Integrated Community Energy System

Phase 2 Study

FINAL – February 6, 2017

Submitted to:

The Corporation of the City of Burlington
426 Brant Street, City Hall
Burlington, ON, L7R 3Z6

Submitted by:

FVB ENERGY INC

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The preparation of this feasibility study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

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1. Executive Summary

Internationally, District Energy Systems (DES) are recognized as the bridge to scaling up energy efficiency and increasing the uptake of renewable and waste energy sources.

District Energy Systems are an integrative community based approach to providing urban heating and cooling, as well as electricity. DESs supply thermal energy to multiple energy users (buildings) through an interconnecting distribution piping network from a centralized source.

The consideration of a DES is an action plan in Burlington's Community Energy Plan (CEP) to meet the city's energy generation, energy security, and resilience objectives.

In Phase 1 of the Burlington Integrated Community Energy System (ICES) study, it was identified that there could be an opportunity to develop a small DES system in the downtown core because of the existing stock of medium density buildings, the presence of municipal buildings and land, and the forecasted infill redevelopment. The development of a ICES in the City of Burlington would begin to aggregate thermal loads to create the necessary economy of scale for Burlington to implement Combined Heat and Power (CHP), thermal storage, utilize waste energy streams, and renewable energy sources. This Phase 2 of the Burlington ICES study, focused on developing a detailed feasibility study and business case for the two priority projects identified in Phase 1. FVB analyzed the feasibility of four scenarios:

1. A new Integrated Community Energy System (ICES) in Burlington integrated into a new proposed downtown development that would eventually serve City Hall and surrounding buildings – Downtown Node 1 DES: Heating Only.
2. Scenario 1 + Combined Heat and Power
3. Scenario 1 + Combined Heat and Power + Cooling
4. Downtown Node 2 - a CHP based DES system joining 2-3 neighbouring buildings with an electrical energy host and separate thermal energy host to utilize the thermal energy.

The ICES would supply heating and/or cooling to the new and existing buildings in the downtown core, while generating new electricity locally in a small-scale, high efficiency, natural gas fired Combined Heat and Power (CHP) facility (with the exception of Scenario 1).

FVB has determined that the ICES would be commercially viable with an unleveraged Internal Rate of Return (IRR) (20 years) of between 4.4% for the Scenario 1 and up to 10.5% in Scenario 4.

Scenario 2, a DES based on a heating only system with CHP in the downtown core, has an 8.0% Internal Rate of Return (IRR) and the highest 20 Year Net Present Value (NPV) based on a 4% discount rate (without incentive). The business case could be improved if there is a qualifying program similar to the existing IESO saveONenergy Process Systems and Upgrade Initiatives (PSUI) program that incentivizes the development of CHP systems.

Scenario 4, a CHP based DES at a Downtown Node 2 with a number of existing buildings, has a projected 10.5% IRR. The business case assumed the application of a capital incentive under the current IESO saveONenergy Process and System Upgrades Initiative (PSUI) program.

Table 1: Burlington ICES Business Case Highlights[1]

Business Case		Financial (Unescalated)						
Scenario	Description	Capital ('000 k $)	Expenses ('000 k $)	Revenue ('000 k $)	Simple Payback (years)	Projected IRR, 20 Years (%)	Projected IRR (30 Years)	20 Year NPV (4%) ('000 k $)
1	Downtown Node 1 DES Heating Only: 4.57 MW	4,695	535	865	14.2	4.4	7.4	138
2	Downtown Node 1 DES Heating Only: 4.57 MW + 0.6 MW CHP	6,975	834	1,441	11.5	8.0	10.3	2,404
3	Downtown Node 1 Heating and Cooling DES: 4.57 MW + 0.6 MW CHP + 1200 tons CLG	14,618	1,082	2,204	13.0	5.9	8.5	2,394
4	Downtown Node 2 CHP-DES	2,880	428	739	9.3	10.5	12.6	1,978

The development of a Burlington ICES would provide value from added economic development, energy security and reduced GHG emissions to key stakeholders, including the City of Burlington, future real estate developers, and future residents. See Table 2 for a summary of benefits to key stakeholders.

Early action by the City is essential to assure development of the proposed ICES. From FVB's experience, most of the CES that have been developed in Canada over the past two decades have been driven by strong leadership from local government, whether through ownership or policy support, including:

- Helping to secure and grow the customer base, such as requiring buildings to meet sustainability and energy efficiency targets in building design and review a proposal for connection to district energy.
- Requiring new buildings (of a certain size) to be compatible with DE ("DE-ready"),
- Engaging with the local building and development community,
- Securing government grants and coordination with municipal infrastructure
- Incentivizing through energy cost savings, density bonusing, reducing development or permitting fees, and/or other obligations. The incentives can be structured as on-going or only for initial cost savings only.
- The City, and preferably all levels of government, acting as a role model and connecting to a DES and implementing DE-ready hydronic thermal energy systems in their buildings.

For municipalities, infrastructure or sustainability projects that are too large and ambitious are challenging to get off the ground. The uptake of renewable energy sources and alternative technologies is cost prohibitive. In FVB's opinion, the strategy for developing a DES Burlington is to develop a small, cash-flow positive systems, using proven technology and conventional fuels as a base. Once a stable thermal base and district energy operation is established, the City can begin to explore expansion, inter-connection of DES nodes, alternate or waste fuel sources, and new technologies. The start of a DES for the City of Burlington is a step toward the fuel flexibility that will future proof the energy resilience of the City.

[1] The business case numbers are based on modeling and are subject to change.

FVB recommends that the City of Burlington pursue the development of Scenario 2, a heating only DES with CHP in the downtown node. Scenario 2 has a positive business case and presents an opportunity to develop a district energy system that can grow and support new future development in the downtown core and the beginning of increasing energy security and sustainability for Burlington.

Table 2: Summary of Benefits to Key Stakeholders from a Heating, Cooling, & CHP ICES in Burlington

	To Real Estate Developers, Building Owners and Residents	**To the City of Burlington**
Economic Development	• Cost savings, deferred capital costs • Energy savings, stabilized energy costs • Alternative income stream, waste fuel sources	• ROI, local economic development • Job creation, risk mitigation • Infrastructure asset • Increase urban densification and planning
Energy security	• Energy reliability • New local electricity to power new development • Increased efficiency and conservation • Reduce impact from loss of power, heating and cooling that can affect productivity	• Increases potential for uptake of waste heat and renewable energy sources • Increased energy security and resilience with local energy production and future proofing • Fuel flexibility • Potential to develop local fuel sources • Lower demand on existing gas/electricity infrastructure • Reduced electrical peak demand
Environmental and Other	• Green image/marketing, environmental stewardship/leadership • Architectural opportunities: roof free for amenity space and enjoyment of residents • Increase comfort from hydronic heating and possibly radiant floor heating • Improved air quality + health benefits • Potential to provide green roof space	• Environmental benefit from efficiency (initial estimates are between 468 - 1867 tonnes CO_2e GHG reduction per year) • Helps to meet GHG reduction targets and fuel conservation methods • Can reduce water usage in cooling systems • Promote energy awareness • Synergy with potential storm water reduction strategy

2. Report Glossary

Below are typical district energy acronyms which may be referenced throughout this report.

BAU	Business as Usual
CHP	Combined Heat & Power is the generation of both electricity and useful heat from a single source. CHP is also known as Cogeneration.
COP	Coefficient of performance is the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.
DES	District Energy System
DPS	Distribution Piping System
EC	Energy Centre
ETS	Energy Transfer Station
FVB	FVB Energy Inc.
GJ	Gigajoule, is an energy measurement unit.
HEX	Heat Exchanger
kWe	Kilowatt Electrical, a measure of instantaneous electrical demand.
kW_t	Kilowatt Thermal, a measure of instantaneous thermal demand.
ICES	Integrated Community Energy System
LDC	A Load Duration Curve (LDC) is a curve representing thermal load of a system over the number of hours per year.
LHV	Lower Heating Value
MWh_e	Megawatt Hour Electrical, is an energy measurement unit.
MWh_t	Megawatt Hour Thermal, is an energy measurement unit.
MW_t	Megawatt Thermal, a measure of instantaneous heating demand.
O&M	Operation and Maintenance
OAT	Outdoor Air Temperature
TM	Trench meters; a measure of trench distance (as opposed to pipe distance). For distribution piping, pipe distance is double trench distance.
TR	Tonnes of Refrigeration, a measure of instantaneous cooling demand.
ΔT	Temperature Differential (delta T)
VFD	Variable Frequency Drive

3. Introduction

"Accelerating the uptake of energy efficiency and renewable energy in the global energy mix is the single biggest contribution to keep global temperature rise under 2 degrees Celsius (°C) and to reap the multiple benefits of an inclusive green economy. Cities account for over 70 percent of global energy use and, 40 to 50 percent of greenhouse gas emissions worldwide. In several cities, heating and cooling can account for up to half of local energy consumption. Any solution for the climate and energy transition must explicitly address sustainable urban heating and cooling, as well as electricity. ***One of the least-cost and most efficient solutions in reducing emissions and primary energy demand is the development of modern (climate-resilient and low-carbon) district energy in cities.*** *To facilitate this energy transition, UNEP has initiated a new initiative on District Energy in Cities, as the implementing mechanism for the SE4ALL District Energy Accelerator." – United Nations Environment Programme*[2]

The City of Burlington through their Community Energy Plan (CEP), completed in 2014, included an action to consider the feasibility of developing a District Energy System (DES) with Combined Heat Power to enable Burlington to achieve the goal of developing sustainable local generation. The development of a DES for the City of Burlington will also contribute to the goals of energy efficiency, security and renewable energy.

In Phase 1 of the Burlington Integrated Community Energy System (ICES) study, it was identified that there could be an opportunity to develop a small DES system in the downtown core because of the existing stock of medium density buildings, the presence of municipal buildings and land, and the forecasted infill redevelopment. The development of a ICES in the City of Burlington would begin to aggregate thermal loads to create the necessary economy of scale for Burlington to implement Combined Heat and Power (CHP), thermal storage, utilize waste energy streams, and renewable energy sources.

This feasibility study is Phase 2 of the Burlington ICES study; the objective of Phase 2 is a detailed feasibility assessment and business case for the two priority projects identified in Phase 1:

1. The Downtown Core Node, centered around the City Hall and the Burlington Performing Arts Centre, and
2. A CHP based district energy system to offset the high cost of electricity to three (3) existing electric resistance heating multi-unit residential buildings.

The study also included a discussion and recommendations on the master planning process and Official Plan policies with respect to the Mobility Hubs: Appleby, Burlington, and Aldershot GO Stations.

[2] United Nations Environmental Programme: District Energy in Cities Initiative http://www.unep.org/energy/districtenergyincities

4. Technical: DES Opportunity

4.1. Burlington Downtown Core Nodes

The Burlington Downtown Core represents a promising opportunity for district energy for several reasons:

- The presence of municipal assets, primarily City Hall and the Burlington Performing Arts Centre and municipally controlled lands in the downtown core; the City also owns a number of surface level parking lots.
- Existing medium multi-unit residential buildings and building density
- The relatively large volume of anticipated future infill and redevelopment in and around the downtown core, over 100,000 m² (1,000,000 ft²) of new Gross Floor Area (GFA) is expected in the next 10 years, all in the form of multi-unit residential or commercial buildings within a 1.0 km radius of City Hall
- Proximity to the Joseph Brant Hospital as an anchor load for the DES
- Interest by City to develop a showcase DES installation

4.2. Potential DES Customer Buildings and Energy Load Profiles

The target customer buildings are generally high density buildings clustered close together (i.e. multiple buildings over 10,000 m² (100,000 ft²)) as close as possible to potential energy centre sites. Buildings must have a centralized hydronic heating and cooling system, preferably with a basement level district energy connection (i.e. basement level boiler and/or chiller room or full size/reverse return building hot and chilled water piping); connections to penthouse mechanical rooms can be more costly. Existing buildings with boilers, chillers & cooling towers nearing expected end of life, buildings between 10-20 years of age present an opportunity and/or new building sites are good candidates for connection to a proposed DES.

FVB, together with The City of Burlington, compiled a list of target buildings and building statistics within the catchment area using a combination of internet sources, meetings, and electronic/telephone building surveys.

A list of potential customer buildings in the Burlington Downtown Core and surrounding areas were identified. A summary of the estimated heating and cooling loads and energy are summarized in Table 3.

Location of potential customer are shown on the SK-6255-001 in Appendix 1.

FVB determined each building's peak load and annual energy requirements generally using up to three (3) methods (where data was available) to converge upon a figure:

1. Fuel and electricity data provided by the building owners or property managers
2. Comparison to available data on existing installed equipment capacities and/or building design data, using Equivalent Full Load Hours (EFLH)[3] generally found for that type of building.

[3]EFLH 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.

3. Empirical demand and energy intensity data based on watts per square meter and kilowatt hours per square meter per year for similar building types from FVB's database, adjusted for climatic conditions and experience factors.

Table 3: Burlington DES: Potential Customer Buildings Load/Energy Summary

City of Burlington - District Energy Business Case								
Building Statistics / Estimated Thermal Loads and Energy								
DES Node	Bldg #	Building/Developer Name Address/Location	Approx Gross Floor Area (m2)	Estimated Heating Load (kW)	Displaced Heating Energy (MWh)	Estimated Cooling Load (tons)	Displaced Cooling Energy (ton-hours)
1	DOWNTOWN DES NODE 1						
		Node 1 (Subtotal)	169,100	10,470	24,837	2,390	2,868,000
2	DOWNTOWN DES NODE 2						
		Node 2 (Subtotal)	76,817	4,610	11,525	920	1,104,000
3	JOSEPH BRANT HOSPITAL NODE						
		Node 3 (Subtotal)	112,950	10,810	27,025	1,660	2,652,000
4	BRANT/GHENT REDEVELOPMENT NODE						
		Node 4 (Subtotal)	69,703	4,180	10,450	830	996,000
5	LAKESHORE EAST REDEVELOPMENT NODE						
		Node 5 (Subtotal)	27,029	1,620	4,050	320	384,000

The development of a business case for DES for the City of Burlington is challenged by the lack of clustered, large density and/or thermal energy intense users. In addition, though it is technically feasible to connect existing buildings to a new DES, the cost, timing and perceived risk (vs. status quo/BAU) can be prohibitive to both the DES and the building owner.

The envisioned strategy is for Burlington to begin the development of a DES system with small system nodes that may eventually be interconnected. The systems would be started with proven technology and conventional fuels until there is a business case to develop or pursue alternate, renewable, local or waste energy streams. The key is to aggregate building thermal load and developing a distribution network for the City of Burlington.

For the financial modelling, it is assumed that 5 buildings are connected in the downtown core:

1. The DES would begin with a new development #1 within the downtown core, assumed to be approximately 300 m from Burlington City Hall.
2. An existing downtown building, within approximately 200 m of the new development would be connected in Year 2.
3. The Burlington City Hall is connected in Year 3.
4. A new development #2 or existing building connected in Year 4, within approximately 300 m of the DES.
5. A new development or existing building load within 50 m of the DES is connected in Year 5;

A summary of the DES connected building loads assumed in the financial model are shown in the Table 4.

Table 4: Target Building Connections Assumed in DES Business Case

Year	Building/Developer Name Address/Location	Gross Floor Area (m2)	Estimated Heating Load (kW)	Displaced Heating Energy (MWh)	Estimated Cooling Load (tons)	Displaced Cooling Energy (ton-hours)
DOWNTOWN DES NODE						
1	New Downtown Development #1	27,881	1,670	4,175	330	396,000
2	Existing Building #1	13,941	840	2,100	170	204,000
3	City Hall 426 Brant St.	8,553	510	663	180	216,000
4	New Downtown Development #2 or Existing Building	18,587	1,490	3,725	400	480,000
5	New Downtown Development #3 or Existing Building	19,981	1,200	3,000	240	288,000
	Subtotal		**5,710**	**13,663**	**1,320**	**1,584,000**
	Diversification (0.8 Heating/0.9 Cooling)		4,570		1,190	

A stand-alone energy centre was initially considered but the business case was deemed unfavorable because of:

1. High capital costs for the distribution piping; an embedded energy centre would eliminate the pipe service cost for the first development.
2. The low density stock of existing buildings and relatively small heating/cooling loads
3. The value of the land in the downtown core and (un)likelihood of the City developing a new building
4. The aesthetic considerations.
5. The standalone facility has the challenge of stack height in relation to nearby buildings; the general rule is that the stack must be as tall as the "adjacent" buildings.

Based on the above, it was assumed that the energy centre and CHP installation would be embedded in a new building development within the Downtown Core for Scenarios 1 to 3. The heating plant would be designed to serve the 5,710 kW of heating load and 1,320 tons of cooling load. A 0.8 diversification[4] factor was assumed for heating and a 0.9 diversification factor for cooling; this would result in a 4,570 kW heating plant and an 1,190 ton chilled water plant. The heating energy centre would be designed with an N+1[5] redundancy factor and the chilled water plant with N redundancy.

[4] Diversification = Sum of Total Demand (of each customer/load) / Maximum Demand Observed and accounts for the fact that the heating loads of all of the customers are not coincident.

[5] N+1 describes a level of redundancy, where there is duplication of a component in the event of a failure. N would represent the base number of components or equipment required to satisfy the system and the +# would indicate the level of backup in the event of a failure in the N component. For example, in a heating system where 3 boilers, each at 500 kW are required to satisfy the heat load. A N+1 redundancy design would have 4 x 500 kW boilers such that in the event of a failure, the level "N" can still be maintained. Typically the "+#" will refer to the loss of the largest size unit.

The cost associated with the host building was not considered in the financial analysis of the DES.

I. Scenario 1: DES in the Downtown Core – HEATING ONLY

Scenario 1 assumed that a heating only DES would be developed in the downtown core.

The energy centre would utilize natural gas fired hot water boilers for peaking/backup. The hot water boilers would be installed in either a below grade (or possibly penthouse level mechanical room). Provision could be made to install additional capacity to satisfy the system load if the DES is anticipated to grow over time.

Hot water generated in the energy centre would be delivered to customer buildings through a new buried piping network that would be developed with the addition of the first customer outside of the new development.

The heating distribution pipe sizes are based on a differential temperature of 30°C for heating and a pressure gradient of 200 Pa/m. The temperature of the district system will be dictated by the customer buildings; a 95 - 65 °C district heating system is suitable to supply buildings designed with low heating water temperature, whereas a 110 – 80°C is suitable to supply buildings designed with a standard "180/160°F" system. The capital cost assumes an open cut construction during regular working hours. The material for the underground heating distribution system is based on European ST37.0, DIN 2458 (EN253 Standard) thin walled steel pipe, insulated with polyurethane (PUR) insulation, and covered with a high density polyethylene (HDPE) protective outer jacket.

A preliminary distribution piping concept was developed, including routing and sizing to provide district heating services to the targeted buildings. The financial analysis assumes a pipe route of approximately 690 m (trench) with a main line size of 150 mm (6") capable of serving 5.0 MW of heating load.

Each customer building is connected to the DES via an energy transfer stations (ETS) or building interface connection. The ETS is physically located in each building and replaces the use of the boilers. It is assumed that that each building is indirectly connected to the main distribution system, meaning that the building and DES systems are hydraulically separated by a heat exchanger. The basic ETS is comprised of isolating valves, heat exchangers, modulating control valves, a digital controller, and energy meters.

The ETS will be designed, installed and owned by the DES utility. All costs to connect the building to the DES are borne by the DES utility; i.e. no capital costs are incurred by the building owner – this will be discussed further with respect to the district energy rate structure.

Additional capital may be spent on the connection of existing buildings to retrofit their systems to effectively utilize the district heating system such as risers to penthouse mechanical rooms.

II. Scenario 2: DES in the Downtown Core – HEATING ONLY + CHP

Scenario 2 is the same as Scenario 1, but incorporates a 600 kWe CHP unit. The 600 kWe CHP unit would be installed in behind-the-meter (BTM) configuration at the energy centre and can provide electricity for both the energy centre and the host building(s).

The heat recovered from the engine and exhaust gases would be used to heat hot water that would be utilized in the district heating system and delivered to customer buildings for space and domestic hot water heating.

III. Scenario 3: DES in the Downtown Core – HEATING ONLY + CHP + Cooling

Scenario 3 assumes a heating and cooling DES would be developed in the downtown core. Similar to Scenario 1, it is proposed that it would be embedded in a new development in the downtown core.

The energy centre would utilize natural gas fired CHP system and hot water boilers for peaking and backup. The hot water boilers and CHP would be installed in either a below grade (or possibly penthouse level mechanical room). Chilled water would be produced using electric centrifugal chillers and wet cooling towers; the cooling towers would be located on the roof.

Hot water and chilled water would be generated in the energy centre would be delivered to customer buildings through a new buried piping network that would be developed with the addition of the first customer outside of the new development. It is assumed that the cooling pipe is installed in a common trench with the heating pipes in 1 x 4 configuration.

The cooling distribution pipe sizes are based on a differential temperature of 8.3°C for cooling and a pressure gradient of 200 Pa/m. The temperature of the district system will be dictated by the customer buildings; a 4 – 12.3 °C (39.2 – 54 °F) district cooling system is suitable to supply buildings designed with a 7.2 °C chilled water supply with a corresponding 14.4 °C return (45 – 58 °F). The capital cost assumes an open cut construction during regular working hours. The material for the underground cooling distribution system is based on a combination of fusion bonded epoxy coated standard schedule pipe and/or preinsulated thin wall steel pipe. (The heating piping is described in Scenario 1 above).

IV. Scenario 4: Downtown Node 2 DES + CHP

It is assumed that a heating only DES would be developed centered around a CHP installation at a downtown building location with an high electrical load; this building would be the electrical host. By having a DES system, a CHP project could be implemented to reduce their electricity costs and provide thermal energy to neighbouring buildings for space and DHW heating.

For the financial modelling, it is assumed that:

1. The electrical connection for a building or number of buildings could be aggregated and considered as one utility address, with a single owner.

2. A 600 kWe CHP unit is installed in a behind-the-meter (BTM) configuration and the project qualifies under the IESO’s saveONenergy Process, Systems, Upgrades, and Improvement (PSUI) program
3. The DES would connect to two existing multi-unit residential buildings within 250 m of the CHP location.
4. The CHP would be located on the property of the electrical host.

The energy centre would be comprised of a containerized Combined Heating and Power (CHP) unit complete with distribution pumping. The CHP unit would produce electricity that would be sold to electrical host at a discounted rate. The heat recovered from the CHP unit would be used to produce hot water that would be distributed to customer buildings for space heating and domestic hot water (DHW) heating. It is assumed that the natural gas supply by Union Gas is adequate for the CHP projects proposed for the Burlington ICES.

The heating distribution pipe sizes are based on a differential temperature of 20°C for heating and a pressure gradient of 200 Pa/m. The temperature of the district system will be dictated by the customer buildings; a 95 - 75 °C district heating system. The capital cost assumes an open cut construction during regular working hours. The material for the underground heating distribution system is based on European EN253 Standard, thin walled steel pipe, insulated with polyurethane (PUR) insulation, and covered with a high density polyethylene (HDPE) protective outer jacket.

The financial analysis for the Burlington DES Node 2 scenario assumes a pipe route of approximately 250 m (trench) with a main line size of 150 mm (6”) capable of serving 3.0 MW of heating load.

No allowance has been made in the capital cost for a backup/peaking boiler plant, it is assumed that the customer buildings connected to the Burlington Towers CHP would operate and maintain their existing hot water boiler systems.

5. Concept Costing

This section discusses the amount of capital investment to construct, operate and maintain the proposed district energy System.

5.1. Capital Cost Estimate

The preliminary capital cost of each district energy concept scenario has been estimated based on established rules of thumb unit costs based on FVB’s previous implementation projects. Overall accuracy is estimated to be Class C +25%/- 15%. The capital cost estimates are exclusive of any energy saving or capital cost incentive programs that may be available, this is further discussed in the business case. Table 5 summarizes the capital cost estimate for each scenario.

Table 5: Capital Cost Summary by Scenario – Full Buildout

		2017 Capital Cost ('000 k $)			
Scenario	Description	Energy Centre	Distribution Piping System	Energy Transfer Station	Total ('000K $)
1	Downtown DES Heating Only: 4.57 MW	1,600	2,095	1,000	**4,695**
2	Downtown DES Heating Only: 4.57 MW + 0.6 MW CHP	3,880	2,095	1,000	**6,975**
3	Downtown Heating and Cooling DES: 4.57 MW + 0.6 MW CHP + 1200 tons CLG	8,680	3,938	2,000	**14,618**
4	Downtown Node 2 CHP-DES	1,505	875	500	**2,880**

The capital investment for a DES in Burlington ranges from $2,880,000[6] for a heating only, CHP based DES in Scenario 4 to $14,618,000 in Scenario 3 to implement a heating and cooling DES in the downtown core. These costs are generally inclusive of major equipment, installation costs, engineering, and contingency. The capital cost estimates do not include:

- Application fees for TSSA and Environmental Compliance Approvals
- Owner's soft costs (i.e. legal and internal resource costs), administration, marketing and sales.
- Cost impact due to major currency exchange rates,
- Contaminated soils disposal and removal,
- Development and/or easement costs,
- Value added taxes, HST.
- Financial incentive from Government/Utility

5.2. Annual Operating and Maintenance Cost Estimate

The annual cost to operate the district energy systems and maintain the equipment plays a significant role in the viability of a district energy project. The following table summarizes this estimated annual costs at full buildout for each scenario.

Table 6 Annual DES Expenses by Scenario – Full Buildout

		2017 Expenses ('000 k $)				
Scenario	Description	Natural Gas	Electricity	O&M	Labour/Admin	Total ('000K $)
1	Downtown DES Heating Only: 4.57 MW	370	22	58	85	**535**
2	Downtown DES Heating Only: 4.57 MW + 0.6 MW CHP	525	48	151	110	**834**
3	Downtown Heating and Cooling DES: 4.57 MW + 0.6 MW CHP + 1200 tons CLG	525	201	211	145	**1,082**
4	Downtown Node 2 CHP-DES	299	0	104	25	**428**

[6] The capital cost for Scenario 3 is $3,780,000 and assumes an incentive amount of $900,000 under the IESO saveONenergy Process, Systems, Upgrades and Initiatives Program.

6. Business Case

6.1. BAU Costs (Self-Generation Costs)

Customers BAU costs, otherwise referred to as avoided or self-generation costs, include the total costs of owning, operating and maintaining heating and/or cooling in-building systems instead of a connection to a DES. This includes utilities, operation and maintenance (including preventative and corrective maintenance, water treatment, and consumables), labour and administration, insurance, and avoidable capital and capital replacement. The BAU costs form the basis for the district energy rates and the revenue for the DES.

A typical BAU cost analysis is shown in Table 7.

Table 7: Typical BAU Cost Analysis

City Hall (426 Brant St.) Self-Generation Costs - Heating and Cooling Budget Summary Jaunary 18, 2017			
Line	**Heating & Cooling Self-Generation Annual Costs (Boiler & Chiller Related)**	**Htg Costs** ($)	**Clg Costs** ($)
1	**Estimated Fuel Consumption**		
2	Peak Heating Load (kW)/Cooling Load (tons)	510 kW	180 tons
3	Equivalent Full Load Hours	1300	1200
4	Annual Heating/Cooling Energy Requirement (MWh)	663 MWh	216,000 ton-hrs
5	Seasonal Efficiency/Coefficient of Performance	70.0%	3.5
6	Total Annual Fuel (Gas)/(Electricity) Input (MWh)	947 MWh	217 MWh
7	Total Annual Fuel (Gas) Input (GJ)	3,410 GJ	N/A
8	Current Average Fuel Price	$6.50 /GJ	$140.00 /MWh
9	**Total Annual Fuel Cost**	$31,200	$33,500
10			
11	**Current Operation & Maintenance**		
12	Electricity Cost (associated with heating plant only)	$600	N/A
13	Water & Chemicals	$1,000	$1,300
14	Equipment (Boiler,Chiller,Cooling Tower) Insurance	$1,600	$3,200
15	Equipment Maintenance (Preventative & Repair)	$5,400	$8,000
16	Reserve Fund (N/A)	$0	$0
17	Administration & Management	$700	$700
18	Labour Cost	$6,500	$6,500
19	**Total Operation & Maintenance Cost**	$15,800	$19,700
20			
21	**Capital Replacement**		
22	Boiler/Chiller Plant Capital and/or Replacement Cost	$213,000	$432,000
23	**Total Capital Annualized at 6% over 20 years**	$18,600	$37,700
24			
25	**Annual Self-Generation Cost**	**$65,600**	**$90,900**

6.2. Revenue: Thermal and Electricity

Revenue for the proposed DE system comes from two sources:

1. Thermal Revenue - displaced natural gas costs, electricity, operation and maintenance costs, and capital that the buildings would have otherwise had to spend to provide heating and cooling.
2. Electricity revenue from CHP, if applicable.

6.2.1. Thermal Revenue

The district energy rates are designed to offer a competitive proposition to the self-generation costs for the hot water customers as an alternative to installing their own individual boiler plants, see Figure 1. The DES can structure the capacity and/or energy charge to provide a savings to the customer to incentivize connection, so long as enough revenue is generated for a positive business case.

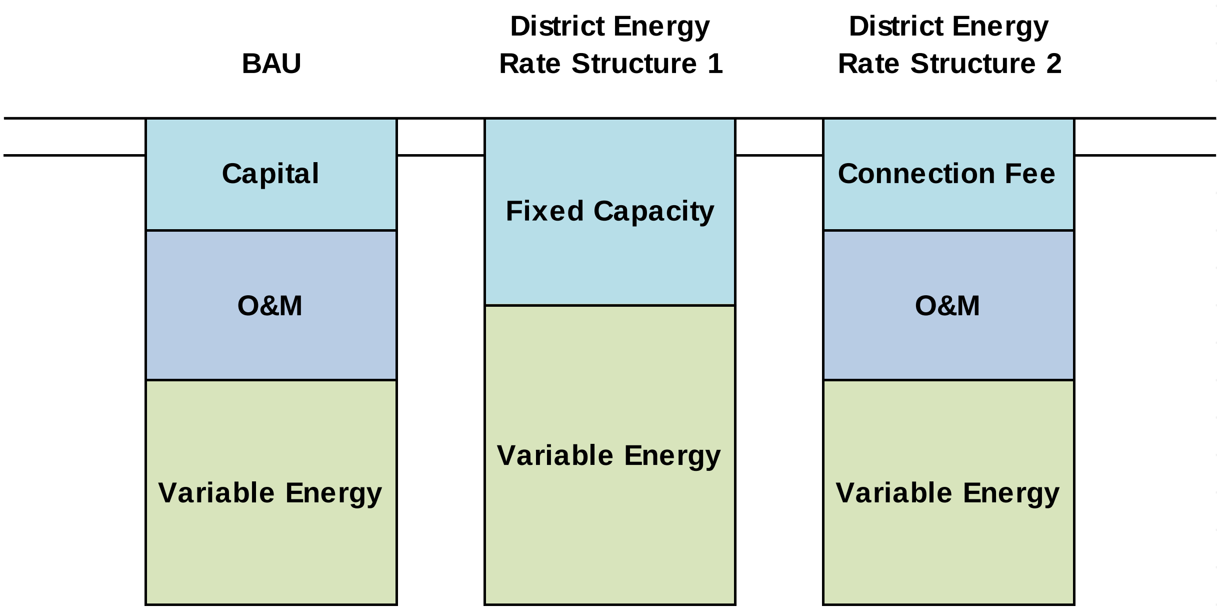

Figure 1: Comparison of BAU Costs and District Energy Rates

The thermal energy rate structure is assumed to utilize a fixed capacity charge and a variable energy charge structure (Rate Structure 1 shown in Figure 1 above). The rates assumed in the calculation of revenue in the financial model are summarized in the Table 8.[7]

[7] A rate structure with an initial connection fee, a fixed capacity charge, and a variable energy charge could also be considered.

Table 8: District Energy Rate Summary – Thermal Energy

	Heating	Cooling
Energy	$33.43 per MWh	$0.15 per ton-hr
Capacity	$75.00 kWt/year	$400 per ton/year

The district energy variable energy charges were calculated based on natural gas rates and BAU seasonal boiler plant of 70% for heating and on $150/MWhe and a BAU seasonal efficiency, COP = 3.5 kWt/kWe (or 1.0 kWe/ton) for cooling.

The capacity charge rates are set to be competitive against the annualized fixed cost of conventional heating and/or cooling. A capacity charge of $75/kWt per year was assumed and should be adjusted to be competitive for Burlington DES and businesses such that building owners can expect their annualized fixed costs to be equal or lower when connecting to a DES compared to conventional self-generation.

6.2.2. Electricity Revenue

The financial model assumes that the value of the displaced electricity is $0.12-0.13 per kWh. While the Customer's total electricity cost would be higher than this, only so much of it can be avoided with "behind the meter" CHP; namely HOEP, Global Adjustment, Wholesale Operation Charge, and the Demand Charge.

The following charges are generally observed on an electricity bill.

Table 9: Typical Electricity Bill Charges

Item	Unit Cost	Note
Electricity Costs		
Electricity	$/kWh	Avoided costs from reduced electricity usage
Global Adjustment	$/kWh	Avoided costs from reduced electricity usage
Delivery Costs		
Customer Charges	Flat fee	Not Avoided
Distribution Charges	$/kW	Partially avoided due to reduced demand
Transformer Allowance	$/kVA	Reduced credit due to reduced demand
Transmission Connection Charge	$/kW	Partially avoided due to reduced demand
Transmission Network Charge	$/kW	Partially avoided due to reduced demand
Regulatory Charges		
Wholesale Market Services	$/kWh	Not avoided
Standard Supply Service Admin Charge	Flat fee	Not avoided
Other Charges		
Debt Retirement Charge	$/kWh	Avoided costs from reduced electricity usage

The financial model assumes that the CHP system is shut down for a minimum of one day per month for general maintenance procedures. Therefore, monthly demand is only partially reduced as a peak will still be registered on the day the CHP system is shut down. It is also assumed that a Standby Charge would be invoiced by the Local Distribution Company (LDC).

6.3. Financial Results

In FVB's experience with the district energy business case development in Canada, a 65%/35% debt to equity ratio is a conservative financial leverage for a municipally owned district energy system. The Infrastructure Ontario lending rate for "Municipal Corporations – District Energy Operators" is ~4.0% for 25 years.[8] By examining the Weighted Average Cost of Capital (WACC) assuming a borrowing rate of 4% and equity value of 10%, the WACC = 0.65 x 4% + 0.35 x 10% = 6.1%. Therefore, an Internal Rate of Return (IRR), based on 100% equity assumed in the financial analysis, above WACC would be considered a financially viable project. For example, the ROI for Scenario 2 is 8.0% and is above the WACC and therefore a good project.

The financial results including simple payback, project IRR and NPV for each scenario are summarized in Table 10.

Scenario 1, The Downtown Node 1 Heating Only DES has the lowest IRR of 4.4% and NPV ($138,000).

Scenario 2, The Downtown Node 1 Heating Only DES with CHP has an IRR of 8.0% and highest 20 Year NPV of $2,404,000. The business case for Scenario 2 can be improved if the project qualifies within an IESO saveONenergy or other similar type program.

Scenario 3, a DES concept provide heating and cooling with a CHP component has the highest estimated full buildout capital cost of $14,618,000.

Scenario 4 has the highest project IRR of 10.5%; the financial model for this scenario includes an estimated $900K capital incentive under the current IESO saveONenergy PSUI program. Scenario 4 also has the lowest initial capital cost, estimated at $2,880,000 after incentive (i.e. $3,780,000 - $900,000).

Most of the risk associated with the development of the DES is with the build out and connection of future development. The way to mitigate the risk that future buildings get built later than planned is to aggressively phase the capital of the project and spend capital as buildings are confirmed.

In FVB's opinion, Scenario 2 has a positive business case represents the best opportunity to develop a base district energy system for the City of Burlington.

Scenario 4 also has a positive business case and is an opportunity to develop a district energy system that would reduce energy costs for both the electrical and thermal energy hosts. It also demonstrates the ability of a DES to develop synergies between energy users but represents a smaller opportunity for developing a springing point for a local DES system for Burlington.

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[8] Infrastructure Ontario Lending Rates as of February 6, 2017
http://www.infrastructureontario.ca/Templates/RateForm.aspx?ekfrm=2147483942&langtype=1033&sector=dis

Table 10: Burlington DES Financial Result Summary

Business Case		Financial (Unescalated)						
Scenario	**Description**	**Capital ('000 k $)**	**Expenses ('000 k $)**	**Revenue ('000 k $)**	**Simple Payback (years)**	**Projected IRR, 20 Years (%)**	**Projected IRR (30 Years)**	**20 Year NPV (4%) ('000 k $)**
1	Downtown Node 1 DES Heating Only: 4.57 MW	4,695	535	865	14.2	4.4	7.4	138
2	Downtown Node 1 DES Heating Only: 4.57 MW + 0.6 MW CHP	6,975	834	1,441	11.5	8.0	10.3	2,404
3	Downtown Node 1 Heating and Cooling DES: 4.57 MW + 0.6 MW CHP + 1200 tons CLG	14,618	1,082	2,204	13.0	5.9	8.5	2,394
4	Downtown Node 2 CHP-DES	2,880	428	739	9.3	10.5	12.6	1,978

Scenarios 2 and 4 both of project 20 Year IRR above the estimated WACC of 6.1%. The 30 Year IRR for all projects is above the estimated WACC of 6.1%.

7. Triple Bottom Line – Economic, Environmental, Energy

7.1. Economic Benefit

The value to the City includes the fact that the ICES is projected to spend more locally than would be spent by building owners on heating and cooling equipment in the Business as Usual (BAU) case. At the same time, the ICES would reduce the flow of energy dollars out of the local economy compared to what would occur in the BAU case for natural gas and electricity consumption by more efficient use of energy and local generation of electricity.

The local capital and operation and maintenance spending of the ICES provides a stimulus to the local economy directly and indirectly through secondary and tertiary suppliers of goods and services and induced spending due to the resulting increased local wages.

Improving the reliability and resilience of local energy systems can have a significant impact on local businesses, residents, and economy. Interruption of service, be it- heating, cooling, and/or electricity can impact work productivity, safety, product storage and possibly production (i.e. food storage, batch processes, manufacturing production, data).

Finally, the proposed ICES is expected to generate a commercially attractive Return on Investment (ROI) of up to 10.5% (before-tax, unleveraged) in Scenario 4 over 20 years.

7.2. Environmental

A key consideration to the implementation of a DES system for the City of Burlington is the environmental benefit, including:

- The reduction of greenhouse gas emissions
- Improved air quality
- Reduced peak electrical demands on the electricity grid through district cooling and/or behind the meter CHP

The presence of a DES enables increased uptake of alternative and waste energy streams as they become available i.e. for example, a DE system can make use of the waste heat from a CHP system. The use of waste heat streams and the forecasted improved efficiency between a purpose-built, maintained and operated facility vs. BAU would result in a net GHG emissions reduction. The ICES could potentially reduce greenhouse gas (GHG) emissions by an estimated 468 – 1867 tonnes CO2e per year, or up to 70% reduction compared to BAU as summarized in Table 11.

Table 11: DES GHG Emissions Reduction by Scenario[9]

Scenario	1	2	3	4
Greenhouse Gas Reduction - Full Buildout	**Downtown DES Heating Only**	**Downtown DES Heating Only + CHP**	**Downtown DES Heating + CHP + Cooling**	**Downtown DES Node 2 with CHP**
Building as Usual				
Total BAU Equivalent Electricity Consumption	*0 MWhe*	*0 MWhe*	*1566 MWhe*	*0 MWhe*
Total BAU Natural Gas Consumption	67,149 GJ	67,149 GJ	67,149 GJ	33,234 GJ
Annual Building as Usual GHG Emissions	**3357 tonnes CO2e**	**3357 tonnes CO2e**	**4167 tonnes CO2e**	**1662 tonnes CO2e**
District Energy System				
Total District Energy System Electricity Consumption	*81 MWhe*	*-4461 MWhe*	*-3364 MWhe*	*-4769 MWhe*
Total District Energy System Natural Gas Consumption	56,958 GJ	80,789 GJ	80,789 GJ	58,972 GJ
Annual District Energy System GHG Emissions	**2890 tonnes CO2e**	**1733 tonnes CO2e**	**2300 tonnes CO2e**	**483 tonnes CO2e**
Net Annual GHG Reduction	**-468 tonnes CO2e**	**-1624 tonnes CO2e**	**-1867 tonnes CO2e**	**-1179 tonnes CO2e**
GHG Reduction over Building as Usual	**-14%**	**-48%**	**-45%**	**-71%**

More efficient use of use of electricity and fossil fuels reduces air pollution. Improved air quality leads to improved health of the environment and the City's residents.

The roof spaces of most buildings are used as penthouse mechanical room. A new building connected to a DES system can free up roof space that can be used for green roofs and rain water harvesting to aid in storm water management.

7.3. Energy Security and Resilience

The DES improves energy security by virtue of generating new electricity locally to facilitate growth and improve reliability and minimize the reliance on energy imports. Local generation provide an island of emergency electricity generation during a blackout. The DES also provides long term fuel and energy source flexibility to switch to alternate fuels and adopt future technologies in response to changing circumstances providing a bridge to renewable energy utilization in the future.

The key energy sources that are impacted by the ICES are natural gas and electricity. These same energy sources are needed for the development of new buildings in the area. The natural gas consumed by the DES hot water boilers will be offset by a reduction in natural gas consumption in the buildings served by the DES. There will be a net reduction in natural gas because the district energy centre will be more efficient than the building heating equipment.

The CHP installations proposed for the Burlington DES are gas-fired generators capture waste heat to produce hot water and/or steam. For every unit of gas consumed approximately 0.4 units of electricity and 0.4 units of thermal energy are produced. Even though there is some offsetting of natural gas consumption by the thermal energy produced in the CHP, there would be a net increase of natural gas

[9] The GHG emission calculation assumes the following emission factors:

- Ontario blended Natural Gas Generating emission intensity: 0.517 tons / MWhe (517 kg CO_2e/ MWhe)
- Natural gas emission intensity (combustion only): 0.05 tons / GJ natural gas (50 kg CO_2e/ GJ)

use to the area. However, there will also be a net reduction in electricity consumption to the area and the capability of supplying hot water in the event of a power outage. This is a significant advantage to the buildings served by the Burlington CES.

The net increase in natural gas consumption caused by the CHP may have an impact on the Union Gas natural gas distribution system since the delivery of large volumes of natural gas to the energy centres is required.[10]

The power distribution system will also be impacted by the installation of a total of 1.2MWe of generation at the two sites. According to the Burlington Hydro Grid Interconnection Capacity Map, there is sufficient ground fault capacity in the area of interest for implementing CHP.

Table 12: Summary of Benefits to Key Stakeholders from a CES in Burlington

	To Real Estate Developers, Building Owners and Residents	To the City of Burlington
Economic Development	• Cost savings, deferred capital costs • Energy savings, stabilized energy costs • Alternative income stream, waste fuel sources	• ROI, local economic development • Job creation, risk mitigation • Infrastructure asset • Increase urban densification and planning
Energy Security	• Energy reliability • New local electricity to power new development • Increased efficiency and conservation • Reduce impact from loss of power, heating and cooling that can affect productivity	• Increases potential for uptake of waste heat and renewable energy sources • Increased energy security and resilience with local energy production and future proofing • Fuel flexibility • Potential to develop local fuel sources • Lower demand on existing gas/electricity infrastructure • Reduced electrical peak demand
Environmental and Other	• Green image/marketing, environmental stewardship/leadership • Architectural opportunities: roof free for amenity space and enjoyment of residents • Increase comfort from hydronic heating and possibly radiant floor heating • Improved air quality + health benefits • Potential to provide green roof space	• Environmental benefit from efficiency (initial estimates are between 468 - 1867 tonnes CO_2e GHG reduction per year) • Helps to meet GHG reduction targets and fuel conservation methods • Can reduce water usage in cooling systems • Promote energy awareness • Synergy with potential storm water reduction strategy

[10] FVB will review the forecasted gas consumption by the district energy plants, including the CHP with Union Gas. The review is high level and only intended to confirm that natural gas can be made available without significant infrastructure upgrades.

8. Ownership Model

There are generally three ownership models that have been used by DES's worldwide and in North America:

- Public Sector – the City maintains the ownership and is able to maintain better control of the DES and its potential for expansion and long term operation. The City is generally better positioned to carry long term, lower interest type projects and is able to seek support from FCM. Examples include Markham, Ottawa, Vancouver, Hamilton etc.
- Private Sector – a private developer takes the lead in the design and operation of the facility. As they seek an appropriate return on investment, the preference is either for high demand new developments of suitable size or the purchase of an existing DES. Examples include Enwave, (Toronto), Creative Energy (Vancouver), Veresen (London, Charlottetown)
- Public Private Partnerships are a hybrid of the above ownership models. Examples include the Sudbury District Energy, District Energy Windsor

Table 13 Ownership Options SWOT Analysis

	100% Public	Hybrid	100% Private
Strengths	• Access to low cost financing. • Long term agreement, stable partner. • Access to Government Grants. • Alignment with other City Departments and levels of government	• Combines private DE experience & capital with City advantages, such as access to senior government grants	• Private sector assumes all risk, is most motivated, minimizes government interference
Weaknesses	• Available capital for large infrastructure project. Management capacity (internal resources) and • No DES experience	• JV complexity with resultant demands on management time. • Split ownership found to inhibit growth	• CES projects may not meet private return/risk curve without government assistance • Higher ROI threshold
Opportunities	• Meets other goals and objectives in addition to business case such as sustainability, economic development, resilience. • Leadership • Synergy with other municipal project	• Monetize City advantages; sell out when CES established, using cash to seed another CES project, maximizing socio-economic and environmental values	• Create environment for the CES to succeed • Realize socio-economic and environmental values without using City's own limited financial resources
Threats	• Risks: cost overruns, performance issues associated with construction, commissioning and O&M costs. • Market penetration • Nuisance complaints	• Disputes due to different goals	• Concessions inhibit motivation to expand or spend maintenance dollars

The experience in Canada has been proven that the majority of successful DES system start-ups have begun with 100% Public Ownership. The City of Burlington has expressed interest in public ownership but are concerned about their lack of experience in owning and operating a district energy system and/or utility. The City of Burlington should consider:

1. Retaining an entity such as Hamilton Community Energy and/or Markham District Energy to manage, operate, and act in an advisory capacity in the initial stages of the ICES development; or
2. Leveraging the experience and resources of Burlington Hydro, an existing public utility entity with existing community ties and connections and experience providing a utility service.

9. CES Implementation Strategy to Encourage District Energy Connection

9.1. Key Barriers and Opportunities to ICES Implementation

9.1.1. Barriers to Implementation

1. Attracting and connecting DES customers
2. DPS crossing of the Transcanada Pipeline in downtown Burlington
3. Timing of ICES with new building developments
4. High upfront capital cost
5. Energy pricing and market structure can put DES at a disadvantage to other technologies
6. Lack of knowledge and understanding of district energy systems by building owners and developers
7. City's lack of human capital and experience to own, operate, and maintain a district energy utility

Note: CHP is identified as a cost effective solution for a low carbon economy and Ontario's new cap and trade regulation is not seen to be a barrier to district energy and CHP. Cap and trade in Ontario is estimated to have an impact on gas cost in the range of +$0.026/m3 of natural gas. This additional cost of natural gas cost is paid by both the DES and the customer buildings and therefore has no impact on the business case.

9.1.2. Key Opportunities:

1. Clarity on the City's position with respect to the development of a DES and the goals, objectives and benefits of the DES to the stakeholders and the residents.
2. Connection of City owned buildings. Smaller buildings such as the Burlington Performing Arts Centre or the Burlington Art Gallery may be considered for connection at an appropriate time in the future depending on equipment replacement requirements, business case, timing with respect to the DES buildout.
3. Connection of public owned buildings – alignment of all levels of government with the City of Burlington's goals and objectives with respect to energy and sustainability.
4. Embedding DES infrastructure in new building development – build on synergies with building developers
5. Improve integrated infrastructure and land use planning and develop or adopt policies that encourage the uptake of district energy i.e. planning, zoning, development control
6. Incentivize district energy connection or district energy ready designs, i.e. density bonus, reduced development fee, reduced taxes, exemptions or relaxation of standards/rules
7. Examine cost recovery mechanisms for district energy i.e. property taxes, user fees, development fees

8. Develop a CHP project under the IESO saveONenergy program to obtain financial incentive.
9. Plan and look for anchor DES customer loads (buildings with large electrical and/or thermal loads)
10. Develop and utilize waste heat sources and local fuel streams
11. Provision for and/or install distribution piping infrastructure in advance of or as part of other City Capital Works projects such as roadway redevelopment/reconstruction or installation of new water/municipal sewer i.e.
    - John Street – between James and Caroline – 2021
    - John Street – between James and Lakeshore – 2022
    - James Street – between John and Martha – 2019
    - Lakeshore – between Nelson & Elizabeth – 2021
    - Mapleview Street – between Lakeshore & Fairview – 2018
    - Ontario Street – between Mapleview and Brock – 2018

It is FVB's opinion without additional levers to motivate building developers/owners to connect to a DES, it is unlikely that new developments would adopt DES, even when presented with a positive business case. In the absence of any such encouragement, it would be expected that even a 50% connection rate amongst new developments would be a highly optimistic and aggressive target.

The following are recent examples of policies implemented in other municipalities:

- The City of Toronto has implemented an Energy Strategy and a Design Guideline for District Energy Ready Buildings[11]. It applies to buildings that are:
    - ✓ "In close proximity to existing or potential new CES nodes
    - ✓ Within a Community Energy Planning (CEP) area*
    - ✓ Part of a large development (over 20,000 m2)*."
    - ✓ *Note: Development proposals in CEP areas or over 20,000 m2 are required to complete an Energy Strategy as part of a complete application. The Energy Strategy includes consideration of opportunities to establish/connect to a CES." The effect is to give CES at least "a foot in the door" to present proposals to developers.
- In Markham, development of the DE system through the entity, Markham District Energy (MDE), which is wholly owned by the City, has been actively supported by the City in the city official plan which encourages new developments to connect to a CES. "One of the performance measures used to evaluate development applications in the Markham Centre area is whether the building design supports the Town of Markham Energy Strategy, which includes (but is not limited to) the use of district energy."[12] The results have been that the connection rate of new developments has been 100% and currently more than 35 buildings are connected.

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[11] City of Toronto Environment & Energy Division – Design Guideline for District Energy Ready Buildings V1.1 Oct 2016http://www1.toronto.ca/City%20Of%20Toronto/Environment%20and%20Energy/Programs%20for%20Businesses/BBP/PDFs/District%20Energy%20Ready%20Guideline_October%202016.pdf

[12]Municipal District Energy Systems: Charting a Path to Greener Heating and Cooling;http://www.ecoissues.ca/Municipal_District_Energy_Systems:_Charting_a_Path_to_Greener_Heating_and_Cooling

- The City of Calgary, through the land use bylaw, permits a development density bonus for green building features including:
    - A district energy connection ability, 0.5 floor area ratio
    - A district energy system connection, 2.5 floor area ratio
    - Onsite cogeneration facility, 2.0 floor area ratio[13]
- In their Official Plan[14], East Gwillimbury requires developments in certain areas to "incorporate sustainable development practices and innovative energy solutions, such as district energy" and identified areas where a district energy feasibility study must be undertaken as part of a Secondary Plan or Community Design Plan. It is also a requirement for a development to design to be district energy ready, only if a DE system exists, including hydronic systems and pre-servicing with insulated pipes within a dedicated trench in the public right-of-way where a CES is available. Though East Gwillimbury has yet to develop a DES, the incorporation of DES in their Official Plan demonstrates leadership and provides opportunities and possibilities to consider in planning and development.
- Lonsdale Energy Corporation (LEC) is a district energy utility wholly owned by the City of North Vancouver (British Columbia). Initially, as part of its overall plan for DE, the City of North Vancouver established a Hydronic Heat Energy Service By-Law that applied to the planned service area, known as Lower Lonsdale. It required new or retrofitted buildings to install hydronic systems, a prerequisite for district heating. In 2010, the City passed a new By Law (8086) that requires any new building in the entire City of more than 1,000 square meters gross floor area to connect to the district heating system unless it is determined by the City's Director of Finance that the cost to the City would be excessive.
- In 2012, the City of Surrey (British Columbia) approved a District Energy System By-law, which includes the requirement for all high density developments to use district energy or have a compulsory hydronic heating/cooling system design.[15]
- Other considerations include:
    - ✓ Accelerated building permit or site plan approval processes for facilities which are DES ready.
    - ✓ Development/improvement fee reductions for DE-ready[16] facilities
    - ✓ Ensure hydronic heating systems are utilized with central domestic hot water heating and storage (vs. point of use systems).
    - ✓ Promote behind-the-meter CHP

[13] City of Calgary Land Use Bylaw; http://www.calgary.ca/PDA/pd/Pages/Calgary-Land-Use-bylaw-1P2007/Calgary-Land-Use-Bylaw-1P2007.aspx

[14] Town of East Gwillimbury Official Plan; http://www.eastgwillimbury.ca/Assets/3+2015+Services/1.1+Planning/OP+(July+2014).pdf

[15] Surrey City Energy; https://www.surrey.ca/bylawsandcouncillibrary/BYL_reg_17667.pdf

[16] "DE-ready" i.e., if a developer includes a hydronic system design and reverse return riser piping (i.e. a full-size pipe header from the basement level to the penthouse mechanical room) in a high rise building so it can more readily connect to a DES in the future.

- ✓ For developments of a minimum size, i.e. greater than 1000 m2, and within the target DES implementation area, establish a requirement in the Site Plan Approval process for the developer to undertake a district energy interconnection feasibility study or consultation with the City. Offer meetings for developers to discuss CES with City of Burlington Community Energy Stakeholders.

10. Mobility Hubs: Planning and Policy

10.1. Policy Considerations

From a policy perspective, at the simplest and most flexible level, a District Energy Plant and associated infrastructure (District Energy System) is, by definition, a utility. The definition from the Official Plan is:

"Part VIII Definitions

Utility *- A water supply, storm or sanitary sewage, gas or oil pipeline, the generation, transmission and distribution of electric power, steam or hot water, towers, telecommunications infrastructure and other cabled services, a public transportation system, licensed broadcasting receiving and transmitting facilities, or any other similar works or systems necessary to the public interest."*

Only a minor planning policy adjustments to the existing Official Plan would be required to facilitate the development of a District Energy System. In support of the "utility" definition, the Official Plan should specifically identify District Energy/Heating within and throughout Part II Section 5.0 UTILITIES. The policies of Section 5.0 would then apply.

To consider a more complex policy framework, one that focuses on the feasibility of District Energy/Heating, and ensuring that the issues of site size and location, supportive density, mix of uses, compatibility/impact mitigation, building design and approach to implementation will come into play. Further, identification of "encouragement for connection" or "connection ready" development should be fleshed out with respect to potential financial incentives or development of energy or sustainability standards and by-laws.

10.2. CES Energy Centre and Infrastructure Location

The best sites for the location of a District Energy Plant will be centrally located within the Mobility Hub or District Energy Node so that the infrastructure to distribute the energy can be maximized within the shortest distances. For planning purposes[17]:

1. Potential sites for a CES energy centre should be identified and be acquired by the City as soon as possible, with consideration given to existing neighbours and access to required service infrastructure such as gas, water, and power; or

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2. While preference is for a municipal or publicly owned stand-alone facility, this may not be feasible and so it is suggested that discussions should be initiated with building developers who own land in the area to embed a municipally owned CES energy centre in a building development.
3. Identify and plan for CES piping infrastructure to be installed concurrently with new municipal infrastructure (water, sewer, street lighting) for new developments.

Where a specific site is identified, its location should be specifically identified within a Local Area Plan. That way, impact mitigation measures and the scale and use of buildings in proximity to the selected site can be managed through Local Area Plan policy frameworks.

[18]A site approximately 5,000 – 6,000 square meters in size would be required for a standalone one or two storey energy centre building; the building footprint would be approximately 2,000 square metres. The criteria for locating a site for a District Energy System may be included within an "Action Plan" that would guide the City in its search for sites to accommodate a District Energy System throughout Burlington.

The key issue is planning around a District Energy Plant. The goal is to maximize GFA in proximity to the energy centre to minimize the cost of underground connecting infrastructure and to maximize the size of the potential customer base. Identify and acquire the site for the CES Energy Centre as early as possible in the planning process to ensure that it is located in proximity to the highest density buildings (to maximize potential customers).

10.3. Development Compatibility

The District Energy Plant itself is considered to be a compatible development within a mixed use, urban environment. Notwithstanding that general assertion, the Plant does require Environmental Compliance approvals from the Ministry of Environment. Typically, appropriate design/technology measures are applied to meet the Ministry's requirements for noise, vibration, air emissions, and light. There are safety concerns identified with the location of a district energy centre within a mixed use, urban environment.

However, in a tall building context, a stand-alone District Energy Plant stack is required to be 50 metres from buildings above 5 storeys in height, or the stack must be as tall as the tallest adjacent building. The height of the stack is determined by air dispersion modeling by an environmental engineer. Rules of thumb are difficult to provide - it is simple for optics to generalize and say that it is preferred for it to be in one of the taller buildings.

If the District Energy Plant is a stand-alone building, the City could require that development close to the site be limited in height to reduce the impact of the stack. This could create a conflict with potential height/density requirements in an area surrounding a District Energy Plant. It is understood that the minimum separation between combustion fuel and/or cooling towers and an air intake is generally between 5 to 7.5 metres.

[18] This is an initial estimate based on a 10 MW heating and 2000 ton cooling energy centre in a stand-alone facility that will serve approximately 1,800,000 sq. ft of development. The physical size of the energy centre could be larger or smaller depending on the development loads and energy to be served.

Notwithstanding that detail with respect to the height of the stack and the separation distances required, a District Energy Plant is not expected to create any land use compatibility issues that cannot be mitigated with appropriate techniques and/or including technology. The Plant will however, require Environmental Compliance approvals from the Ministry of Environment. The existing Official Plan makes specific reference to development compatibility and sensitive uses in PART II, Section 6.5 Design Guidelines Policies:

"Compatibility
a) The density, form, bulk, height, setbacks, spacing and materials of development are to be compatible with its surrounding area.

Buffering and landscaping
b) The compatibility of adjacent residential and non-residential development shall be encouraged through site design and buffering measures, including landscape screening and fencing."

More specifically, Policies under Part II, Section 5.0 Utilities, that cover compatibility issues are included in subsections j) through o).

While the existing Official Plan covers the issue of development compatibility well, it is suggested that the policies of Part II Section 5.0 be adjusted to identify that approvals for a District Energy Plant will require Environmental Compliance Approvals (ECA) from the Province.

In addition, the policies of a Local Area Plan should anticipate and explicitly deal with the compatibility requirements in proximity to a District Energy Plant. Land use controls, building setbacks, and building height regulations may need to be included, in addition to the typical development compatibility issues. A policy that specifically identifies the requirement for Environmental Compliance approvals would be useful as an indicator that compatibility issues will be fully considered.

Size of the Centre/Mobility Hub – It has been suggested that a Centre with a radius of about 1 kilometre would be appropriate for the consideration of a District Energy Plant. A Centre of that size would incorporate an area of about 315 hectares. This is a very large centre in the Burlington context.

The City's four Centres/Mobility Hubs range in size between approximately 90 and 200 hectares. In a general sense, the size of the Centres/Mobility Hubs identified within the draft proposed policy direction for the new Official Plan are based on a 400 to 800 metre radius – this is likely based on the 5-10-minute walk criteria measured from the centre (typically a transit station) to the edge – and are appropriate for the development of a District Energy System. This is large enough to establish an appropriate customer base, and compact enough to facilitate an efficient delivery network.

Minimum Density – The business case for a District Energy System needs to be evaluated on a case-by-case basis, however, it was noted that approximately 100,000 – 200,000 square metres of GFA would be a good starting point for a financially feasible District Energy System. This is a relatively small amount of floor space, given the land area identified for the size of a Centre and a Mobility Hub, and the density targets included in the draft proposed policy direction for the new Official Plan.

The target densities for the various Centres/Mobility Hubs identified within the draft proposed policy direction for the new Official Plan identify a target of 300 people and jobs combined per hectare. Based on the identified land areas for the Centres/Mobility Hubs, and the minimum density requirements of 300 persons and jobs combined per hectare, the identified minimum of 200,000 square metres of GFA can be easily achieved, even utilizing what are considered very conservative assumptions. The Centres/Mobility Hubs will, if the density targets are achieved, generate an appropriate customer base in terms of Gross Floor Area within a reasonable proximity.

Mix of Uses – It was confirmed that density was considered a more important issue than the mix of uses, notwithstanding that a full range and mix of uses tends to spread out energy demand patterns, maximizing the efficient use of all infrastructure. A key element of success, however, is the establishment of anchor users, which are typically defined as very large buildings that demand significant energy resources at the outset of District Energy System development. Again, the Markham example is noteworthy.

In the Burlington Context, many identifiable anchor users may also be "public" users, such as the Hospital, schools, and local and Regional government facilities. These users should be targeted as "priority users" for the District Energy System. The identification of large scale anchor customers, regardless of land use, is considered a key objective, and such anchors, either existing or planned, should be identified in Local Area Plans as key candidates for connection to the District Energy System.

Local Area Plans should include, as a key objective, that consideration must not only be given to site design and development compatibility, but also to the architectural design of the District Energy Plant itself. Further, the District Energy Plant must include a Public Art element and may serve as an educational opportunity, in additional to fulfilling its public utility function.

The success of a District Energy System may also be linked to the clear commitment by the City to build the District Energy Plant and install the necessary underground infrastructure. It will be difficult to convince private sector developers to participate in the program without such commitment from the City. It is also important to note that the District Energy System (the Plant and associated underground infrastructure) can be phased to meet the requirements of an expanding customer base. This is dependent on customer uptake, whether policy encourages or requires a connection, and may also impact the initial financial/business plan in terms of forecasting versus actual implementation.

10.4. Local Area Plans

Local Area Plans should include a policy framework that establishes an appropriate trigger for the development of a District Energy System. The trigger should include:

1. The acquisition by the City of an appropriate site for the District Energy Plant;
2. A minimum Gross Floor Area of proposed new development and/or connection ready buildings, and preferably one or more anchor customers;
3. A maximum distance from the proposed District Energy Plant; and,
4. A commitment that the City shall initiate construction of the District Energy System when all of the trigger elements are achieved.

10.5. City Planning and Development Documents

The City's planning and development documents, while including wording that is supportive of enhanced sustainability, are not as explicit as they could be with respect to the establishment of District Energy Systems and the development necessary to ensure their financial feasibility. The City should review a number of policy documents with the intention of identifying connection to, or connection ready development, to be a key contributor of a more sustainable City and a community benefit by:

1. Amending Part VI, Section 2.3.2 a) of the existing Official Plan to explicitly identify connection to an existing District Energy System, or to promote connection ready construction that facilitates connection to a planned District Energy System within the defined Centres/Mobility Hubs as a specific Community Benefits Consideration, in exchange for an increase in height and/or density, in compliance with the requirements of Section 37 of the Planning Act;
2. Utilizing the provisions of Section 28 of the Planning Act, and the policies of Part II, Section 10.0 COMMUNITY IMPROVEMENT of the existing Official Plan for the purposes of establishing financial incentive programs to facilitate the connection to an existing District Energy System, or to promote connection ready construction that facilitates connection to a planned District Energy System within the defined Centres/Mobility Hubs; Consider amending the Development Charges By-law to allow a reduction or waiver of Development Charges to facilitate the connection to an existing District Energy System, or to promote connection ready construction that facilitates connection to a planned District Energy System within the defined Centres/Mobility Hubs;
3. Consider amending the Parkland Dedication By-law to allow a reduction or waiver of parkland dedication/cash-in-lieu of parkland dedication to facilitate the connection to an existing District Energy System, or to promote connection ready construction that facilitates connection to a planned District Energy System within the defined Centres/Mobility Hubs; and/or,
4. Consider amending the Zoning By-law to permit reduced residential and commercial parking standards to facilitate the connection to an existing District Energy System, or to promote connection ready construction that facilitates connection to a planned District Energy System within the defined Centres/Mobility Hubs.

11. Appendix A - City of Burlington CES Map – System Layout

City of Burlington - District Energy Business Case
Building Statistics / Estimated Thermal Loads and Energy

DES Node	Bldg #	Building/Developer Name Address/Location	Approx Gross Floor Area (m2)	Estimated Heating Load (kW)	Displaced Heating Energy (MWh)	Estimated Cooling Load (tons)	Displaced Cooling Energy (ton-hours)
1		DOWNTOWN DES NODE 1					
		Node 1 (Subtotal)	169,100	10,470	24,837	2,390	2,868,000
2		DOWNTOWN DES NODE 2					
		Node 2 (Subtotal)	76,817	4,610	11,525	920	1,104,000
3		JOSEPH BRANT HOSPITAL NODE					
		Node 3 (Subtotal)	112,950	10,810	27,025	1,660	2,652,000
4		BRANT/GHENT REDEVELOPMENT NODE					
		Node 4 (Subtotal)	69,703	4,180	10,450	830	996,000
5		LAKESHORE EAST REDEVELOPMENT NODE					
		Node 5 (Subtotal)	27,029	1,620	4,050	320	384,000

1 SITE PLAN
SCALE: 1:4000

0 100 200 300 400m

LEGEND

DOWNTOWN DES NODE 1
DOWNTOWN DES NODE 2
JOSEPH BRANT HOSPITAL NODE
BRANT/GHENT NODE
LAKESHORE EAST NODE

STAMP:
CONCEPTUAL

REVISIONS

DATE	REMARKS	NO.	INIT.
JAN 27/17	DRAFT REPORT		

CLIENT:
City of Burlington

CONSULTANT:
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VAUGHAN, ONTARIO L4L 8L5
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PROJECT TITLE:
CITY OF BURLINGTON INTEGRATED CES STUDY

SHEET TITLE:
CITY OF BURLINGTON CES MAP

DGN: S.YEE	SCALE: AS SHOWN
DWN: E.CAI	JOB NO.: 216255
APPR:	DATE: NOV 2016
DWG NO.: SK-6255-100	