C3 - Energy. Ideas. Change.

The City of Edmonton Energy Transition Plan

2.3.10 Energy Mapping Feasibility Study

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INTRODUCTION

The City of Edmonton has initiated their Energy Transition Strategy, with goals of decreasing dependence on fossil fuels, reducing the emission of greenhouse gases (GHGs), ensuring resilience of energy delivery systems, increasing electrical and heating self-sufficiency, and positioning Edmonton to participate in sustainable economic opportunities now and into the future.

One way to help achieve many of these goals is to capitalize on waste energy resources. These wasted resources can be in the form of heat that is vented to the atmosphere, natural gas that is flared, or even cooking grease that is disposed of in landfill. In the following sections we will focus on waste **heat** resources and outline the steps necessary to recover and redeploy this resource in useful ways.

WHAT IS ENERGY MAPPING?

At its most basic level, any mapping exercise is about providing a base of knowledge about the relationship between a data set and space. The most familiar maps are scaled representations of cities that show the spatial relationship between geographical features, the roadways and building infrastructure.

The same is true of energy mapping, in that we want to show the geographic distribution of waste heat supply and potential users of that heat resource. Energy mapping is not simply about conducting energy audits of buildings and industrial sites. Energy audits typically uncover opportunities for energy efficiency improvements within an individual facility. While energy auditing is an important step in the energy mapping process, the mapping exercise is a more holistic approach, with the end goal being to define integrated energy solutions across as many end users as possible.

To integrate waste energy streams into the current energy supply in useful ways, there must be some sort of balance between what waste energy is available and what energy is required by those who would receive the heat Both the quantity and the quality of the waste stream must match the needs of potential consumers of that energy. In terms of waste heat, the quality is typically measured by the temperature, with higher temperatures offering greater potential for

re-deployment. Also important to consider is the geographic proximity of the waste heat resource to regions where a demand for heat exists. This is less of an issue in instances where the waste heat quantity and quality allow for the generation of electricity which can be exported to the grid.

Identifying, capturing and re-deploying waste energy in a way that is beneficial to participating companies and to the City of Edmonton requires:

1. Identifying the amounts (MJ), types (steam, air emissions), and qualities (temperatures, pressures, contaminant levels) of waste energy streams across the strategic areas identified.
2. Grouping waste energies by type, quality, and geographic location.
3. Determining economically and environmentally viable uses for the waste energies by proposing and evaluating potential options.
4. Implementing the most viable options along with measuring key performance metrics to demonstrate performance improvements.

Ultimately, the goal of energy mapping is to survey the area of interest to determine which sites have waste heat that is currently discarded and which sites have heating demand, what is the quantity and quality of heat that can be recovered, and what is the physical proximity of heating supply to heating demand. This knowledge can be applied to implement technologies that save money, reduce GHG emissions and enhance productivity.

BENEFITS OF ENERGY INTEGRATION/WASTE HEAT USAGE

Waste heat energy projects can generate multiple economic, financial, and environmental benefits for companies, the municipal and provincial governments, and Albertan citizens.

ECONOMIC AND FINANCIAL BENEFITS

Waste heat projects and energy integration can reduce costs in three general ways:

1) **Save energy costs** – Waste heat energy projects can provide significant energy cost savings to the entity using the waste heat and an additional income to the company capturing the waste. The magnitude of energy and cost savings are dependent on key factors such as the type of waste heat capture and use technologies, characteristics of the facilities involved, and the contractual arrangements between waste heat “supplier”

and consumer (the most simple scenario is one company is in both roles). This helps to keep money flowing within the local economy rather than going elsewhere.

2) **Capital cost savings** – Some waste heat energy projects can save the user from capital cost investments they would have required in absence of the project. For example, buildings on a district heating loop do not require their own heating boilers and the associated operating and maintenance expense. Facilities on a district heating network also have the benefit of increased resiliency to shocks associated with extreme weather events. For example, during the Quebec ice storm of 1998 the electricity grid was knocked out for 4 million people at the peak of the outage. The period of the black-out varied from days to, in some instances, months. At least 25 people died in the affected area in Canada, primarily due to hypothermia. However, complexes such as hospitals and university campuses with integrated power and heating systems were able to continue functioning since they could operate independently of the grid. The same is true of New York City during Hurricane Sandy. While the electricity went out for many parts of the city, those office and residential towers with back-up generators or combined heat and power units (CHP) were able to act independently of the grid and offer tenants electricity and heating services. As a third example, during the 2013 flood in Calgary most of the buildings downtown lost electricity and heating service since the transformers and mechanical rooms are often in the basement. However the ENMAX District Energy Centre continued to operate throughout the flood providing heating services to connected buildings.

3) **Reduce GHG emission costs or provide a GHG income stream** - For Albertan facilities subject to a carbon price under the Specified Gas Emitters Regulation (SGER), waste heat energy projects that reduce their GHG emissions from their baseline will reduce their GHG cost liability. A company can generate cost savings or income by either or a combination of:
    a. reducing the amount of offsets or emissions performance credits they have to purchase,
    b. reducing the amount the company must pay into the technology fund ($15/t$CO_2$e), or
    c. creating emissions performance credits they can sell.

Companies exposed to the SGER regulations can protect against future increases in the carbon pricing (currently proposed at $40/tonneCO2e) by increasing efficiency within their own operations. Recovering heat energy that is currently wasted is a good way to increase efficiency, and may even provide a revenue stream for customers of that waste heat. Facilities, not regulated by the SGER, can generate an income stream from a waste heat reduction project. For example, Millar Western's Whitecourt pulp mill captured low grade waste heat to offset the use of natural gas in its boiler and flash dryers. For operation between 2005 and 2012, they have generated over 55,000 tCO_2e of offset credits which could have brought in almost $780,000 in additional income to the project. [1]The Alberta Government publishes a Quantification Protocol for Waste Heat Recovery projects which provides waste heat recovery projects with a template to quantify the GHG reductions associated with their project.

Energy clustering specifically can achieve greater production efficiency due to large scale installations achieving economies of scale thereby increasing accessibility to more efficient techniques and technologies (Maes, 2011). All of the above cost savings can help waste heat energy projects provide a good return on investment for investors on the supply and demand side.

Ultimately, energy integration including waste heat projects have the potential to increase a firm's productivity and ultimately the productivity of Edmonton's industrial sector. Waste heat capture and use can play a role in helping businesses in Edmonton become more competitive. Maintaining and increasing the productivity and profitability of Edmonton's commercial, manufacturing, and other sectors is in the interest of all Albertans. Improving opportunities in the oil and gas sector is particularly important for Edmonton and the province as a whole right now given the economics for heavy oil and natural gas are eroding due to price of natural gas and the refining process for heavy oil. Also, reduction of waste and improvements in energy efficiency in Alberta's oil and gas sector will improve public perception of this important sector of Edmonton's (and Alberta's) economy.

[1] This assumes Millar Western is receiving $14/$tCO_2e$ for the offsets they are generating.

REDUCE ENVIRONMENTAL IMPACT FROM ALBERTA'S INDUSTRIAL SECTOR

Waste energy projects, along with other aspects of energy integration, have positive environmental impacts by displacing or avoiding the use of fossil fuel-based energy fuels. The result is fewer greenhouse gases emitted, as well as other air emissions such as SOx, NOx, VOCs, CO and particulate matter. These air emissions negatively affect the local air quality and result in health consequences of citizens, so reduction of these emissions increases the quality of life in the city. By using fewer non-renewable resources reduces negative land use and water impacts. These positive environmental impacts can improve a company's relationship with a community and increase their social license to operate.

, Edmonton has unique opportunities when considering waste-heat redeployment. In particular, once a map of known waste heat resources is developed the information can be used to influence decisions around new developments and infrastructure within the city. It is much easier to integrate waste-heat redeployment options such as district heating **before** a new subdivision is designed and built. This type of heating system may be attractive to real-estate developers who can increase the livable floor space by eliminating the need for furnaces and therefore reducing the size of mechanical rooms. The main barrier to implementing these types of symbiotic relationships is the lack of information. This is the gap that Energy Mapping fills.

ROADMAP FOR ENERGY MAPPING IN EDMONTON

Energy mapping is a multi-phase process that builds a foundation that will allow the City of Edmonton to achieve meaningful GHG reductions by capitalizing on energy that currently is lost as waste. To build this foundation, the City of Edmonton should engage in three distinct phases of the project. These include:

Phase 1: Energy Mapping Feasibility Study

- Identify strategic areas or sites that are likely to have waste heat being vented. Engage City of Edmonton business units as needed in the assessment process. These sites could include industrial sites, hospitals, electricity generators, etc.;

- Identify the City of Edmonton facilities that should be included. These could be either generators of waste heat or facilities that have a high heating demand;
- Survey to identify types of industry, commercial and retail space that are willing and interested to participate;
- Engage select companies (heat sources) and communities (recipients) and complete necessary documentation i.e. NDA's) to permits data and information sharing;
- Collect baseline data and information on waste heat streams available across the strategic area;
- Complete comprehensive research and analysis of global best practice for municipal energy mapping;
- Complete a review and analysis of utility bills as needed;
- Conduct site visits and audits as required;
- Convene and facilitate discussion amongst a diverse set of experts to identify potential on-site and regional uses for the waste heat streams identified;
- Evaluate and rank these options in terms of their economic and technological viability;
- Identify those options which should be analyzed in greater detail;
- Provide the City with an analysis of the findings around the opportunities for redeploying waste heat and work with City of Edmonton data, GIS and other mapping functions to produce a map and share the data as required; and
- Communicate the benefits of capturing and redeploying waste heat. More companies with waste heat supply, or potential customers of heat, may show their interest once they learn about the program.

Phase 2: Implement Outcomes

- Provide support services to implement the viable solutions that emerge;
    - Provide business case development support services.
- Provide sustainability services as needed to manage implementation;
- Scale energy mapping processes to a broader set of businesses, municipal, or industrial sites;
- Establish monitoring and reporting mechanisms on key performance metrics to enable companies to claim potential GHG credits; and
- Share the data on City of Edmonton open data site.

Phase 3: Inform and Communicate

- Contribute to the development of a province-wide network that shares knowledge from energy mapping and the deployment of innovative technological solutions.

TIMELINES

The completion of these three phases is a long-term program, with the success of Phase 1 determining if there is a waste heat resource to be financially viable, and if it is worth-while to scale up.

Depending on the number of businesses, buildings, sites and other stakeholders identified, Phase 1 could take up to one year to complete.

Completing of Phase 2 and 3 actions are dependent on the companies involved, the business case to proceed, the availability of technology and any operational issues. Phase 2 could take up to 2 years to complete. As for Phase 3, a province-wide network does not exist at this time, but this vision is part of a number of other Alberta energy mapping projects. This may be an opportunity for the City of Edmonton to host an energy mapping portal on the City's open data website. Both Phase 2 and 3 are outside of the scope for this report.

PHASE 1: ENERGY MAPPING FEASIBILITY STUDY

The first phase in Energy Mapping is to identify the potential size of the waste heat resource that is available. A number of factors must be considered:

- The number of waste heat sources in a city is typically large;
- The entities owning or controlling the waste heat can range from public institutions to private industries. Each of these entities will have their own interests and governance structures to navigate; and
- Waste heat is rarely instrumented or measured.

Identify strategic areas or sites that are likely to have waste heat being vented.

- Candidate sites that are likely to have waste heat resources include heavy industrial and light industrial parks. Key to successful heat capture and redeployment will be identifying industrial areas that are in close proximity to districts or facilities with heating demand such as concentrated housing (ie apartments), shopping centres or recreational facilities like indoor swimming pools;

- Engage City of Edmonton business units and community connections as needed in the assessment process. These sites could include industrial sites, hospitals, electricity generators, etc.; Key city personnel may include, but are certainly not limited to:

    - Charleen Currie – City of Edmonton
        - Industrial Planning Unit
        - Urban Planning and Environment Branch
        - Sustainable Development Department
        - charleen.currie@edmonton.ca
        - 780-496-4082

    - Gary Woloshyniuk – City of Edmonton
        - Senior Environmental Engineer
        - Office of Environment
        - Sustainable Development Department
        - gary.woloshyniuk@edmonton.ca

    - Charlie Barton – City of Edmonton
        - Senior GIS Planner / Team Lead
        - Sustainable Development Department
        - charlie.barton@edmonton.ca
        - 780-496-6075

    - Mike Mellross – City of Edmonton
        - Senior Environmental Project Manager
        - mike.mellross@edmonton.ca
        - 780-442-6975

    - Heather Wheeliker – City of Edmonton
        - Office of Sustainability
        - heather.wheeliker@edmonton.ca
        - 780-496-4611

- Paul Reid – Edmonton Economic Development Corp
  - Economic Analyst
  - preid@edmonton.com
  - 780-969-0447

- Craig Aumann, PhD - Alberta Innovates Technology Futures
  - Project Leader – Energy Efficiency Analysis
  - Craig.Aumann@albertainnovates.ca
  - 780-450-5260

Survey to identify types of industry, commercial and retail space that is willing and interested to participate.

- Generate baseline data and awareness for energy mapping technology and methodology;
- Develop interest and awareness for the project; and
- Invite companies to participate.

Identify the City of Edmonton facilities that should be included.

- Engage City of Edmonton business units as needed in the assessment process; and
- Ideal candidates are City facilities that have high levels of waste heat (ice arenas perhaps) that have close proximity to other City facilities (such as recreation centres or libraries).

Engage selected companies and communities (recipients) and complete necessary documentation (i.e. NDA's) to promote data and information sharing.

- Some industrial or commercial participants may not wish to release information around waste heat, since waste or inefficiency may be seen in a bad light, or the information may reveal confidential information around their processes.

Collect baseline data and information on waste heat streams available across the strategic area. Data that may be required include:

- Publically available data;
- Utility data; and
- Company specific data collection and analysis.

Complete comprehensive research and analysis of global best practice for municipal energy mapping.

- Review case studies, industrial parks and other data to understand global best practice for energy mapping at the municipal level.

Utility bill review and analysis as needed.

- Natural gas utility bills can identify sites with high natural gas consumption. This can indicate sites with high heating demand, and also sites with potentially high waste heat resources; and
- Analyzing monthly natural gas consumption can also illustrate how natural gas consumption varies over time, indicating whether the waste heat resource is consistent or not.

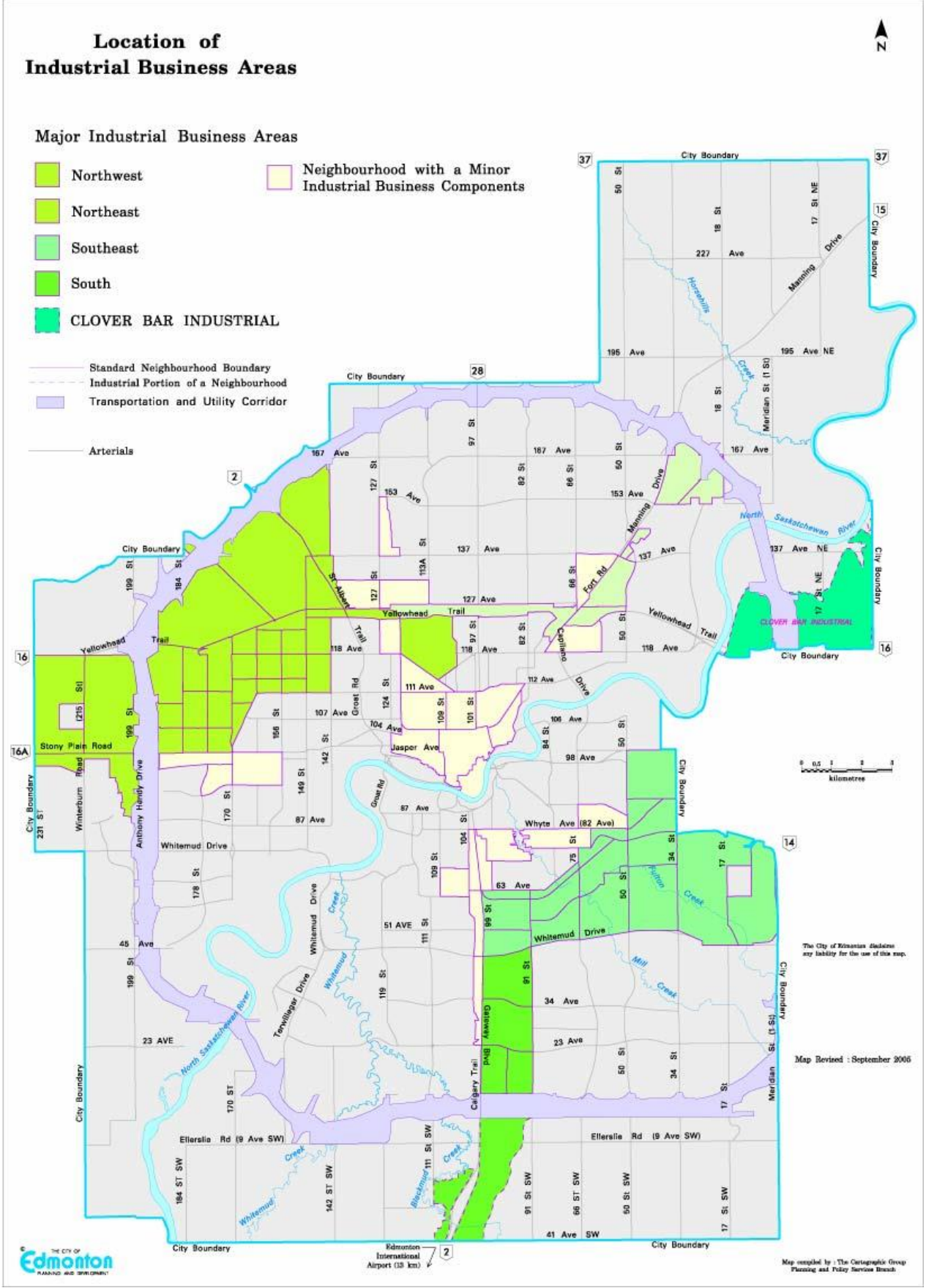
Conduct site visits and audits as required.

- Site visits can achieve a number of goals, not least of which is providing personal contact with participating companies. This will build confidence in the data collection process and allay any fears or suspicion around the use of the data or release to other agencies;
- Identify and collect nameplate information for heat rejection equipment;
- Interview site operators to gather information about typical operations of heating equipment and heat rejection equipment. They may have data logs about flow-rates, temperature in and temperature out of equipment that would indicate the quantity of heat leaving the facility;
- Touring the facility will also give an idea of space restrictions for adding new equipment and systems for capturing waste heat; and
- Build relationships that support data sharing, capacity building and awareness of emerging solution technologies.

Figure 1: Location of Industrial Business Areas within the City of Edmonton.

Early investigation suggests that the Glover Bar Industrial area (due to proximity to AIHA), the Southeast Industrial area (proximity to residential development) and the Northwest Industrial Park (heavy emitter area) offer areas for initial investigation.

Location of Industrial Business Areas



Convene and facilitate discussion amongst a diverse set of local, national and international experts to identify potential on-site and regional uses for the waste heat streams identified. C3 has close to 400 partners, organizations and networks from which to build an expert panel.

- Depending upon the quality of the heat resources identified (temperature, pressure, contaminant levels), many different opportunities exist for redeployment of waste heat and each has their own requirements, benefits and limitations;
- Coordinate efforts with City of Edmonton business units and C3 networks and partners to assemble an expert committee to review and prioritize potential actions;
- High-temperature or high-pressure resources may be used in industrial processes;
- Electrical power generation may be an option by employing Organic Rankine Cycle machines depending on the temperature and consistency of the heat resource;
- Building space heating is often a good match for waste heat resources since buildings require low temperature supply; and
- Waste heat has been successfully redeployed to commercial greenhouse operations.

Evaluate and rank these options in terms of their economic and technological viability.

- One of the key economic considerations is the proximity of points of heating supply to areas with heating demand. This is largely due to the piping required to transport the heat from one location to another;
- Heat sources with high contamination (smoke stacks with particulates for example) have greater challenges and costs to recovery than clean sources; and
- Potential sites with waste heat can be grouped based on similarities of temperature. If high temperature sources are blended with low temperature sources, the greater possibilities surrounding the use of the high-temperature source are diminished. It is best to match the characteristics of the heat source to the requirements of possible end users if possible.

Identify those options which should be analyzed in greater detail.

- Each industrial plant or heat source will have specific challenges to the recovery of that heat.
- Attention should be paid to the pipeline that will carry the heat from the source to the recipient. This will typically be a buried, insulated pipe so it will be important to gain understanding of existing buried infrastructure in the area.

Report on the findings and work with City of Edmonton data, GIS and other mapping functions to produce a map and share the data as required.

- Depending on disclosure arrangements, it is possible that waste heat supply could be included as a layer in a GIS database. This would facilitate the communication and use of the data in implementation phases.

PHASE 2: IMPLEMENT OUTCOMES

Once the results of Phase 1 are fully defined and understood, we can begin to develop the full business case for prioritized implementation of the results. The steps associated with these actions are beyond the scope of this proposal and are inherently based on what emerges from the feasibility study. Under separate contract C3 has the capacity and expertise to:

- Provide support services to implement the viable solutions that emerge.
    - Provide business case development, partnership support, regulatory approval assistance, understand potential carbon offsets, explore innovative funding mechanisms, technology selection, etc.
- Provide sustainability services as needed to manager implementation.
    - Collegial approach to project management that focuses on capacity building, measurable results and effective communication of achievement.
- Scale energy mapping processes to a broader set of businesses, municipal, or industrial sites;
- Establish monitoring and reporting mechanisms on key performance metrics to enable companies to claim potential GHG credits; and
- Share the data on City of Edmonton open data site.

PHASE 3: INFORM AND COMMUNICATE

Energy mapping is a new and growing approach to energy efficiency, GHG reductions and overall productivity improvement. These are the first regional scale energy mapping projects in Canada, which once again demonstrate the City of Edmonton's innovative leadership.

- Contribute to the development of a province-wide network that shares knowledge from energy mapping and the deployment of innovative technological solutions.

OTHER ENERGY MAPPING INITIATIVES IN ALBERTA

ALBERTA'S INDUSTRIAL HEARTLAND

C3 is partnered with Alberta Innovates Technology Futures and the Alberta Industrial Heartland Association in a similar $650,000 (funded by NRCan) waste heat mapping program in Alberta's Industrial Heartland, of which the City of Edmonton is a member. Building on principles which have guided that work, successful waste heat integration in the City of Edmonton will likely include:

- Starting with a small, focused set of companies or waste-heat sources that offer the greatest chance of demonstrating value;
- Once key milestones have been met, more sources and companies can be added and the project scaled up;
- Leverage existing data, information and expert knowledge to keep costs down. Plant managers and facility operators may have data on-hand regarding waste heat sources in their operations;
- Maintaining a focus on working collaboratively with participating companies to build on existing expertise, improve capacity and enhance methods for communicating results; and
- Providing the necessary coaching for participating companies to implement the results.

Merging the results of energy mapping projects in the Industrial Heartland and the City of Edmonton would significantly enhance knowledge of energy consumption across a wide area and provide a rich source of data on which to base business case development for action.

COUNCIL OF OIL SANDS INNOVATION ALLIANCE (COSIA)

COSIA and C3 are partnered to conduct an energy mapping feasibility study in the Regional Municipality of Wood Buffalo area. This offers some significant opportunities:

- Many companies that operate in the Industrial Heartland and the City of Edmonton also operate within COSIA;
- The opportunity to share technology solution and scale accordingly improves the business case for implementation; and

- The total data set that would result from all these projects represents a significant increase in knowledge.

BACKGROUND RESEARCH: THE GLOBAL VIEW ON ENERGY MAPPING

The following are examples from around the world where energy mapping or energy sharing have taken place. Energy integration can strengthen and diversify existing industrial clusters by attracting other companies, or potentially creating new local customers for existing products. Ontario holds two excellent examples of energy integration opportunities acting as a key draw to a region. The Bruce Energy Centre industrial park, in London Ontario, is a 245 acre park adjacent to Bruce Power, a nuclear power reactor producing approximately 5,000 megawatts of electricity and delivering 250,000 lbs/hr of steam to other businesses. Operating since 1996, six of the 18 lots are currently occupied. The industries currently in the Bruce Energy Centre include: an alfalfa dehydration cubing plant, a plastic film extrusion plant, an eight acre greenhouse capable of growing hydroponic vegetables, and a commercial alcohol plant (Bruce Energy Centre, 2011). The Bruce Energy Centre promotes the environmental benefits of their energy supply and the principles of industrial symbiosis when attracting tenants and promoting their industrial park.

The Bluewater Energy Park is a 268 acre industrial park in Sarnia, Ontario, owned by TransAlta who operate a 506 MW cogeneration plant that provides steam and electrical power with "behind-the-fence" benefits acting as the anchor energy industry. Tenants are able to share the benefits of avoiding certain transmission and overhead costs that are typically charged when power is taken from the Ontario power grid. Created in 2009, the only other industry in the technology park to date is Solutions4CO2 Inc. a company who designs, builds, operates, and maintains industrial solutions to capture waste gas and water streams and process them into value added co-products.

Both the Bruce Energy Centre and the Bluewater Energy Park in Ontario use favourable energy prices to attract industry to establish in their industrial park.

District heating networks are more common in Europe than in North America, and these systems facilitate the collection and distribution of waste heat. The dense urban environment in European cities is conducive to district heating, however with the right conditions heat can be

delivered for many 60 km or more so it is very possible for cities in North America as well; especially Edmonton with its strong industrial base.

A good European example of a city using waste heat from an industrial park is Göteborg, Sweden. The neighbouring industrial park is host to a Shell oil refinery and Preem Göteborg Oil Refinery. These industrial plants own the waste heat capture technologies in their operations and sell heat to the municipal heating utility, Göteborg Energi. In 2008 approximately 363 GWh of waste heat was delivered to the system (heat that would otherwise have been vented to the environment) which displaced approximately 37,800 m^3 of fuel oil for heating of the buildings on the district heating network, and resulted in the reduction of 101,700 tonnes of CO_2 emissions (Sustainable Energy Technology at Work, 2011).

BUDGET

Phase 1: Energy Mapping Feasibility Study

The following activities would be completed within Phase 1. An approximate cost would be **$220,000**. A final cost estimate would be provided once the full scope and scale of the project was defined.

- Identify strategic areas or sites that are likely to have waste heat being vented. Engage City of Edmonton business units as needed in the assessment process. These sites could include industrial sites, hospitals, electricity generators, etc.;
- Identify the City of Edmonton facilities that should be included. These could be either generators of waste heat or facilities that have a high heating demand;
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Phase 2: Implement Outcomes

Costs associated with Phase 2 are not addressed in this report and would be defined on a case by case basis pending the outcomes of Phase 1. Cost would be covered by the companies involved, any available grant and incentive programs and through innovative funding mechanisms that returned investment from efficiency achievements back to recover capital investments.

Phase 3: Inform and Communicate

Costs associated with Phase 3 are not addressed in this report and would be part of C3's efforts to develop an energy mapping portal that provided:

- An opportunity for anyone interested in energy mapping to confidentially enter data into a portal that would help define a high level business case to help understand the value proposition for engaging in energy mapping; and
- Access to the best and most current energy consumption data available.

CONCLUSION

Energy mapping represents a significant opportunity for the City of Edmonton to advance the targets and objectives associated with the Energy Transition Plan. Current knowledge and understanding of the qualitative and quantitative of waste energy available is not known. Relationships across and between industrial operators are minimal and focused more on productivity rather than efficiency. Proven new technologies exists that could be put in place once the full opportunity was defined. Research into the energy conservation and GHG reduction potential of industrial energy efficiency suggests a better return on investment that investing is residential upgrades. Energy mapping is a cost effective method for pragmatically defining this potential. Alberta is showing leadership in being the first to conduct regional energy mapping to better understand the energy efficiency potential.

Mapping waste energy in the City of Edmonton will provide critical and essential data, build effective partnerships and relations and support understanding new technologies that can all be put towards understanding the business case for the implementation of energy efficiency actions that save money, reduce greenhouse gas emissions and improve overall productivity. Addressing solutions to climate change has been most successful if championed at the municipal government level. Edmonton already has a very good reputation around promoting (and actually accomplishing) positive change. Mapping potential synergies in waste heat and heating demand is a necessary foundation to facilitating greater energy integration and overall city-wide energy efficiency. This is a foundation that Edmonton can undertake without significant input or support from either the Provincial or Federal levels of government, and the positive outcomes of improving economic and environmental conditions would be credited to the municipal government of Edmonton.