized locally as an important soil amendment. This also assumes a separate straw burning boiler.

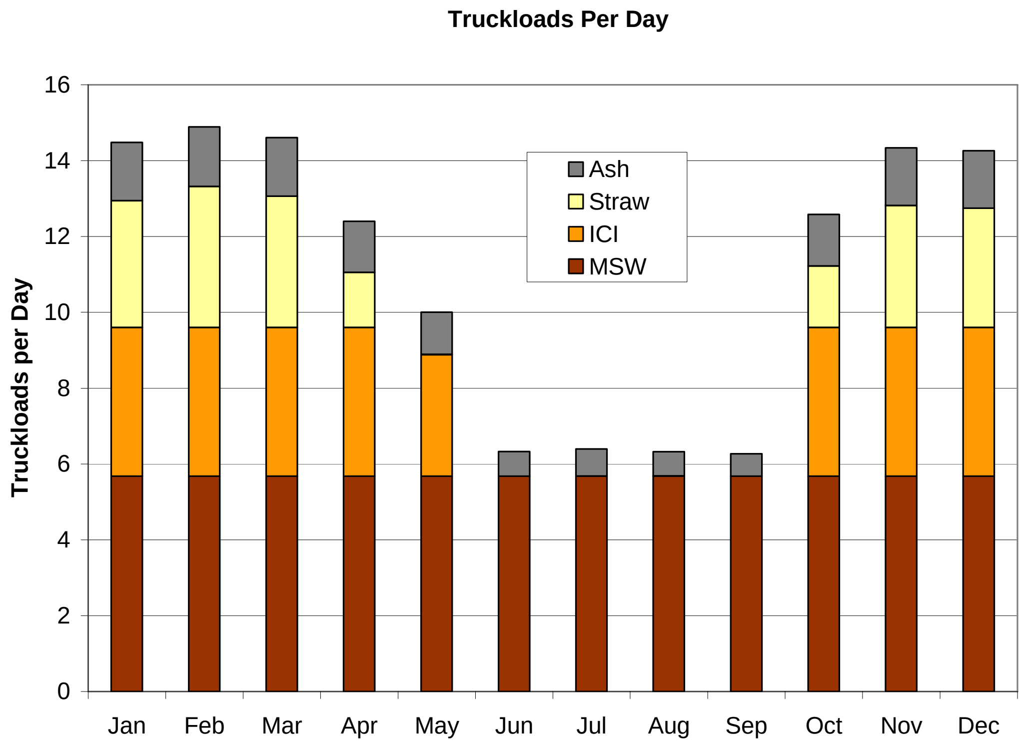


Figure 7. Truckloads per Day

Truck traffic is seasonal with heating demand varying from 6 to 15 loads incoming and outgoing per day. Assumed load sizes of 15 MT for incoming and 17 MT for outgoing ash.

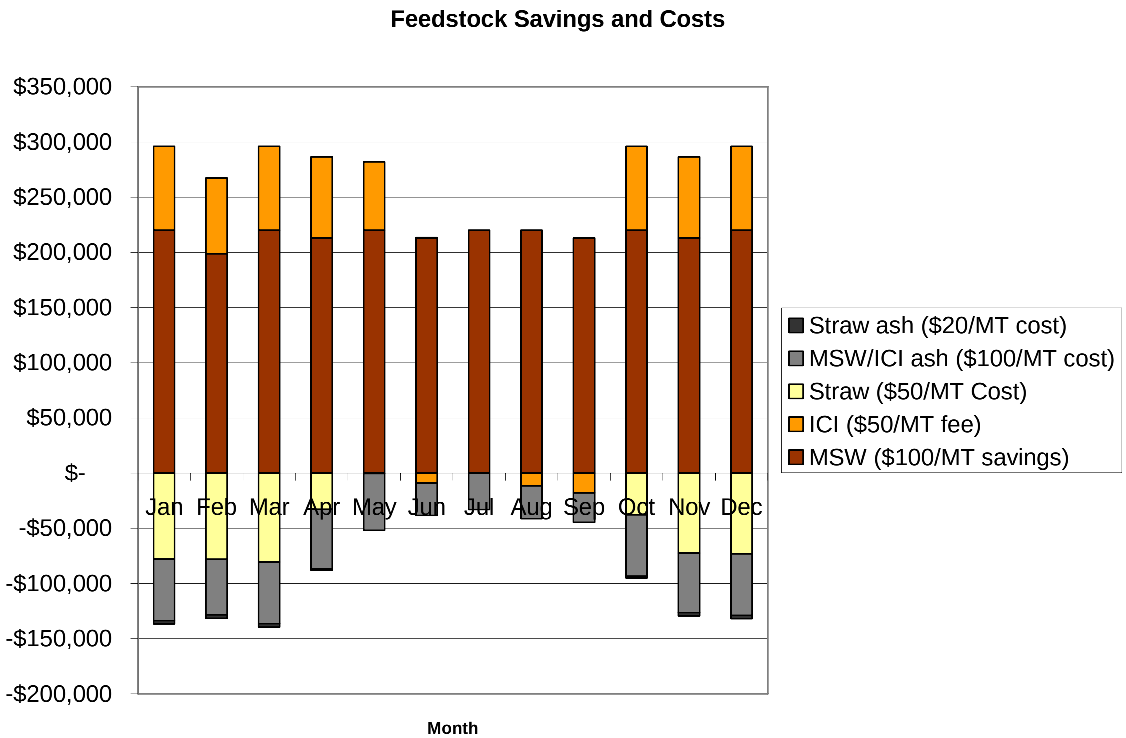


Figure 8. Feedstock Savings and Cost

There are very attractive economics in maximizing the use of MSW which reduces by $100/MT the cost of sending this material to Riley. This saves the County of Strathcona $2.6 million per year. Utilizing as much ICI as possible and charging a $50/MT tipping fee assuming they would be otherwise paying the same $100/MT fee adds an additional $520,000 per year of revenue. Purchasing straw during the peak season represents a cost of $400,000 per year and ash disposal costs another $545,000 per year assuming disposal at Riley. Total feedstock net savings and revenue is $2.14 million based on the assumptions in this model. Generating the same assumed heat requirement of 424,755 GJ per year with natural gas at a cost of $7.50/GJ would cost $4.55 million per year (assuming a 70% heating efficiency).

6. Case Studies

For each resource option (forestry, agricultural and municipal residues) three case studies are presented in the following chapter.

6.1 Forestry Residues

- **Skive, Denmark** (adapted in part from www.gastechnology.org/webroot/downloads/en/6NewsRoom/CarbonaPressRelease.pdf)

The Skive CHP plant is based on a new concept for biomass power generation that is a combination of gasification/gas cleanup technology developed by Carbona and its partners and gas engines. Such plants are referred to as Biomass Gasification Gas Engine (BGGE) power plants. The BGGE plant, which is the first commercial application of Carbona's novel technology, started initial operations in 2005.

The incentive for building a BGGE plant in Skive was to increase heat and electricity production from renewable resources in Denmark. The CHP plant, besides providing 70% of the annual district heating production of I/S Skive Fjernvarme, produces 40 GWh "green electricity" per year using biomass which is a CO_2 neutral renewable fuel.

The BGGE concept was selected by Skive, because in small scale decentralized CHP power generation, the electrical efficiency must be maximized to make the plant economically feasible. The Carbona technology enables the BGGE plant to produce about 50% more electricity than a conventional steam process from the same amount of biomass.

The BGGE plant consists of two modules - the gasification plant and the power plant. The main systems of the gasification plant are fuel feeding, gasification and gas cleanup. The fuel feeding prepares and introduces the fuel - wood pellets - into the gasifier. The gasifier is a fluidized bed reactor that operates at a temperature of about 850°C and converts the wood pellets into a fuel

gas containing carbon monoxide (CO), hydrogen (H_2) and methane (CH_4) as main combustible components. In the gas clean-up section, harmful impurities are removed.
The project is financed on a commercial basis. However, since the plant will be a first of a kind, subsidies are being provided by the U.S. Department of Energy, the European Union and the Danish Energy Agency. DOE has provided continued financial support to Carbona for the project under its Small Modular Biopower program through the National Renewable Energy Laboratory.

This project is also a unique model of international cooperation between public and private sectors to fulfill the environmental demands of the Kyoto Protocol. Successful completion of this project will provide an attractive option to achieve carbon emission reductions targets and also enable Carbona to offer competitively the BGGE technology to the world wide “green electricity” power market. Such CHP plants being small and modular meet the requirements of distributed power generation, renewable portfolio standards and the Clean Forest initiative in USA.

- **Vörå, Finland** (www.managenergy.net/download/biom0203wasberg.pdf)

Vörå municipality is located in the Ostrobothnia region in Western Finland. In order to convert all municipal buildings to biomass heating, Vörå municipality has implemented the following activities:

- Introduction of biomass heating based on heating entrepreneurship in elderly peoples home in 1993.
- Establishment of the first wood pellet factory in Finland in 1997
- Conversion to wood pellet heating (20-100 kW) in 9 municipal buildings in 1997-2002.
- Conversion from heavy fuel oil to biomass heating in the district heating plant in the centre of the municipality in 2002.
- Pilot plant for small scale CHP with Stirling engine in 2000-2001.
- Host organisation for Wood Energy Forum – a regional wood energy development project since 1997.

By 2003, around 95% of the municipal buildings were being converted to biomass heating. The good example and the experiences from the municipal sector have contributed to the installation of around 15 wood chip heating plants and 20 wood pellet heating plants in the private sector.

The activities have had the following positive impact:

Employment: 13 local jobs created

- 3 part time jobs for heat entrepreneurs
- 6 jobs in the wood pellet factory
- 1 person in the supply of pellet burners
- 3 jobs in fuel supply to the district heating plant
- 2 jobs in the wood energy development project

Environment: 2.5 million kg/a less CO_2 –emissions by substituting fuel oil with wood fuel.

The construction of a district heating plant for wood chips is an important step in converting all municipal buildings to biomass heating Vörå, Finland. The production and provision of heat for sale provide local farmers with additional employment and income during the winter months when farming activities are low. The lessons learned include the following:

- An energy vision or energy strategy with clear goals may be more practical and flexible than a detailed energy plan.
- Successful implementation of a municipal energy strategy requires long time, long -term political support, and foresighted and motivated officials.
- Conversion of all municipal buildings to biomass heating was in this case only possible through installation of range of various types of heating systems; heating entrepreneurship, wood chips heating plants, and wood pellet heating plants.
- The good examples and experiences in the public sector have contributed to the installation of 35 biomass heating system in the private sector.
- Economic aspects, local employment and environmental impact are important aspects when deciding on heating systems at local level. Energy agencies and wood energy projects have here an important role to play by making pre-feasibility studies and comparative impact assessments of conversion to biomass heating.

➢ Fittja, Sweden

Söderenergi’s Fittjaverket (Southern Energy’s Fittja Power Station) – can now boast increased fuel flexibility and energy efficiency by converting from liquid bio fuels, such as tall oil (a pulp mill by-product), to a solid alternative in the form of wood pellets. Today, Söderenergi supplies heating to approximately 70,000 households, small industries and hospitals. This year, TPS, Termiska Processer AB, which is a subsidiary to the TallOil Group, will convert one of Söderenergi’s heating boilers into a dual purpose unit capable of burning tall oil and if necessary, normal heating oil, and wood pellets.

The conversion involves installing a multifuel burner at the plant. This has been specially designed so that it can be retrofitted into older installations that use traditional fuels such as coal, oil, tall oil and gas, or be used in new power plants. The TPS multifuel burner delivers high efficiency, meets a broad spectrum of environmental regulations while providing excellent results in furnaces that have high fuel pressures.

The conversion contract is one of the largest ever won by TallOil and is worth around € 15 million. Once converted, the furnace should provide a heat efficiency equivalent to that required to heat a town housing 30,000 inhabitants. The new burner has a total output of 140 MW using wood pellets as fuel. The system also allows for the use of tall oil or, in certain cases, normal heating oil which currently accounts for less than 4% of the total fuel used by Söderenergi.

The reason that so many local authorities all over the world are seeking convert their municipal heating plants to burn bio fuel is based upon a concern for the environment and the operational cost. Using bio fuels in municipal and communal heating plants is very cost effective. For example, the cost per produced unit of energy can be reduced by between 30 to 50 percent when using pellets rather than traditional heating oil.

Fittjaverket is situated in a suburb to Stockholm, Sweden called Botkyrka. The plant has its own port where oil is brought in by ship, and its own oil storage facilities that are located underground. Oil is only used when the winter cold increases demand on the plant’s capacity to provide heat, or when there are disruptions or planned stoppages at Söderenergi’s other installation, Igelstaverket.

One problem with using heating and tall oil is that its price has increased considerably over the past few years. This is also one of the reasons why many heating plants have chosen to convert their furnaces to pellets which has proven to be both profitable and, when considering current and future environmental legislation, a necessity. Pellets are part of the world’s so called renewable energy sources which traditional fossil fuels, like coal and oil, are not.

At TallOil’s Swedish port facility, Södertörns Fulham, some 50,000 MT of pellets are shipped each year. The company’s partners can also import pellets or buy the fuel directly from TallOil. By assuring this kind of supply, the availability of cheap and energy rich pellets can be assured. The TallOil Group, which last year had sales of more than € 90 million, is currently one of Europe’s leading suppliers of bio fuels and bio energy solutions. The company is active in Sweden and throughout the world through a network of subsidiaries.

The new building is made up of a silo where the pellets are stored. The silo can hold up to 2,500 cubic meters of fuel which is enough for two days energy production. The grinding unit will comprise four mills which grind the pellets into powder, and a dosage silo.

Facts - Fittjaverket components:

- Tip unit – 200 m^3
- Off-loading capacity of tip unit - 140 MT/h
- Pellets silo 2,500 m^3
- Magnet and stones separators
- Four mills with a capacity of 9 MT/h per line
- Cyclone filter for powder separation
- Powder silo 250 m^3
- Dosage container with four distributors are connected to each burner
- System for NOx reduction
- Smoke gas fan rated at 450 KW
- Burner effect - Multifuel burner:
- Wood powder 140 MW
- Pine oil 160MW
- Oil 160 MW

6.2 Solid Agricultural Residues – Straw

- **Nakskov, Denmark** (adapted in part from http://www.managenergy.net/products/R415.htm)

Nakskov http://www.nakskov.dk is a city situated in the southern part of Denmark on the Island of Lolland. The municipality has approximately 15,500 inhabitants. The municipality of Nakskov owns and runs 100 % the heat supply system in the city. It is based on district heating from a combination of fossil - and biomass fuelled furnaces, which have been installed since 1957.

Today, the city of Nakskov has a fully municipal owned district heating system with a heat capacity of 44 MW of which 14 MW is purely straw based. This biomass capacity uses a base production, thus, the furnaces burning fossil fuels are only used for peak loads. As early as 1957, an oil fuelled heat plant was built in Nakskov city centre to supply the citizens with district heating. The plant was initiated, built, and owned by an association of citizens, but the construction was supported by the municipality, which immediately implemented it in the planning schemes. The heat capacity was 20 MW divided between 4 boilers.

Later, in 1984, two straw fuelled boilers with a heat capacity of respectively 4 and 3 MW were built in the western part of the city burning pressed straw pellets. These straw pellets where produced/pressed in a building next to the heat plant. The reason for using pellets instead of burning the straw directly is the higher energy content per volume of the pellets. This makes the combustion easier to control and decreases the additional oil co-firing. But after approximately one year it was concluded, that the pressing of these pellets was too expensive, and thus, the boilers were replaced by one furnace for pure coal firing. A few years later this coal furnace was removed - again due to bad economy. By now, the association had very bad economic results and they were forced to either close or sell the production capacity to the municipality, the latter was done. The coal furnace was replaced by a straw furnace (NordFab) of 6 MW plus 2 new coal furnaces.

In 1996, these two coal furnaces were then also removed, and replaced with another straw fuelled furnace (Vølund), this time with a capacity on 8 MW. In addition, a 20 MW boiler (Vølund) was installed burning gas oil.

Today, heat in Nakskov is produced at 2 heat plants, one in the middle of the city, commissioned in 1957 and one in the western part of the city commissioned in 1984. The plant of 1957 was originally oil fired, but today it is fuelled with technical grease due to its lower price. The district heating network has constantly been increased in the city and today the main connection lines are approximately 35 kilometres in length and the minor connection has a similar length.

The two straw fuelled heat plants are different in the way the straw is fed into the furnaces. The older one, built in 1984, works with a tearing system, where the large straw bales are torn up thoroughly before the straw is fed into the furnace. The combustion of the straw is supported by oil in the start-up. The newer furnace, built in 1996, works with another process, whereby the whole bale is stuffed into the furnace and combusts on a grate. The reason for using two different technologies is the state of the art concerning straw burning in 1984 and 1996, respectively.

Today, all new straw furnaces use the whole bale input. The objective and reason for building the straw fuelled heat plants has in general been based on economic evaluations. Due to national Danish energy policy, there is no tax on biomass fuel, thus, it is cheaper to fire with straw than with fossil fuels. In a heat plant, where the restrictions/demands in temperature in the boiler is not as high as in a combined heat and power plant, it is obviously better to install biomass fired boilers, in particular in regions where the biomass resources are as rich as in the area surrounding Nakskov. The yearly heat production from the straw fuelled plant in Nakskov was 64.5 GWh in 1999. This replaces firing with fossil fuel.

The straw is delivered locally by farmers who normally make contracts with the heat plant for a period of three years. There are strict rules for the quality of the big straw bales which are delivered. They have to have a defined size (2.4x1.2x1.3 m, and a minimum weight of 500 kg) and the straw has to have a moisture content of less than 19 %. If this is not the case, reductions in the price paid can be expected. In very bad cases the straw is refused. The daily consumption of straw is approximately 200 large bales, which thus equals approximately 100 MT/day. The storage capacity at the plant is only about 1,000 big bales which equals 4-5 days at full run. The straw is stored during winter at the farms and delivered continuously by the farmers, who are also obliged to take the surplus ash in return, which is proportional to the amount of straw delivered.

- **Ely, Cambridgeshire** (text adapted from http://www.dti.gov.uk/energy/sources/renewables/renewables-explained/biomass/case-studies/page17025.html)

Ely straw-burning power station in Cambridgeshire is the first modern, and the world's largest, straw-fired power station. It became fully operational in September 2000. The 36MW facility consumes around 200,000 MT of straw and generates sufficient electricity every year to satisfy the needs of 80,000 dwellings. The plant is also capable of burning a range of other baled energy crops, such as miscanthus, and can use mixtures of up to 10% natural gas. The facility has created about 50 long-term jobs. Long-term contracts are in place for the sale of the plant's entire output. The plant is a partnership formed between Energy Power Resources Ltd and Synergy Global Power.

- **Lubañ, Poland** (adapted in part from http://www.managenergy.net/products/R424.htm)

Lubañ is situated in Dolnooel¹skie Voivodeship in south-western Poland. It lies in the valley of the River Kwisa, on the edge of the Pogórze Izerskie (Izerskie Foothills). The town, which has 24,500 inhabitants, is located 22 km from the German border and 30 km from the Czech border.

The analysis of the use of straw within 20 km of the town of Lubañ showed that a significant quantity of this material was not used in the place where it is produced and is a burdensome waste product. The production of a straw surplus is a permanent phenomenon. The estimated quantity of straw available is from 10,000 to 12,000 MT of straw per year. This quantity could be used to produce up to 50% of the thermal energy required by the town of Lubañ.

The first stage of implementation of the program for producing energy from biomass was the construction of a 1 MW straw-fired boiler plant. In the years 2000 and 2001, two further 3.5 MW boiler plants were constructed. Preparations for introducing straw for energy production started in 1992 with the analysis of the straw market and straw-fired boilers. Due to the lack of affordable technologies for burning straw, the project could not be implemented until 1998. The implementation was divided into two stages:

Stage 1, finished in the first half of 1999, included:

- the purchase of know-how and the preparation of the technical documentation,
- the construction of a 1 MW straw-fired boiler with the necessary ancillary equipment,
- the purchase of a tractor, press, trailer and the construction of a straw warehouse.
- the construction of 7 heating substations together with connections,
- the modernisation of 27 heating substations (the installation of outdoor temperature monitoring, highly efficient heat exchangers and heat meters)

Stage 2, finished in 2001, included:

- the construction of two 3.5 MW straw-fired boilers with the necessary ancillary equipment,
- the purchase of the equipment necessary to collect and transport the straw (two presses, two tractors, two loaders, two trailers, a rake),
- the construction of a 1060 m^2 straw warehouse,
- the construction of a 90 m^2 boiler room.

One 3.5 MW straw-fired boiler was put into operation in December 2000, the other in 2001. The straw-fired boiler plant was constructed as an upgrade and extension of the existing coal-fired boiler plant. This solution has allowed the utilisation of existing technological infrastructure and the implementation of a safe multi-fuel heat production system. This system enables the full exploitation of the advantages of straw and the operation of straw-fired boilers which utilise 80% of the material available, while the existing coal-fired boilers serve as a flexible safeguard.

The main factors influencing the choice made by the PEC Lubañ (the heating utility) regarding the boiler to be used was the tolerance of wet straw, the resistance to physical damage and the possibility of using the same device to burn other fuels, e.g. wood chips.
The nominal combustion efficiency of the straw-fired boiler plant is 84% (reaching 90% with very good quality straw). Most of the straw is stored in heaps in the stacking yards of PEC Lubañ. These are covered with plastic sheets to protect them from the rain. The rest is regularly delivered by the farmers. The straw contains about 3.5% ash and particulate matter. Research results have confirmed the suitability of the ash as a mineral fertiliser. Construction of a straw-fired boiler plant is included as a priority in the strategy for supporting environmental projects adopted by the EkoFundusz foundation and the WFOOEiGW (Voivodeship Fund for Environmental Protection and Water Management) in Wroclaw. The costs of implementing the program, amounting to €1,608,275, were covered from three sources:

- EkoFundusz € 688,625 subsidy 43 %
- WFOOEiGW € 311,875 loan 19 %
- PEC Lubañ € 607,775 own funds 38 %

The operating costs for straw-fired boiler plant are not significantly different from the operating costs for boiler plant fuelled with coal dust. In the case of straw, the cost of fuel, including transportation costs, is around 20% lower. The costs of operation are comparable. There is a significant difference in depreciation costs resulting from the fact that the coal-fired boilers were constructed much earlier. This difference is partly compensated for by higher maintenance costs and the exemption of straw combustion for energy purposes from environmental fees.

The implementation of the program has a positive impact on the natural environment because renewable fuel is utilized. Apart from balancing the carbon dioxide emissions, straw combustion emits significantly smaller quantities of sulphur dioxide and particulate matter than coal combustion. The adopted technological solutions utilising straw as a source of energy conform to the basic national guidelines concerning environmental protection and contribute towards limiting the emission of pollutants.

The experience of PEC Lubañ (a private company which is 100% owned by the Municipality) covers the investment process and 3 years of operation of a straw-fired boiler plant. It testifies that in Polish conditions straw, or more generally locally produced biomass, constitutes an excellent basis to promote economic growth at the level of the Municipality. A serious approach to energy planning by the local authorities at the level of the Municipality is a precondition for achieving a favourable result. It is not necessary that the Municipality itself should directly engage in the implementation of specific projects. It is enough that the proper conditions are created – transparent investment and tax policies conducive to economic growth. The project implemented in Lubañ shows that a broader view of local policy – encompassing more than the obligations placed upon the Municipality by the Energy Law – results in significant social and economic activity, which is not only linked to energy production. Almost naturally, this opens the way towards the creation of new jobs, the expansion of the agricultural market, increased use of uncultivated land and the disappearance of threats connected with the existence of such land.

6.3 Municipal Residues

- Hoegdalen Plant, Stockholm, Sweden

The Hoegdalen Plant serves the southern suburbs of Stockholm with district heating. Its output is based on household waste and other biofuels. It was build beside existing boilers burning municipal and industrial waste. About 85% of Hoegdalen’s district heat production is waste fuelled. The existing boilers produce steam (36 bar - 360˚C) for the steam turbine and for the district heating system. The location for the plant was chosen based on the fact that the infrastructure was ready, and a need for increased district heating for the City. As the plant is located central in Stockholm all strict environmental obligations had to be fulfilled. The investment costs for the new power plant were € 70 Million and were financed by the owner, Stockholm Energi AB. The total production capacity for district heating and power production is 92 MWth. A new steam turbine will produce approximately 42 MWe. The plant uses about 200,000 MT per year, of which 150,000 MT is industrial and municipal waste, 50,000 MT are biofuels.

The incoming waste is already prepared and needs to undertake further shredding and metal separation processes. Part of the fuel handling system are a receiving station with two stoker reclaimers, different disc streams, a two rotor ECO crusher, a metal detector, a secondary crusher as well as a chain, belt and screw conveyors, belt elevators, 2 fuel silos of 4,000m^3 each, LPE screw reclaimers, 3 boiler silos of 100m^3 each with screw reclaimers, boiler infeed system, dust removal system and spark extinguisher system. The power plant includes a CFB boiler specially designed for waste fuel, SCNR, fuel handling in boiler house and boiler house steel structure. The Foster Wheeler CFB boiler has some specialized features, which were derived from other waste burning units. A water-cooled furnace with an integrated water cooled separator and loop seals equipped with INTREX™ superheaters are the main parts of the boiler system. A semi-dry scrubber with baghouse (NID), a two stage wet scrubber, a flue gas condenser and a water treatment plant are parts of the flue gas cleaning system. The EU emission standard was already fulfilled after the NID system. Activated carbon reacts with the dioxin and mercury in the gas stream. A solid component is formed and collected in the filter bags. More than 15 MW of heat is recovered from the condensate water in the flue gas. Some highlights of the initial operation (2001) period were

- Tight time schedule, 19 months from boiler ordering to start-up, was successful.
- Fuel handling and boiler system were able to take a range of fuel quality due to initial variation, although plant should have reliable and specified (analysed) feedstock
- Low emissions, already in the commissioning phase (dust emissions Dec 1999 and May 2000) were 2.8 mg/mm^3 at 11% O_2, CO emissions were 22.5 mg/MJ, NOx emissions were 65 mg/MJ, S emissions were under 1 mg/MJ)
- Plant fulfilled all existing and evolving requirements of the EU directive on co-incineration of waste.
- No upset in the boiler system caused by unburnable matter
- Superheater system more efficient then expected no signs of corrosion.

➢ Knudmosevarket, Herning, Denmark

The municipality of Herning, a medium-sized municipality, situated in the centre of Jutland, owns Energi Gruppen Jylland, a modern utility company. The utilitiy has carried out a massive extension of the heat supply in Herning but also to neighbouring villages. The extension is based on renewable energy sources. Denmark has focused on a two-string CHP strategy, allowing large-scale plants for denser populated areas and smaller units, generally operated by local district heating companies for medium-sized towns. Energi Gruppen Jylland had a goal to supply 30% of the heat demand in the municipality through biofuels by the year 2005. To achieve this goal several biomass CHP technologies were implemented from

- Biogas and landfill gas,
- Waste incineration and wood gasification, and also
- Heat production of wood chips and straw.

Knudmosevarket is a waste incineration CHP plant which was built in 1995. It incinerates residential and industrial waste and can take an additionally 25% of biomass. The waste consists out of non-recycable materials as these are separated out of the waste stream before. Treatment capacity is 38,000 MT per year, with waste of a calorific value between 7 to 13.5 GJ/MT. Total electricity produced is about 23,500 MWh, serving approximately 5,500 households. Heat production is about 80,500 MWh, serving the consumption of approximately 3,800 households. The waste is transported from a silo into the oven where it is incinerated on grids. The steam produced is turned into electricity in a steam turbine, and is then cooled down with district heating water for Hering. Approximately 15% of the heat for the city can be provided by the plant. The residues from incineration (ashes) are cleaned of iron and other metals and used in road construction projects in the city. Flue gas treatment consists out of an electrofilter to catch fly ash and a scrubber, where it is washed. A 75 meter high chimney acts as an exhaust. The water from the scrubber is purified in a plant and reused. Per year the water consumption is 31,000 m^3, including rain-water and boiler water. Knudmosevarket needs 3,500 MWh electricity for own production. That is just under 15% of the total electricity produced. Price per MT of residential waste at the plant is about 50 $CAD. Figure 9 shows a flow diagram of the plant.

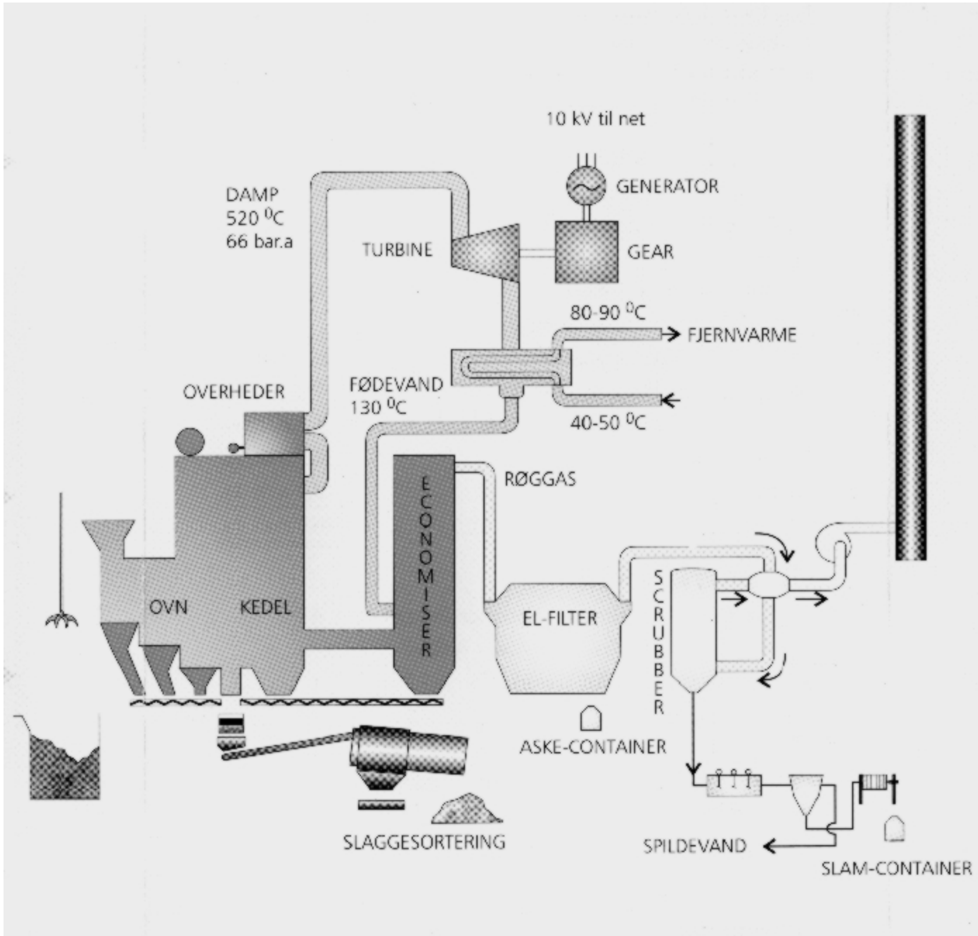


Figure 9. Flow Diagram of the Knudmosevarket Plant

- **Shetland, Waste to Energy Plant, Lerwick, Scotland**

The district heating scheme in Lerwick has been funded by the Shetland Islands Council Charitable Trust (with assistance from the European Regional Development Fund) as an investment in the Shetland economy. The operation fell into the hands of the Shetland Heat Energy and Power Ltd. Special requirements for this plant were laid out in the planning process: it should be the “best value for money” solution and also include “well proven technology”. Originally oil fired boilers were used to generate energy, but from 1999 these boilers were left as a standby mode and peaking plant.

The waste to energy plant has a maximum capacity of 26,000 MT per year. Most of that waste comes from Shetland. Lerwick, the capital of Shetland has a population of approximately 8,000. A total amount of 8,000 MT household and industrial wastes per year is imported from Orkey. Waste generated by the offshore oil & gas industry (3,000 MT per year) is also treated in the plant. The size of the furnace is 3.3 MT per hour and the plant has a heating effect of 7MW. The plant consists of a fire tube boiler with a supply temperature of 115°C. Further 100% cooling efficiency is installed. The flue gas cleaning deals with the increasing demand of emissions from waste incineration by the EU. A dioxin filter with activated charcoal injection and a CeNOx installation have been built into the boiler. The plant has been operating since June 2000 and is expected to operate at 90% availability to allow for scheduled maintenance. To maximise plant operation the incoming wastes have to be mixed properly to generate a "homogenous" waste mix and not having e.g. a dominant plastic waste stream. On occasion certain waste streams can be diverted from the plant to a landfill or to a recycling operation. A picture of the plant can be found in Figure 10.

Metals, including food and drink cans are separated from the waste, collected and recycled. Fly and bottom ashes are landfilled. Operation is governed by an Integrated Pollution Control (IPC) Authorisation issued by the SEPA and currently meets all processing and emission standards. The potential for Health & Safety risks and environmental pollution are closely monitored and systems are in place to minimize any potential risk. Quality management systems are to be put into place to assist with risk management. The integration of the Shetland waste-to-energy plant in an integrated waste management system, including recycling and composting, can be seen in Figure 11.

The plant supplies hot water for a district heating system for domestic and commercial premises in Lerwick. By August 2005 690 properties were connected to the system. They include a sport centre with swimming pool, two schools, the largest pelagic fish factory in Europe, a dairy (using heat for pasteurization), residential care centres, a library, the main hospital, offices, retail premises, museum, guest houses, public buildings, council and private housing amongst other. In 2005 the system includes 26km of mains. More expansions were planned over the last years. A combined heat and power plant operation was discussed to serve the surrounding communities with electrical energy

Figure 10. Shetland Waste to Energy Plant

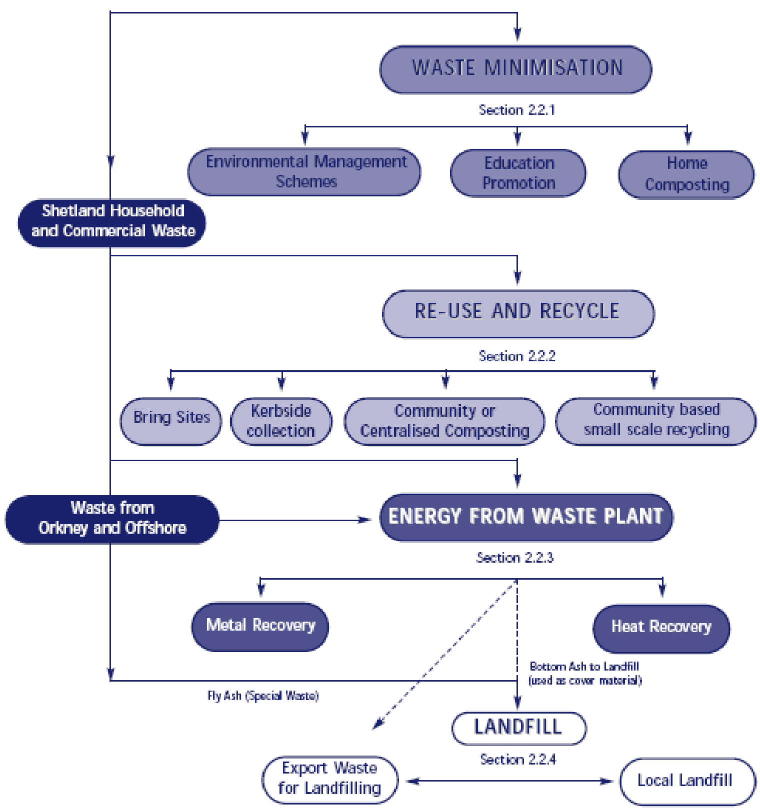


Figure 11. Integration of the Waste–to-Energy Plant in the Waste Management System in Shetland

The plant, already in 2001, has made a significant contribution to the Shetland economy by employing 17 people and indirectly generating work for local service providers and the construction industry through the implementation of the Lerwick District Heating System.

7. Summary and Recommendations

- Residential MSW and ICI fuel resource streams offer the greatest predictability and supply reliability followed by straw. There is little forestry biomass available to use as a fuel resource.
- SC has the greatest control over the residential MSW fuel supply stream in terms of logistics management, cost structure and potentially over quality as well.
- Further detailed analysis in form of a waste composition study of the residential MSW and ICI waste streams should be undertaken to verify the as-received higher heating values.
- The ICI stream is attractive with its higher fuel value and because it is facing the same steep disposal cost structures as residential MSW.
- Both residential MSW and ICI options offer the greatest Greenhouse Gas offset and opportunities for future potential Greenhouse Gas credits. They also offer a significant net reduction in diesel consumption and Greenhouse Gas emissions associated with transportation.
- Straw is widely available but its supply represents a hard cost to the County and carries with it a logistics management burden.
- Under the assumptions used in the energy and feedstock supply cost model, MSW is the preferred supply option and can be utilized in its entirety year round assuming summer usage rates are not over-estimated.
- The next preferred supply option is ICI waste which, if facing the same economics as residential MSW in terms of transport and tipping fees at Riley could serve as a revenue generator by paying a tipping fee to SC.
- Peak winter demands can be achieved by augmenting with straw bales. Winter is a preferred time to utilize straw owing to availability of farm resources and access to a drier feedstock.
- Utilizing a certain amount of straw demonstrates an interest in engaging the entire County constituency as part of its renewable energy and environmental commitment and is a way of building overall community unity in this project both urban and rural.
- The model predicts a feedstock net cost savings of over $2 million by maximizing the use of residential MSW and ICI whereas natural gas alone would represent a cost of over $4.5 million. This represents a positive rate of return of 7% on a $30 million investment. This creates additional options for the County in terms of alternative financing through private equity

markets. It is also necessary revenue offset for additional capital required for more intensive flue gas treatment.

- There are many renewable feedstock small scale distributed heating plants throughout northern Europe with various degrees of success. It is essential that SC officials visit a variety of these facilities to gain first hand knowledge and to network with other municipalities that are further down this path. It will also be helpful to look at the European approach in terms of developing a public consultation and communication plan over the use of MSW and ICI for energy generation.
- The County may wish to consider this facility in a much broader scale as a demonstration facility that would also fulfill a public education role and serve as a template for other communities across Alberta and around North America to follow. This will serve as a way to attract additional public sector investment into the capital cost. It would also serve to build SC's reputation as an environmentally sustainable community.

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Appendixes

– Residential Waste Generation & Diversion Summary 1989-2006 predicted to 2026

Strathcona County - Environmental Operations

Residential Waste Generation & Diversion Summary
1989-2006 predicted to 2026

Waste Generation - Residential *

		Years																					
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2010	2015	2020	2026
Growth projected to 2005																				12.52%	25.31%	40.30%	60.60%
Total Waste to Landfill (tonnes)		12,940	12,254	12,234	12,119	12,936	13,440	12,936	12,555	14,297	14,691	15,281	15,278	14,690	15,325	14,069	11,705	14,549	16,241	16,370	18,231	20,412	23,365
	Co-Composter												0	0	0	3,604	8,606	5,948	5,511	6,693	7,454	8,346	9,553
	Co- Composter - WF												0	0	0	1,262	3,012	2,082	1,929	2,343	2,609	2,921	3,344
	WF												15,278	14,690	15,325	12,807	8,693	12,467	14,312	14,028	15,622	17,491	20,022
Waste to EWMC		12,940	12,254	12,234	12,119	12,936	13,440	12,936	12,555	14,297	14,691	15,281	15,278	14,690	15,325	16,412	17,299	18,415	19,823	20,721	23,076	25,836	29,575
No. of HHs		11,754	12,320	12,955	13,616	14,700	15,218	15,567	15,672	15,993	16,300	16,446	18,303	18,977	19,795	20,479	21,465	22,345	23,176	25,143	28,001	31,350	35,886
Recycling - Residential																							
Metal Cans		0	22	72	92	94	86	84	110	105	100	94	94	103	84	64	99	70	99	79	88	98	112
Glass		0	34	81	120	68	114	103	85	85	146	139	121	129	122	130	140	132	131	149	165	185	212
Yard Waste & Brush	(includes brush)	0	0	44	235	1,342	2,434	2,172	3,692	3,946	3,007	3,241	3,182	3,852	2,259	1,414	1,673	1,628	1,410	1,832	2,040	2,284	2,615
Yard Waste	Total Yard Waste												918	959	296	646	642	587	585	661	736	824	943
	County compost operation												918	959	296	0	0	0	0	0	0	0	0
	Gore Organic operation site (100% diversion credit)												0	0	0	31	161	155	104	174	194	217	249
	Co-composter (100% diversion credit)												0	0	0	592	470	370	462	417	464	520	595
	Wood/Chips site (100% doverson credit)												0	0	0	0	0	4	0	5	5	6	7
	Working face (no diversion credit)												0	0	0	24	11	58	20	65	72	81	93
Brush	Total Brush												2,264	2,893	1,963	768	1,031	1,041	825	1,171	1,304	1,460	1,672
	Chipped (100% diversion credit)												2,264	2,893	1,963	768	1,031	1,035	825	1,165	1,297	1,452	1,662
	Gore Organic operation site (100% diversion credit)												0	0	0	0	0	5	0	6	7	7	9
	Transfer Station												0	0	0	0	0	1	0	1	1	1	1
Curbside Grass & Leaves	(curbside prog.)	0	0	0	0	356	556	797	575	721	1,310	1,238	1,545	2,431	2,327	2,573	3,117	4,051	2,412	4,558	5,076	5,684	6,506
	County compost operation												1,545	2,431	2,327			0	0	0	0	0	0
	Gore Organic operation site (100% diversion credit)												0	0	0	110	1,285	1,757	1,249	1,976	2,201	2,464	2,821
	Co-composter (100% diversion credit)												0	0	0	2,463	1,832	2,291	1,164	2,578	2,871	3,214	3,679
	Wood/Chips site (100% doverson credit)												0	0	0			3	0	4	4	5	5
	Working face (no diversion credit)												0	0	0	~~88~~	~~165~~	19	15	22	24	27	31
Plastics	Mixed plastics (milk jugs comprise approximately 9.5% of total weights)	0	0	8	54	87	129	137	132	143	154	98	187	198	80	0	42	49	34	55	61	69	79
	Plastic milk jugs (#2 clear HDPE)	0	0	1	6	9	14	15	15	16	18	11	21	22	9	33	39	43	61	48	54	60	69
	Plastic bottles (#2 coloured HDPE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0
																				0	0	0	0
Cardboard		0	8	55	184	327	295	298	289	346	371	451	433	495	590	790	688	770	881	866	965	1,080	1,237
																				0	0	0	0
Newspaper	(station prog.)	2	328	768	909	776	596	441	476	576	691	731	716	750	738	736	645	908		1,022	1,138	1,274	1,458
	(curbside prog.)	0	0	0	0	451	494	410	378	248	276	357	425	579	552	572	597	404		455	506	567	649
	sub-total=	2	328	768	909	1,227	1,090	851	854	824	967	1,088	1,140	1,329	1,290	1,309	1,242	1,312	1,285	1,476	1,644	1,841	2,107
Mixed Paper		0	0	0	0	0	339	390	427	529	568	656	645	769	794	802	769	1,045	1,106	1,176	1,309	1,466	1,678
Paper milk cartons								6	7	8	9	10	10	8	8	8	8	10	0	11	13	14	16
Total Recycled		2	392	1,028	1,594	3,500	5,043	4,838	6,171	6,707	6,632	7,015	7,300	9,335	7,568	7,118	7,806	9,093	7,437	10,231	11,394	12,757	14,603
Total Waste Stream - Residential		12,942	12,646	13,262	13,713	16,436	18,483	17,774	18,726	21,004	21,323	22,296	22,578	24,025	22,893	23,530	25,105	27,508	27,260	30,952	34,470	38,594	44,178
Waste Generation - Industrial																							
Total Waste Stream - Industrial		12,942	12,646	13,262	13,713	16,436	18,483	17,774	18,726	21,004	21,323	22,296	22,578	24,025	22,893	23,530	25,105	27,508	27,260	30,952	34,470	38,594	44,178
Paper	33.17%	4,293	4,195	4,399	4,549	5,452	6,131	5,896	6,211	6,967	7,073	7,396	7,489	7,969	7,594	7,805	8,327	9,124	9,042	10,267	11,434	12,801	14,654
Newspaper	1.90%	246	240	252	261	312	351	338	356	399	405	424	429	456	435	447	477	523	518	588	655	733	839
Corrugated Cardboard	10.92%	1,413	1,381	1,448	1,497	1,795	2,018	1,941	2,045	2,294	2,328	2,435	2,465	2,624	2,500	2,569	2,741	3,004	2,977	3,380	3,764	4,214	4,824
Office Paper	9.52%	1,232	1,204	1,263	1,305	1,565	1,760	1,692	1,783	2,000	2,030	2,123	2,149	2,287	2,179	2,240	2,390	2,619	2,595	2,947	3,282	3,674	4,206
Compostable Paper	1.70%	220	215	225	233	279	314	302	318	357	362	379	384	408	389	400	427	468	463	526	586	656	751
Other paper	9.12%	1,180	1,153	1,209	1,251	1,499	1,686	1,621	1,708	1,916	1,945	2,033	2,059	2,191	2,088	2,146	2,290	2,509	2,486	2,823	3,144	3,520	4,029
Plastics	12.93%	1,673	1,635	1,715	1,773	2,125	2,390	2,298	2,421	2,716	2,757	2,883	2,919	3,106	2,960	3,042	3,246	3,557	3,525	4,002	4,457	4,990	5,712
PET (#1)	0.80%	104	101	106	110	131	148	142	150	168	171	178	181	192	183	188	201	220	218	248	276	309	353
HDPE (#2)	0.30%	39	38	40	41	49	55	53	56	63	64	67	68	72	69	71	75	83	82	93	103	116	133
LDPE (#2)	5.21%	674	659	691	714	856	963	926	976	1,094	1,111	1,162	1,176	1,252	1,193	1,226	1,308	1,433	1,420	1,613	1,796	2,011	2,302
Other Plastic	6.61%	855	836	877	906	1,086	1,222	1,175	1,238	1,388	1,409	1,474	1,492	1,588	1,513	1,555	1,659	1,818	1,802	2,046	2,278	2,551	2,920
Glass	1.70%	220	215	225	233	279	314	302	318	357	362	379	384	408	389	400	427	468	463	526	586	656	751
Food/Beverage	0.80%	104	101	106	110	131	148	142	150	168	171	178	181	192	183	188	201	220	218	248	276	309	353
Other Recycables	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Recycables	0.90%	116	114	119	123	148	166	160	169	189	192	201	203	216	206	212	226	248	245	279	310	347	398
Ferrous	7.11%	920	899	943	975	1,169	1,314	1,264	1,331	1,493	1,516	1,585	1,605	1,708	1,628	1,673	1,785	1,956	1,938	2,201	2,451	2,744	3,141
Food/Beverage	0.40%	52	51	53	55	66	74	71	75	84	85	89	90	96	92	94	100	110	109	124	138	154	177
Other Recycables	6.71%	868	849	890	920	1,103	1,240	1,193	1,257	1,409	1,431	1,496	1,515	1,612	1,536	1,579	1,685	1,846	1,829	2,077	2,313	2,590	2,964
Other Non-Recycables	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Ferrous	1.10%	142	139	146	151	181	203	196	206	231	235	245	248	264	252	259	276	303	300	340	379	425	486
Food/Beverage	0.80%	104	101	106	110	131	148	142	150	168	171	178	181	192	183	188	201	220	218	248	276	309	353
Other Recycables	0.30%	39	38	40	41	49	55	53	56	63	64	67	68	72	69	71	75	83	82	93	103	116	133
Other Non-Recycables	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organics	18.54%	2,399	2,345	2,459	2,542	3,047	3,427	3,295	3,472	3,894	3,953	4,134	4,186	4,454	4,244	4,362	4,654	5,100	5,054	5,738	6,391	7,155	8,191
Food	15.43%	1,997	1,951	2,046	2,116	2,536	2,852	2,743	2,889	3,241	3,290	3,440	3,484	3,707	3,532	3,631	3,874	4,244	4,206	4,776	5,319	5,955	6,817
Yard/Landscaping	1.90%	246	240	252	261	312	351	338	356	399	405	424	429	456	435	447	477	523	518	588	655	733	839
Other Organics	1.20%	155	152	159	165	197	222	213	225	252	256	268	271	288	275	282	301	330	327	371	414	463	530
Textiles/Rubber/Leather	2.20%	285	278	292	302	362	407	391	412	462	469	491	497	529	504	518	552	605	600	681	758	849	972
CRD	13.13%	1,699	1,660	1,741	1,801	2,158	2,427	2,334	2,459	2,758	2,800	2,927	2,964	3,155	3,006	3,090	3,296	3,612	3,579	4,064	4,526	5,067	5,801
Asphalt Pavement	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asphalt Roofing	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendixes

– Assumption of As-received HHV, Moisture and Ash Content and 2006 Tonnage

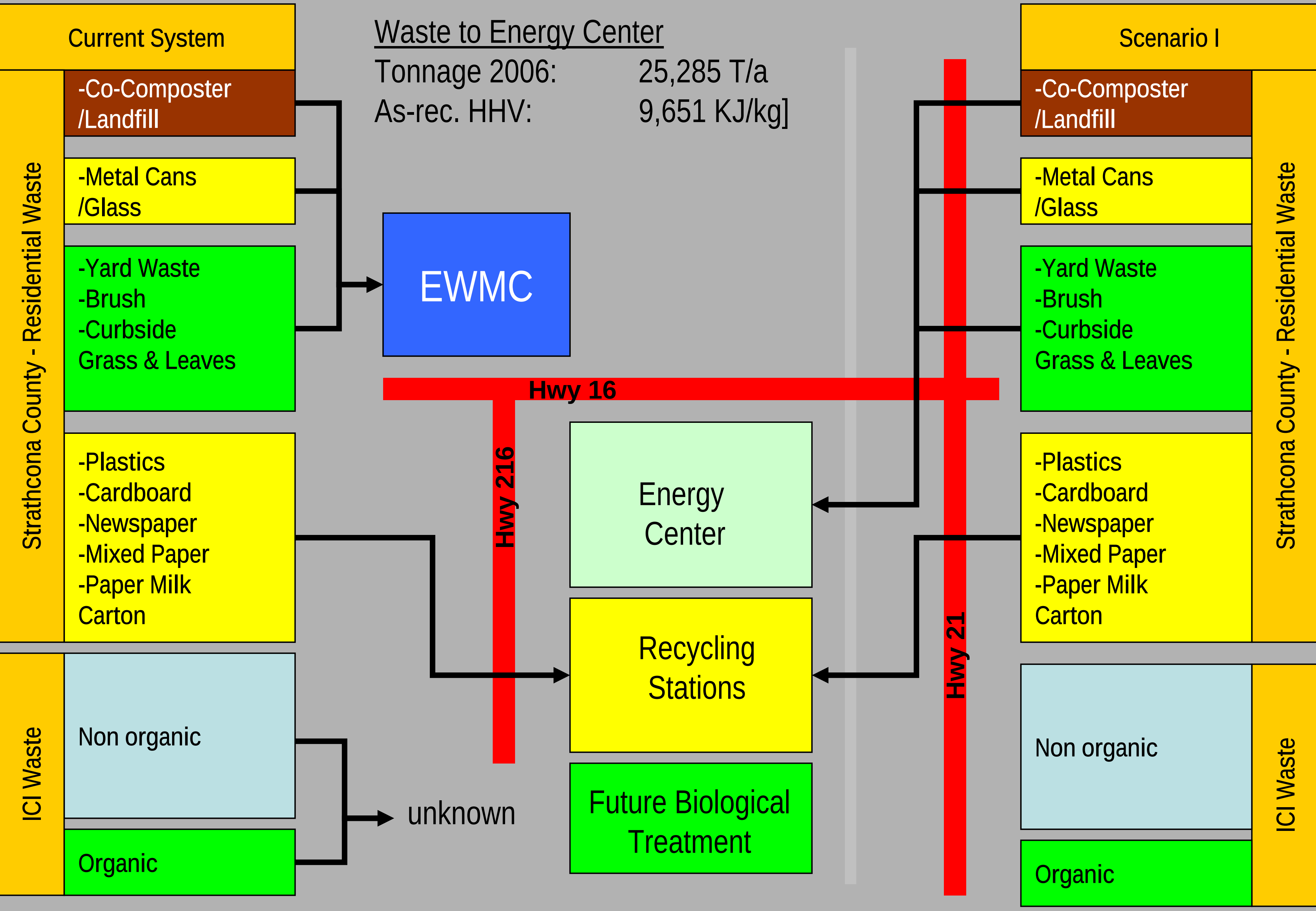
Strathcona County - Environmental Operations

Waste Generation - Residential *		HHV (received)	Moisture Content	Ash Content	2006
		[KJ/kg]	[%]	[%]	[MT]
Total Waste to Landfill (tonnes)		10,467	25%	15%	19,823
	Co-Composter				
	Co- Composter - WF				
	WF				
Recycling - Residential					
Metal Cans		700	2%	98%	99
Glass		139	2%	98%	131
Yard Waste & Brush	(includes brush)	4,578	60%	5%	1,410
Yard Waste	Total Yard Waste	4,578	60%	5%	585
	County compost operation				
	Gore Organic operation site (100% diversion credit)				
	Co-composter (100% diversion credit)				
	Wood/Chips site (100% doverson credit)				
	Working face (no diversion credit)				
Brush	Total Brush	15,431	20%	2%	825
	Chipped (100% diversion credit)				
	Gore Organic operation site (100% diversion credit)				
	Transfer Station				
Curbside Grass & Leaves	(curbside prog.)	6,045	60%	5%	2,412
	County compost operation				
	Gore Organic operation site (100% diversion credit)				
	Co-composter (100% diversion credit)				
	Wood/Chips site (100% doverson credit)				
	Working face (no diversion credit)				
Plastics	Mixed plastics (milk jugs comprise approximately 9.5% of total weights)	32,800	2%	10%	34
	Plastic milk jugs (#2 clear HDPE)	43,429	2%	10%	61
	Plastic bottles (#2 coloured HDPE)	43,429	2%	10%	0
Cardboard		16,268	5%	5%	881
Newspaper	(station prog.)	16,944	6%	6%	1,285
	(curbside prog.)				
	sub-total=				
Mixed Paper		15,000	6%	6%	1,106
Paper milk cartons		26,324	6%	6%	0
Total Recycled					
Total Waste Stream - Residential					

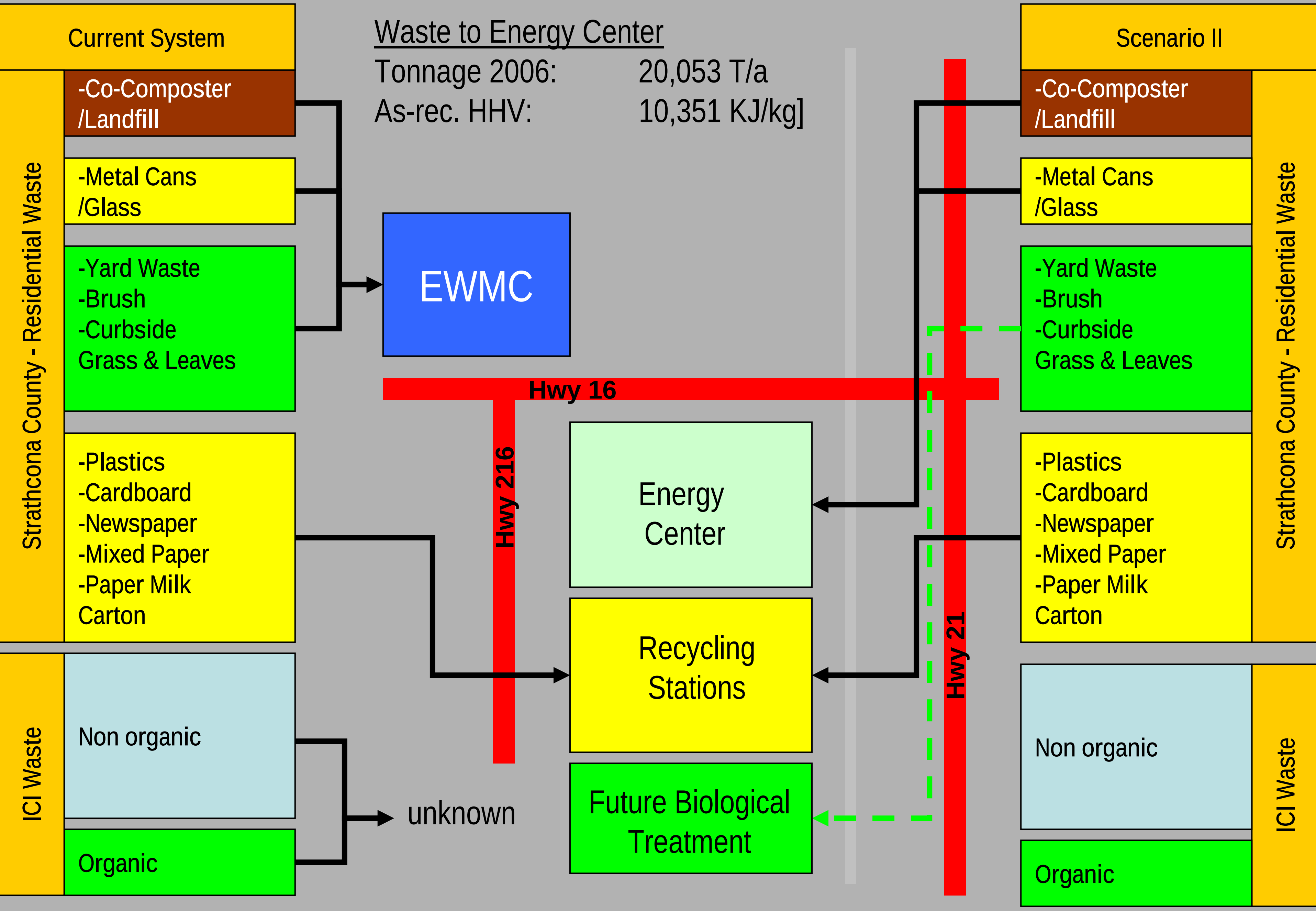
Waste Generation - Industrial		HHV (received)	Moisture Content	Ash Content	2006
Total Waste Stream - Industrial		[KJ/kg]	[%]	[%]	[MT]
Paper	33.17%				
Newspaper	1.90%	16,944	6%	6%	518
Corrugated Cardboard	10.92%	16,268	5%	5%	2,977
Office Paper	9.52%	15,000	6%	6%	2,595
Compostable Paper	1.70%	15,022	6%	6%	463
Other paper	9.12%	15,000	6%	6%	2,486
Plastics	12.93%				
PET (#1)	0.80%	43,429	2%	10%	218
HDPE (#2)	0.30%	43,249	2%	10%	82
LDPE (#2)	5.21%	43,249	2%	10%	1,420
Other Plastic	6.61%	32,800	2%	10%	1,802
Glass	1.70%				
Food/Beverage	0.80%	139	2%	98%	218
Other Recycables	0.00%	139	2%	98%	0
Other Non-Recycables	0.90%	139	2%	98%	245
Ferrous	7.11%				
Food/Beverage	0.40%	700	2%	98%	109
Other Recycables	6.71%	700	2%	98%	1,829
Other Non-Recycables	0.00%	700	2%	98%	0
Non-Ferrous	1.10%				
Food/Beverage	0.80%	700	2%	96%	218
Other Recycables	0.30%	700	2%	96%	82
Other Non-Recycables	0.00%	700	2%	96%	0
Organics	18.54%				
Food	15.43%	2,594	70%	5%	4,206
Yard/Landscaping	1.90%	4,578	60%	5%	518
Other Organics	1.20%	2,594	70%	5%	327
Textiles/Rubber/Leather	2.20%	19,030	7%	8%	600

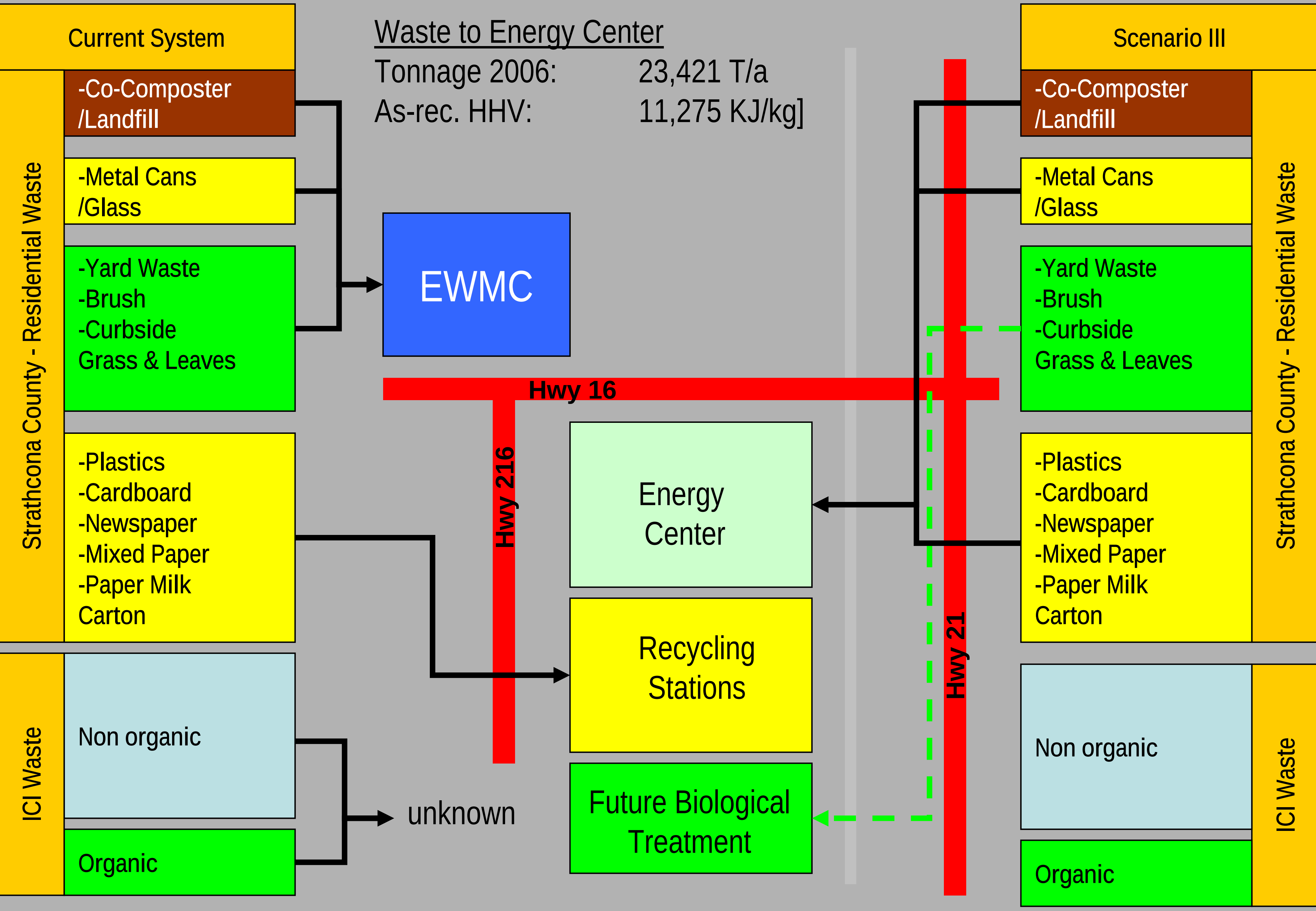
Appendixes

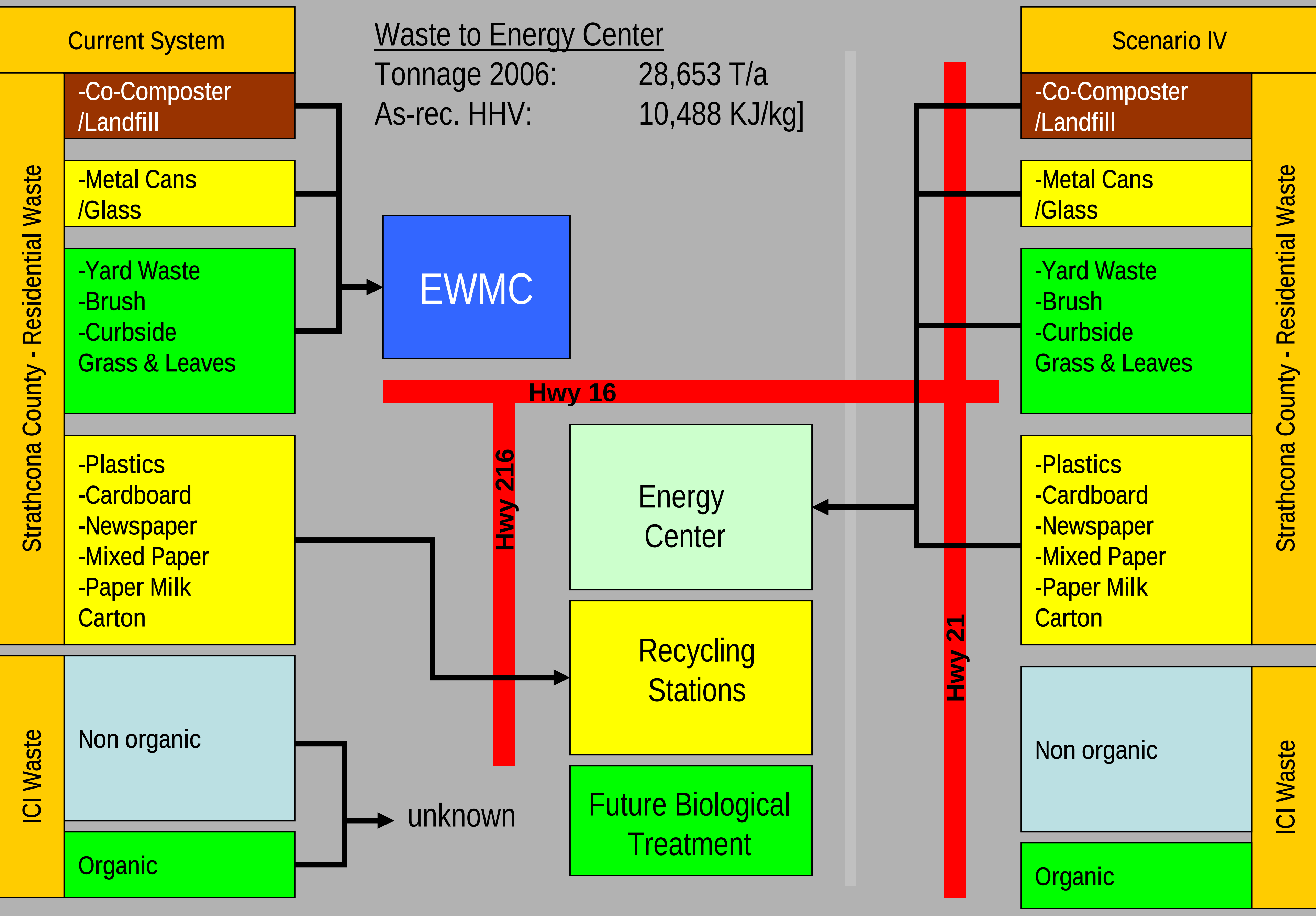
– Solid Waste Scenarios, “Waste to Energy Center”

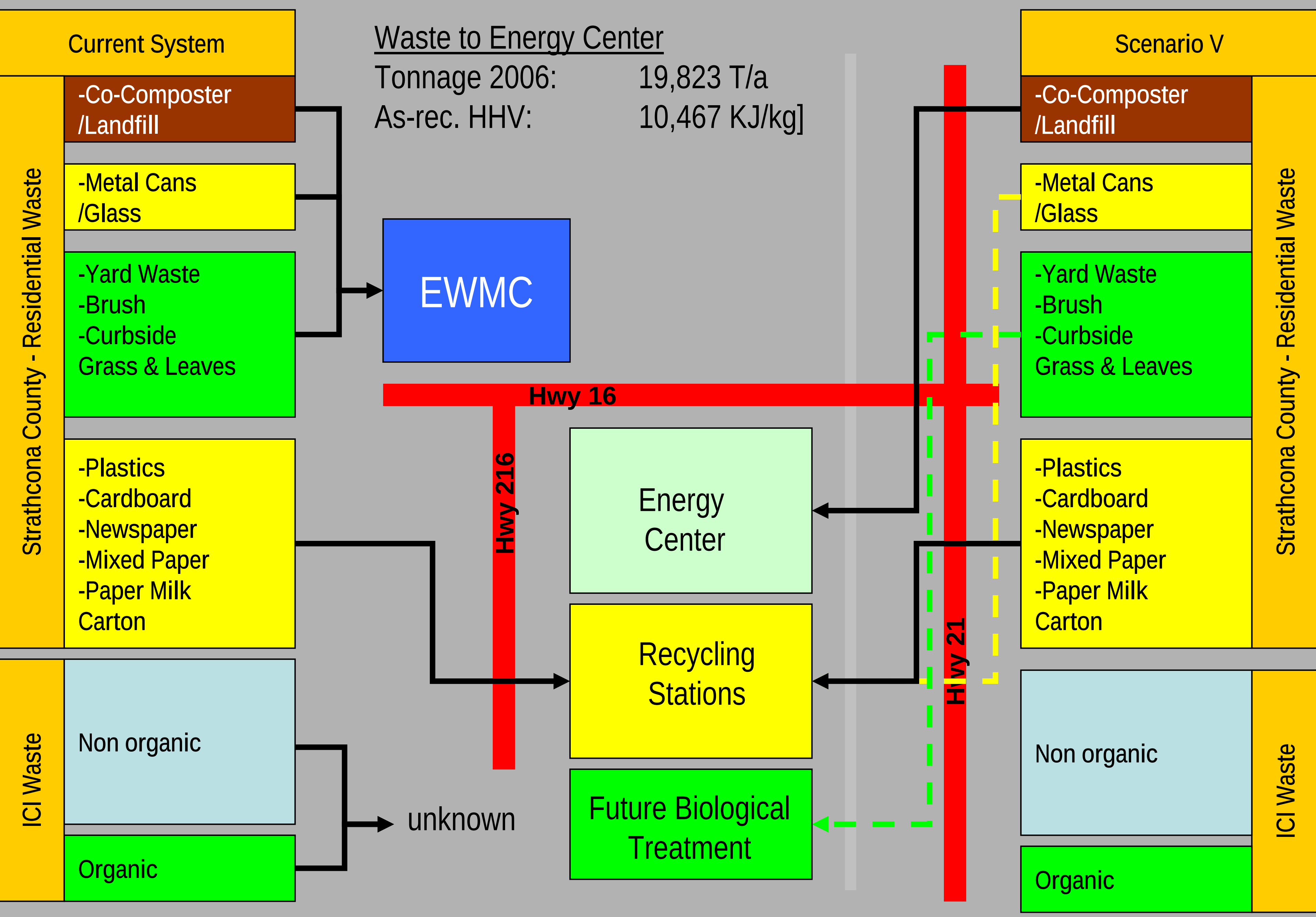


Current System
Waste to Energy Center
Tonnage 2006: 25,285 T/a
As-rec. HHV: 9,651 KJ/kg]
Scenario I
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste -Brush -Curbside Grass & Leaves
-Plastics -Cardboard -Newspaper -Mixed Paper -Paper Milk Carton
Strathcona County - Residential Waste
Non organic
Organic
ICI Waste
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy Center
Recycling Stations
Future Biological Treatment
unknown
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste -Brush -Curbside Grass & Leaves
-Plastics -Cardboard -Newspaper -Mixed Paper -Paper Milk Carton
Strathcona County - Residential Waste
Non organic
Organic
ICI Waste

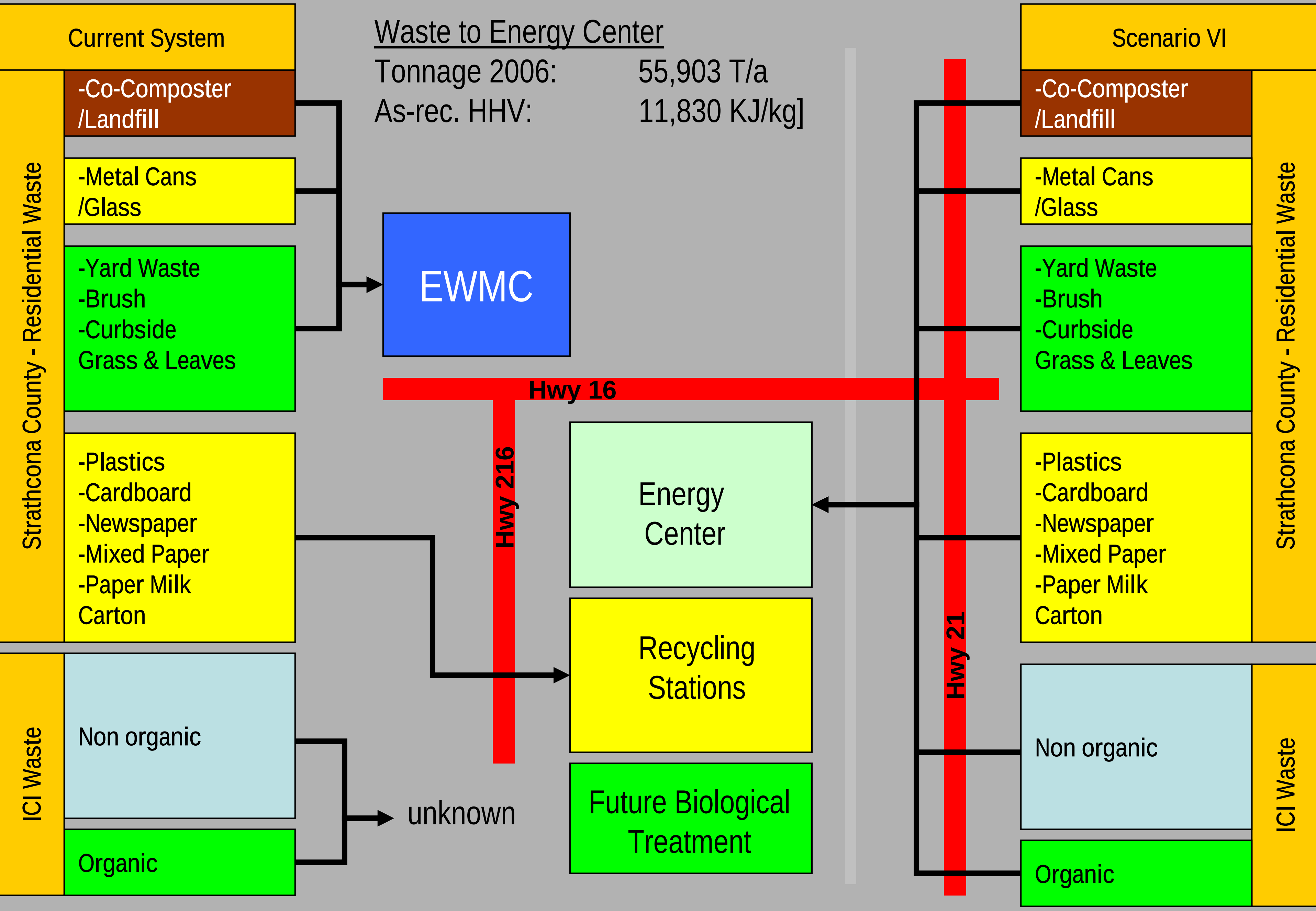

Current System
Scenario II
Waste to Energy Center
Tonnage 2006: 20,053 T/a
As-rec. HHV: 10,351 KJ/kg]
Strathcona County - Residential Waste
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy
Center
Recycling
Stations
Future Biological
Treatment
unknown

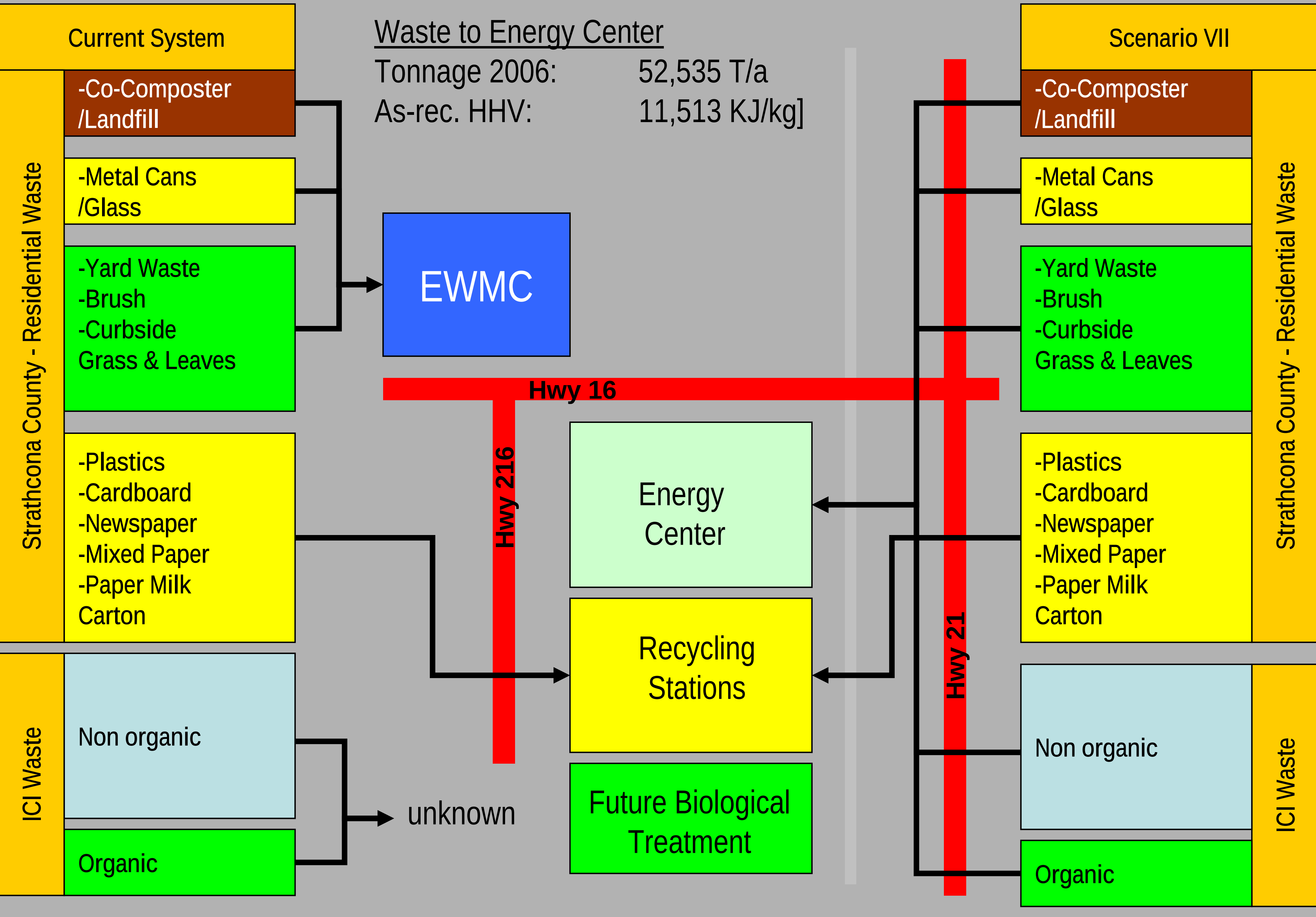

Current System
Waste to Energy Center
Tonnage 2006: 23,421 T/a
As-rec. HHV: 11,275 KJ/kg]
Scenario III
Strathcona County - Residential Waste
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy
Center
Recycling
Stations
Future Biological
Treatment
unknown
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
Strathcona County - Residential Waste
Non organic
Organic
ICI Waste

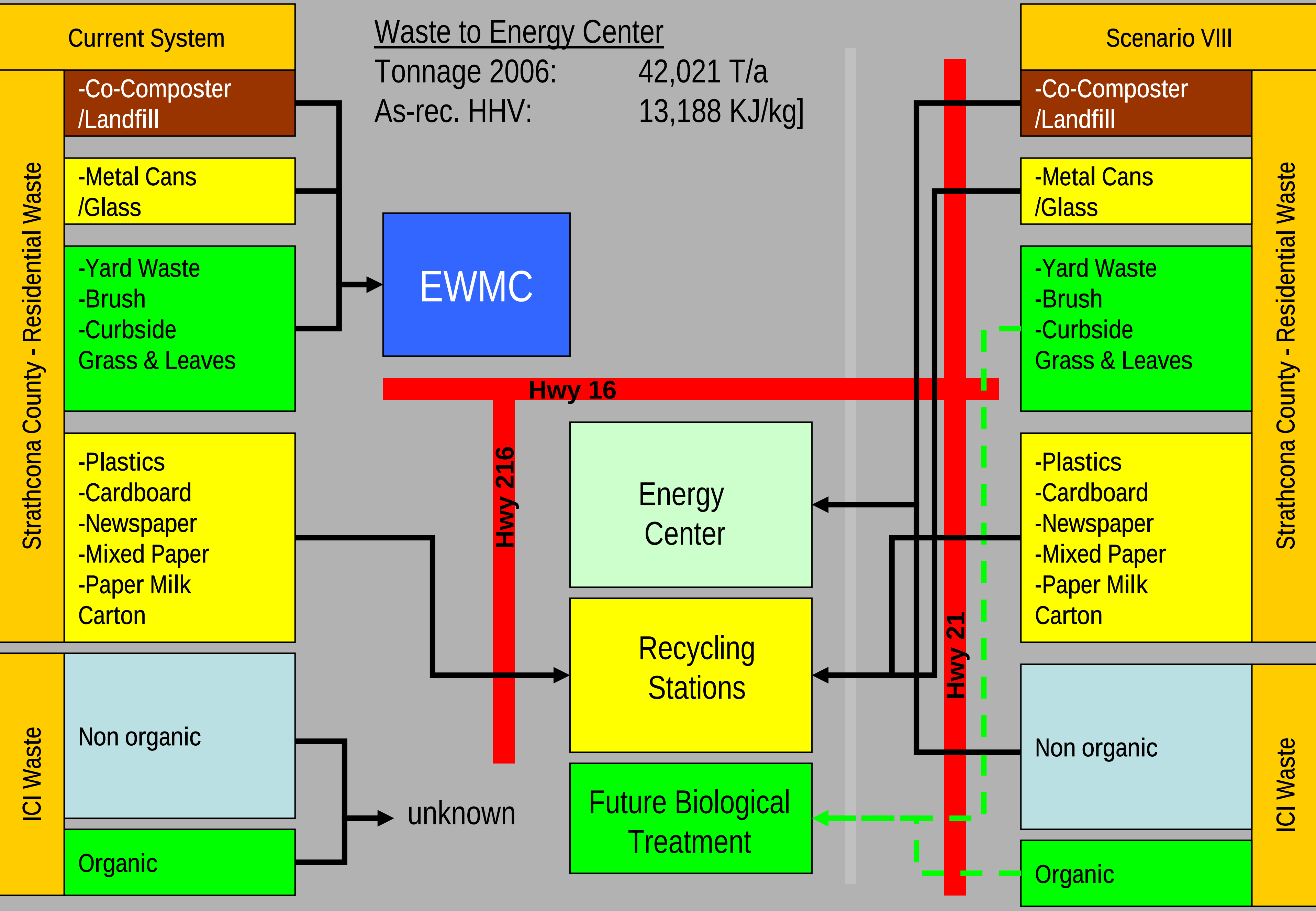

Current System
Waste to Energy Center
Tonnage 2006: 28,653 T/a
As-rec. HHV: 10,488 KJ/kg]
Scenario IV
Strathcona County - Residential Waste
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy Center
Recycling Stations
Future Biological Treatment
unknown
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
Strathcona County - Residential Waste
Non organic
Organic
ICI Waste



Current System
Waste to Energy Center
Tonnage 2006: 19,823 T/a
As-rec. HHV: 10,467 KJ/kg]
Scenario V
Strathcona County - Residential Waste
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste -Brush -Curbside Grass & Leaves
-Plastics -Cardboard -Newspaper -Mixed Paper -Paper Milk Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy Center
Recycling Stations
Future Biological Treatment
unknown
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste -Brush -Curbside Grass & Leaves
-Plastics -Cardboard -Newspaper -Mixed Paper -Paper Milk Carton
Strathcona County - Residential Waste
Non organic
Organic
ICI Waste


Waste to Energy Center
Tonnage 2006: 55,903 T/a
As-rec. HHV: 11,830 KJ/kg]
Current System
Strathcona County - Residential Waste
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste
-Brush
-Curbside Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk Carton
ICI Waste
Non organic
Organic
unknown
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy Center
Recycling Stations
Future Biological Treatment
Scenario VI
Strathcona County - Residential Waste
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste
-Brush
-Curbside Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk Carton
ICI Waste
Non organic
Organic


Current System
Waste to Energy Center
Tonnage 2006: 52,535 T/a
As-rec. HHV: 11,513 KJ/kg]
Scenario VII
Strathcona County - Residential Waste
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Hwy 21
Energy Center
Recycling Stations
Future Biological Treatment
unknown
Strathcona County - Residential Waste
-Co-Composter
/Landfill
-Metal Cans
/Glass
-Yard Waste
-Brush
-Curbside
Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk
Carton
ICI Waste
Non organic
Organic


Waste to Energy Center
Tonnage 2006: 42,021 T/a
As-rec. HHV: 13,188 KJ/kg]
Current System
Strathcona County - Residential Waste
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste
-Brush
-Curbside Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk Carton
ICI Waste
Non organic
Organic
EWMC
Hwy 16
Hwy 216
Energy Center
Recycling Stations
Future Biological Treatment
unknown
Hwy 21
Scenario VIII
Strathcona County - Residential Waste
-Co-Composter /Landfill
-Metal Cans /Glass
-Yard Waste
-Brush
-Curbside Grass & Leaves
-Plastics
-Cardboard
-Newspaper
-Mixed Paper
-Paper Milk Carton
ICI Waste
Non organic
Organic