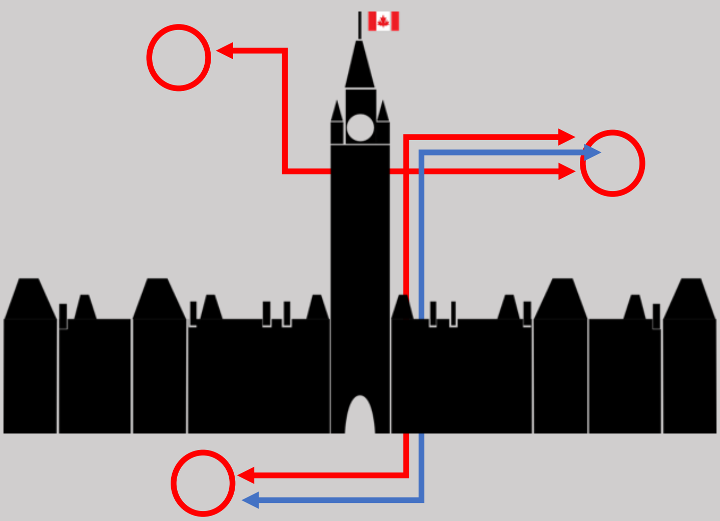
SURP 824

ENERGY AND CITY BUILDING: THE FUTURE OF DISTRICT ENERGY IN THE NATIONAL CAPITAL REGION



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SURP 824 PROJECT COURSE – FINAL REPORT, DECEMBER 18, 2017

Standards Limitations

Graduate students at Queen's University in the School of Urban and Regional Planning program developed this report as part of the SURP 824 project course. The report was prepared for Public Services and Procurement Canada and their Energy Services Acquisition Program.

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Acknowledgements

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EXECUTIVE SUMMARY

SURP 824 PROJECT COURSE

Objective

As part of the Queen's University School of Urban and Regional Planning (SURP), the SURP 824 Project Course Team ("the team") was retained by Public Services and Procurement Canada (PSPC) to evaluate the feasibility of expanding the National Capital Region's (NCR's) district energy system (DES). The team conducted a multi-level government policy context analysis, a case study review, a geographic information systems (GIS) land-use analysis, and a Strengths, Weaknesses, Opportunities, and Challenges (SWOC) analysis to form recommendations for the Energy Services Acquisition Program (ESAP). The team worked in partnership with ESAP over a four-month period from September 2017 to December 2017, developing recommendations for moving ESAP forward on the expansion of the NCR's DES.

The team was tasked with the following:

1. Demonstrate an understanding of the ESAP DES;
2. Evaluate existing planning policy and government context in the NCR and identify key stakeholders;
3. Create a list of "lessons learned" from successful and unsuccessful DES case studies in comparable places to the NCR;
4. Identify potential locations for expansion of the DES in the NCR by analyzing supportive land use policy conditions and potential users; and
5. Recommend next steps for ESAP on how to achieve expansion of the DES in the NCR.

Energy Services Acquisition Program

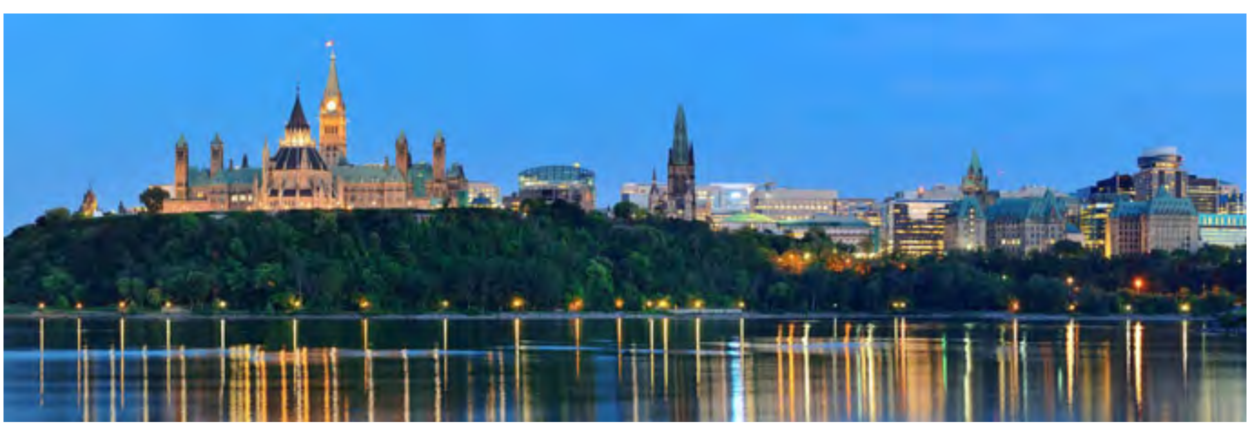
Phase One of the program includes upgrading the system from steam-powered to low temperature hot water and chilled water. This phase also includes the testing of new carbon-neutral fuels to reduce the system's environmental impact.

Phase Two includes using the successful alternative fuels as well as the system expansion to new buildings in the NCR.

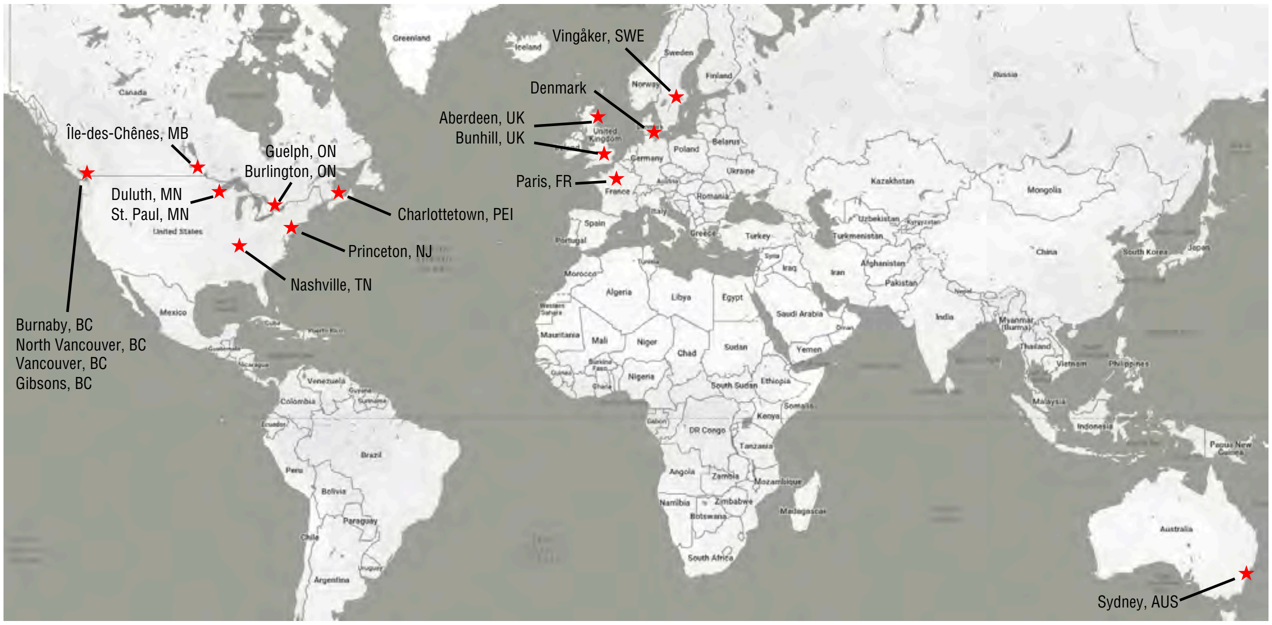
The Findings

Government Context

A rigorous review of relevant government policies was conducted, in order to gain a complete appreciation for the multi-jurisdictional playing field within which ESAP's DES must function. Policy and legislation from the Government of Canada, National Capital Commission, Provinces of Ontario and Québec, and municipalities of Ottawa and Gatineau were reviewed. Overall, it was found that while all jurisdictions are supportive of the environmental benefits and objectives that ESAP's system provides, they were not always perfectly aligned with, or supportive of the system itself. In many cases, different organizations used different metrics for calculating or determining which environmental initiatives to pursue. In the case of Gatineau, this largely precluded it from future DES expansion due to the municipality's focus on reducing greenhouse gas emissions. Due to HydroQuébec's existing cheap and low emission hydroelectricity, the environmental benefits of connecting to the DES in Gatineau are not the same as elsewhere in the NCR. Conversely, the Province of Ontario's Provincial Policy Statement was explicitly supportive of DES technology being implemented and included in Ontarian planning. These diverging policy frameworks led to a larger focus on the Ottawa portion of the NCR.



Case Study Review



An analysis of 18 DESs from all over the world were investigated to understand the benefits and drawbacks of implementing district energy systems. By looking at small rural towns, universities, major cities, and everything in-between, the case study analysis proved district energy systems can work at all city sizes and scales. Through this analysis of the challenges and innovations found in district energy around the world, three overarching themes began to emerge. These themes are: Land Use & Expansion, Growing the Client Base, and System Governance. These three themes were pulled out of the case studies because we found that land use policies are intrinsically tied to the success of expanding a DES. Furthermore, the land use policies and patterns also helped in identifying potential clients. This in turn, aided the addition of clients connecting to district energy. Lastly, the selected case studies consistently proved that a competent and effective model of system governance must be employed in order for the system to run effectively, efficiently, and successfully.

Burnaby British Columbia, Canada	**St. Paul** Minnesota, USA	**Aberdeen** United Kingdom
North Vancouver British Columbia, Canada	**Nashville** Tennessee, USA	**Bunhill** United Kingdom
Vancouver British Columbia, Canada	**Guelph** Ontario, Canada	**Paris** France
Gibsons British Columbia, Canada	**Burlington** Ontario, Canada	**Denmark**
Île-des-Chênes Manitoba, Canada	**Princeton** New Jersey, USA	**Vingåker** Sweden
Duluth Minnesota, USA	**Charlottetown** PEI, Canada	**Sydney** NSW, Australia

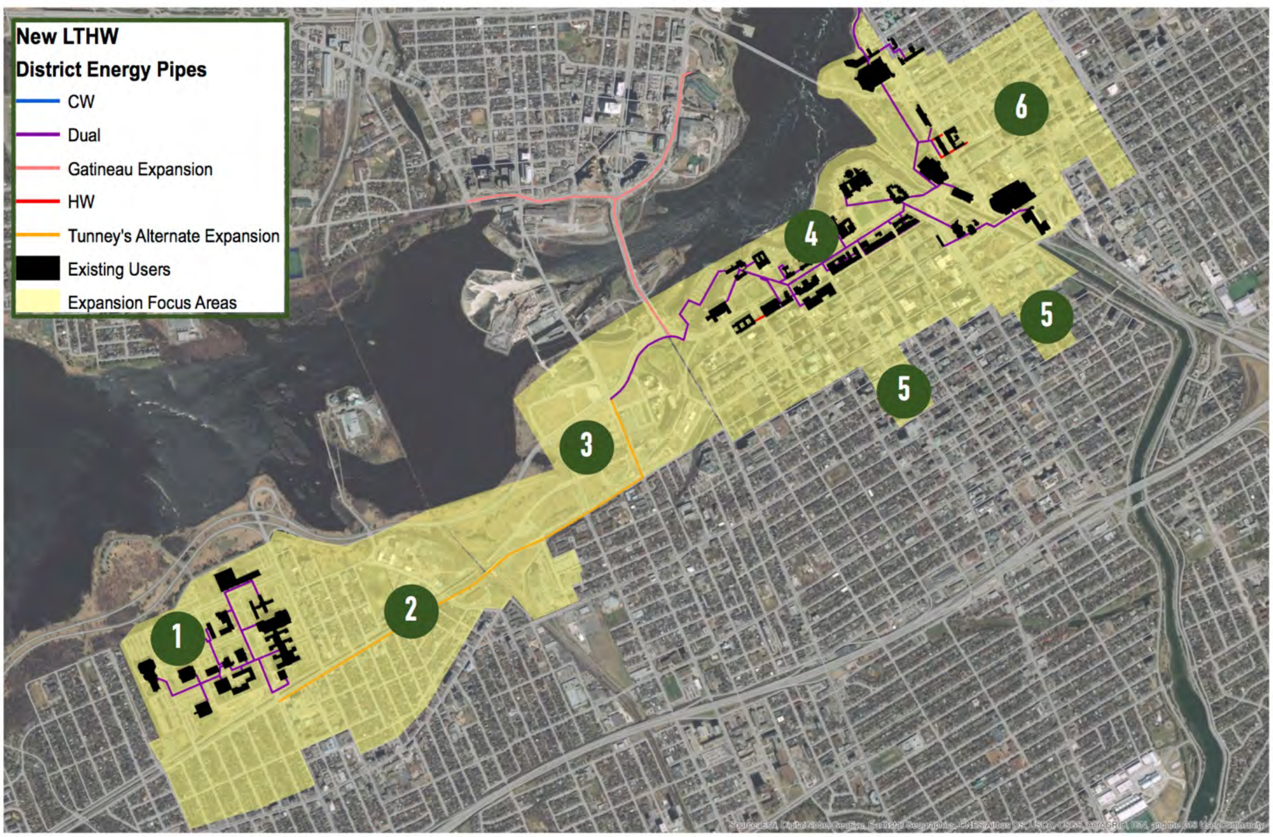
SWOC Analysis

A SWOC Analysis was conducted for DES expansion in the NCR with the developed understanding of the existing DES, policy context, projected growth in the NCR, and lessons learned from the case studies. The most important findings from each of the three themes established in the case study review are detailed in the table below.

	Land Use & Expansion	Growing Client Base	System Governance
Strengths	• The system is being modernized and will run on renewable energy	• Several plants are already located in close proximity to mixed-use, dense areas well suited for connecting	• All governments and agencies support green initiatives • Private sector connections and engagement have been prioritized
Weaknesses	• Several opportunities for connecting to greenfield developments near the network have been missed • Expansion in highly developed core areas is expensive and disruptive	• Several competing DES's exist or are being developed • Poor communication with private actors has hindered ESAP's ability to bring in new connections	• ESAP is beholden to the in-power government's priorities • There is no existing business model for the delivery and expansion of the DES
Opportunities	• The Government of Canada desires and has the capacity for expansion	• The completion of ESAP's phase 1 and 2 can stimulate interest and marketing potential in the DES	• ESAP is well-positioned to take a leadership role in initiating expansion and bringing all stakeholders together
Challenges	• Capitalizing on the existing political support for the environmental objectives DES can serve	• Developers need both heating and cooling to connect • There is a lack of awareness about ESAP's DES	• Meeting divergent environmental priorities across stakeholders • Lack of dialogue and buy-in from potential customers

Land Use Analysis – Conceptualizing DES Expansion in the NCR

From the lessons learned in the case studies and SWOC analysis, it was concluded that DES is best supported by a mix of uses, high density, high concentrations of building, and anchor users with high energy demands. The purpose of the land use analysis was to identify areas with land use policy that supports a mix of uses, and intensification of density and built form. Following this, areas within those that demonstrate potential for a high concentration of users from planned new development and from existing built form were identified. The results of this analysis yielded the figure below, which highlights the priority areas for DES expansion



1 Tunney's Pasture Master Plan:
- TOD
- High density
- Mix of uses
- Large buildings

2 Scott Street:
- Natural connection between Tunney's and LeBreton
- TOD
- Infill potential
- Large buildings

3 RendezVous LeBreton:
- High density
- Mix of uses
- Large scale under one developer

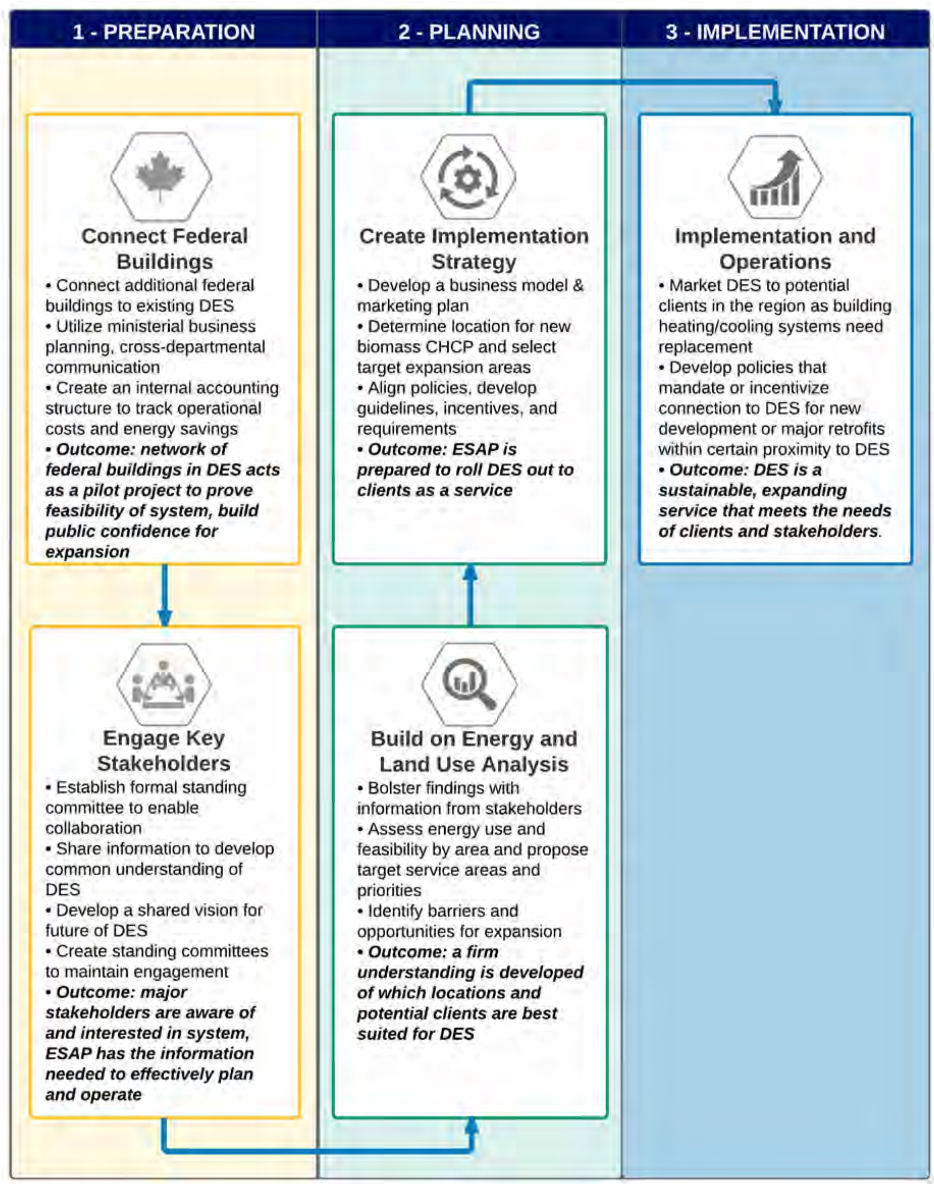
4 Downtown:
- High concentration of large buildings
- Mix of uses
- Government buildings
- High 'visibility' for marketing and pilot project

5 Centretown Spurs:
- Natural extension to downtown
- High concentration of large buildings

6 Byward Market:
- Natural extension to downtown
- Government buildings and large buildings

Recommendations: A Roadmap for Expansion

From the lessons learned a variety of recommendations for the expansion of ESAP's DES in the NCR were generated. These recommendations come together to form a roadmap charting out a long-term process for expansion. The chart below displays an overview of these recommended steps. Three stages are recommended for long-term implementation: Preparation, including completion and streamlining of the internal federal system and engagement with key stakeholders; Planning, including further analysis of conditions and the creation of a clear implementation strategy for expansion in the market; and Implementation, which covers the ongoing operation of the DES with an aim of continual expansion and improvement. As an ultimate outcome, DES in the NCR is envisioned as a sustainable, financially feasible product that delivers high quality service to clients while meeting the environmental goals of stakeholders.



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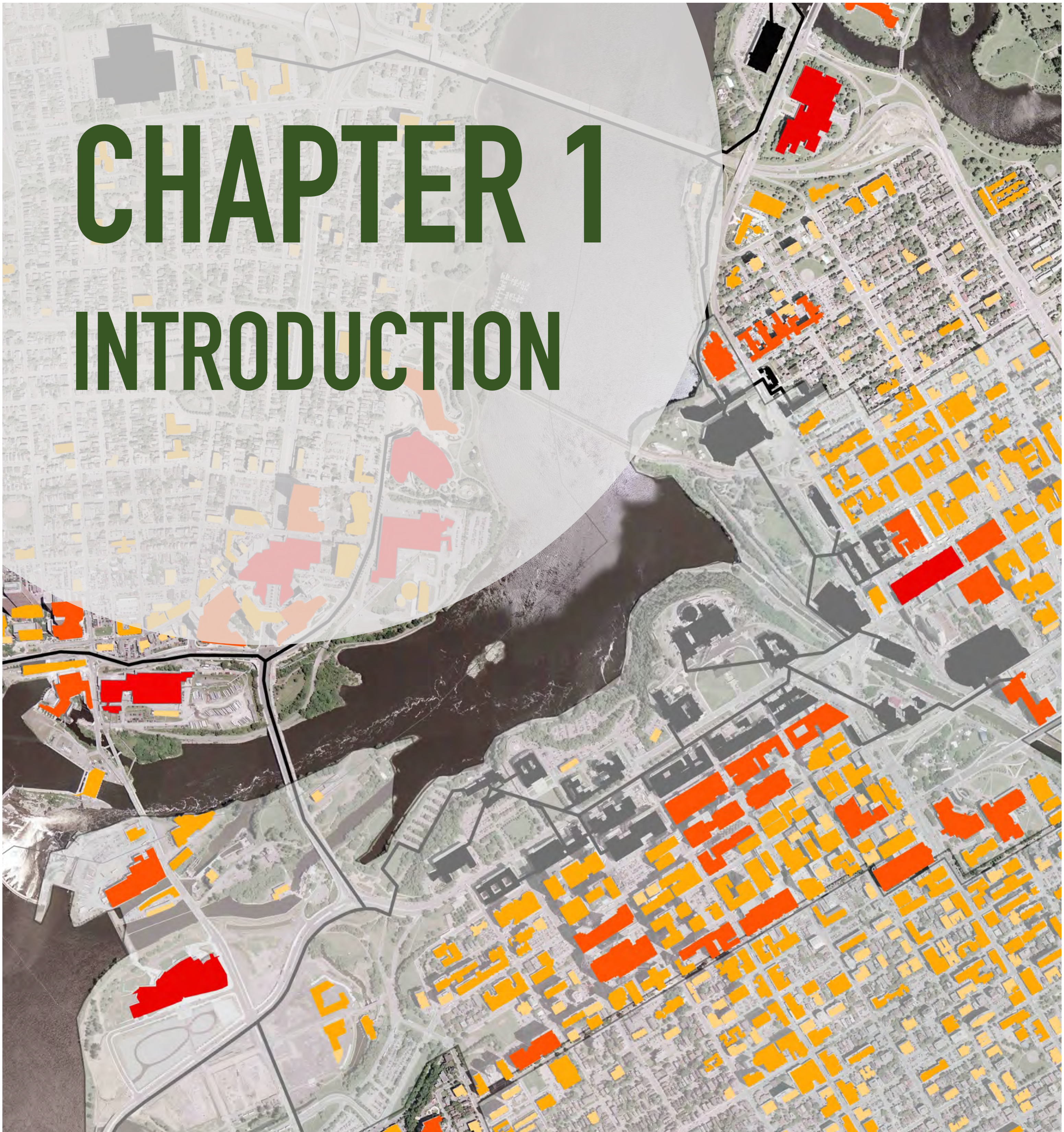
CHAPTER 1

INTRODUCTION



SURP 824 PROJECT COURSE

1.0 Introduction

1.1 Purpose of the Report

Public Services and Procurement Canada (PSPC) retained the Queen's University School of Urban and Regional Planning (SURP) 824 project course team to develop an implementation strategy for District Energy System (DES) expansion in the National Capital Region (NCR). The team was tasked with the following:

1. Demonstrate an understanding of the Energy Services Acquisitions Program (ESAP) and the PSPC DES;
2. Evaluate existing planning policy and government context in the NCR and identify key stakeholders;
3. Create a list of lessons learned from successful and unsuccessful DES case studies in comparable places to the NCR;
4. Identify potential locations for expansion of the DES in the NCR by analyzing supportive land use policy conditions and potential users; and,
5. Recommend next steps for ESAP for how to achieve expansion of the DES in the NCR.

The team satisfied these objectives through a multi-faceted analysis of three themes, which are Land Use and Expansion, Growing Client Base, and System Governance. These efforts were informed by stakeholder interviews, contextual research, policy review, case studies, SWOC analysis, and land use mapping (Appendix D). This report acts as a culmination of this work, which includes a chart of the lessons learned from case studies, the identification of areas on which to focus further expansion studies in the form of detailed maps, and a process roadmap for how to feasibly expand the DES.

1.2 Context

1.2.1 Client

PSPC is the federal authority for real estate and servicing of federal lands within the NCR. Currently, PSPC is responsible for providing heating and cooling services, in the form of a DES, to over 80 federal buildings in Ottawa and Gatineau.[1] In 2009, PSPC established ESAP to implement extensive upgrades and greening to this aging DES.[2] The first phase, which includes the modernization of the DES, is projected to be completed by 2025. The second phase, which includes the greening of the DES, is long-term and will continue beyond 2050.

As part of the Government of Canada, PSPC's interest in DES modernization, greening, and expansion stems from the federal *Greening Government Strategy* and vision for Ottawa to be the greenest capital city in the world.[3] Successful district energy is efficient, reliable, and more cost-effective compared to other conventional energy systems. When combined with renewable fuel sources, DES can significantly reduce environmental impact by decreasing the amount of greenhouse gas (GHG) emissions produced for heating and cooling in urban areas. The work of the SURP 824 project team included in this report is intended to build upon the existing work of ESAP, with a specific focus on the land use considerations of expanding the DES.

1.2.2 Study Area

The NCR is an expansive area (4,715 square kilometres[4]) extending into the provinces of both Ontario and Québec. The NCR, intersected by the Ottawa River, includes both the municipalities of the Ville de Gatineau and the City of Ottawa (Figure 1), as well as the surrounding rural areas. With a population of 1,323,783 as of the 2016 census, the NCR is the fifth-largest metropolitan area in Canada after Toronto, Montreal, Vancouver, and Calgary.[5] Due to Ottawa's unique status as the national capital of Canada, there are additional governmental agencies, as well as federal institutions and buildings, that set this area apart from other Canadian cities. Because of the federal presence as well as the fact that the region spans between two major cities in two provinces, this region is jurisdictionally complex. In a semi-continental climate that experiences extremely cold winters and high summer temperatures, Ottawa is one of the coldest capitals in the world.

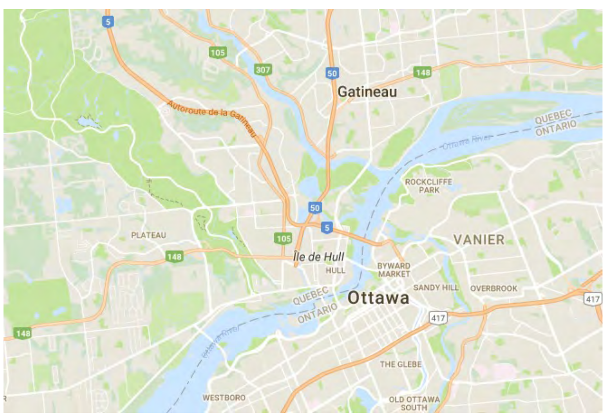


Figure 1: The National Capital Region (NCR) including both Gatineau and Ottawa.[6]

1.2.3 Growth

1.2.3.1 General Trends

Urban development covers 10% of Ottawa's 2,760 square kilometre area, while the remaining area is predominantly rural land. By 2036, the population of the NCR is projected to increase to almost 1,800,000, of which the City of Ottawa is projected to account for 70% of the total population, slightly higher than its current 66.7% share of the region.[7]

Ottawa has experienced a steady increase of occupied private dwellings and an ongoing decline in average household size in recent years. The City of Ottawa projected that such changes in demographics, combined with the shifting housing market, would create a trend away from lower-density single-detached housing to higher-density housing forms, such as apartments. This has happened more quickly than anticipated. Studies provided by the City of Ottawa also note an increase in various types of townhouses. Housing projections show a need for 131,000 additional housing units over the 2014 to 2036 period, an increase of 34% from 2014, of which apartment units are projected to make up 36%.[8]

Overall, the cost of dwellings in Gatineau are much lower than in Ottawa, while offering a larger selection of types for both sale and rent. As per the 2016 Canada Mortgage and Housing Corporation (CMHC) Housing Market Outlook, the combination of a more favourable job market and an increase in the population aged 25 to 44 will start to improve housing activity in Gatineau. Starting in 2017, lower inventories and an increased demand will fuel residential construction moving forward.

Total jobs in Ottawa in 2036 are projected to be 745,000, which represents an increase by 167,000 jobs, with 95% of this increase occurring in the urban area. In Gatineau, employment is expected to continue to grow over the next few years, which will in turn support demand for housing.[9]

Both the job market and demand for office space is changing due to the rise in entrepreneurship, design industries, and popularity of the shared economy model. In recent years, there has been an increase in office environments that offer flexible leases and shared space, rather than the traditional model with cubicles and corner offices. The shared-space model is one where those using the office can commit to a specific workspace for a period or opt to occupy the occasional free desk. Some studies point to the shared space market eventually making up 20% of all downtown office real estate in Canada.[10]

Given the impact of new technologies, an uncertain economy, and the demands of a new generation of employees, the future of the workplace is less focussed on place. The large companies that dominate Canada's private sector and some government agencies, alike, are starting to embrace these changes by using new methods to both attract and retain the younger generation. The workplace dynamic is beginning to shift largely over concerns about topics such as commute times, vacation days, and child care.[11]

In January 2010, the Ottawa City Council approved the functional design for the new Light Rail Transit (LRT) corridor from Tunney's Pasture to Blair Station, called the Confederation Line, which is shown in Figure 2. The system includes 12.5 kilometres of new rail, 13 stations, and a tunnel through the downtown core. The new line, scheduled to open in the spring of 2018, will bring transit-supportive and intensified land development to the areas surrounding the transit stations.

Figure 2: The new Light Rail Transit corridor from Tunney's Pasture to Blair Station, called the Confederation Line, set to open in the spring of 2018.[12]

1.2.3.2 New Development

Urban infill provides an opportunity for the more efficient use of existing infrastructure and community facilities, while also reducing the investments required for new infrastructure, transit systems, and energy production.[13] Several brownfield redevelopments are planned for the Ottawa area, the most notable of which are LeBreton Flats and Zibi. In Gatineau, an urban redevelopment of particular note is Place des Peuples. Table 1 acts to summarize the information on these developments, which is also included below in more detail.

Situated along the Ottawa river near Chaudière Falls west of downtown Ottawa, LeBreton Flats is a parcel of significant land that has been vacant since 1960. The revival of the area poses a unique opportunity to create one of the largest and most sustainable master planned communities in North America. The LeBreton Flats, RendezVous LeBreton, redevelopment is a multi-phase master planned community posed to create a vibrant urban centre that will transform Ottawa. Phase one of the plan began in 2017, with the intention to move onto phase two in 2026 and phase three in 2036. The estimated capital investment for construction is $5.7-billion, which will create 22,000 jobs. To date, Claridge Homes has proposed five residential towers, including three 25-storey towers, one 30-storey tower, and one 55-storey tower, to deliver a mix of 1,650 market and affordable housing units. Fusion LeBreton Flats is a condominium development already under construction with three residential components, including two condominium mid-rise buildings with six-storeys and eight-storeys, as well as a collection of stacked townhomes. In addition, LeBreton Flats redevelopment will be the new home for the Ottawa Senators NHL hockey arena.

Zibi is a master planned community located on the Chaudière and Albert Islands of Ottawa and a slice of Gatineau's shoreline. The fact that Zibi is located partly in both the City of Ottawa and Ville de Gatineau makes it unique, as this is something that has never been done before in the NCR.

Project Name	Type of Project	Size	Estimated Cost	Number of Units	Phasing
Lebreton Flats/RendezVous LeBreton	Multiple phase master planned brownfield redevelopment	21 hectares (52 acres)	$3.5-billion	One proposed development so far: 1,650 market and affordable housing units	Phase 1: 2017-2026 Phase 2: 2026-2036 Phase 3: 2036+
Zibi	Multiple phase master planned brownfield redevelopment	15 hectares (37 acres)	$1.2-billion	1,200 residential units, office space, hotel, and retail space	10 to 12 phases
Place des Peuples	Two high-rise towers	Not known	$400-million	420 residential units, 320 hotel rooms, 125,000 sq. ft. of commercial space	N/A

Table 1: A summary of the major new/proposed developments in the NCR.

The development provides the opportunity to take advantage of the disconnected and underutilized islands on the Ottawa side and to extend Gatineau out to the banks of the Ottawa River. Over the next twelve years, office spaces, hotels, retail spaces, and 1,200 residential units will be constructed at Zibi based on the design principles established to create one of the world's most environmentally conscious communities. This $1.2-billion brownfield redevelopment by Windmill Development Group and Dream Unlimited Corp. will blend this mix of land uses with extensive public spaces, including parks, plazas, and trails. With a total of 15-hectares of land, Zibi will be made up of unique districts, each having their own identity and spaces to support a vibrant urban lifestyle. As part of meeting environmental targets, the development will include its own DES using waste heat capture from the Kruger Pulp and Paper Mill.

Place des Peuples is a unique condominium development proposal in Gatineau. The proposed development is set to act as a cornerstone of the revival of downtown Gatineau and boasts 420 residential units divided between two towers, which will be 35-storeys and 55-storeys. In addition, there will be 125,000 square feet of commercial space and 320 hotel rooms. Situated next to the Canadian Museum of History, Place des Peuples is intended to become a center of attraction and a symbol of civic pride for Gatineau and the NCR.

[1] Public Services and Procurement Canada (PSPC). (August 31, 2017). Request for Qualifications for the Energy Services Acquisition Program (ESAP) Energy Service Modernization RFQ # EP635-173247/B. Retrieved from https://buyandsell.gc.ca/cds/public/2017/09/11/414f470ce21c1ef9a57793627ff9e7b2/ABES.PROD.PW__NB.B011.E73350.ATTA009.PDF

[2] Public Services and Procurement Canada, 2017.

[3] Smetny-Sowa, Tomasz. (November 17, 2016). Real Property Institute of Canada 2016 Real Property National Workshop. Retrieved from http://www.rpic-ibic.ca/documents/2016_RP_NW/Presentations/RPIC_Presentation_2016_ESAP_EN.pdf

[4] Statistics Canada. (2017). Focus on Geography Series, 2016 Census. Statistics Canada Catalogue no. 98-404-X2016001. Retrieved from http://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=505

[5] Statistics Canada. (2017). Focus on Geography Series, 2016 Census. Statistics Canada Catalogue no. 98-404-X2016001. Retrieved from http://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=505

[6] The National Capital Region Map. Retrieved from Snazzy Maps.

[7] Statistics Canada. (2016). Ottawa – Gatineau CMA population and housing counts. Retrieved from http://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=505

[8] City of Ottawa. Growth Projections for Ottawa 2006-2031. Retrieved from https://ottawa.ca/en/city-hall/get-know-your-city/statistics-and-economic-profile/statistics/growth-projections-2006-0

[9] Statistics Canada. (2016). Ottawa – Gatineau CMA labour. http://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-CMA-Eng.cfm?TOPIC=11&LANG=Eng&GK=CMA&GC=505

[10] Marr, G. (September 2017). "Sharing spaces: A shift in Canada's office culture." National Post. Retrieved from https://www.pressreader.com/canada/national-post-national-edition/20170916/281835758871107

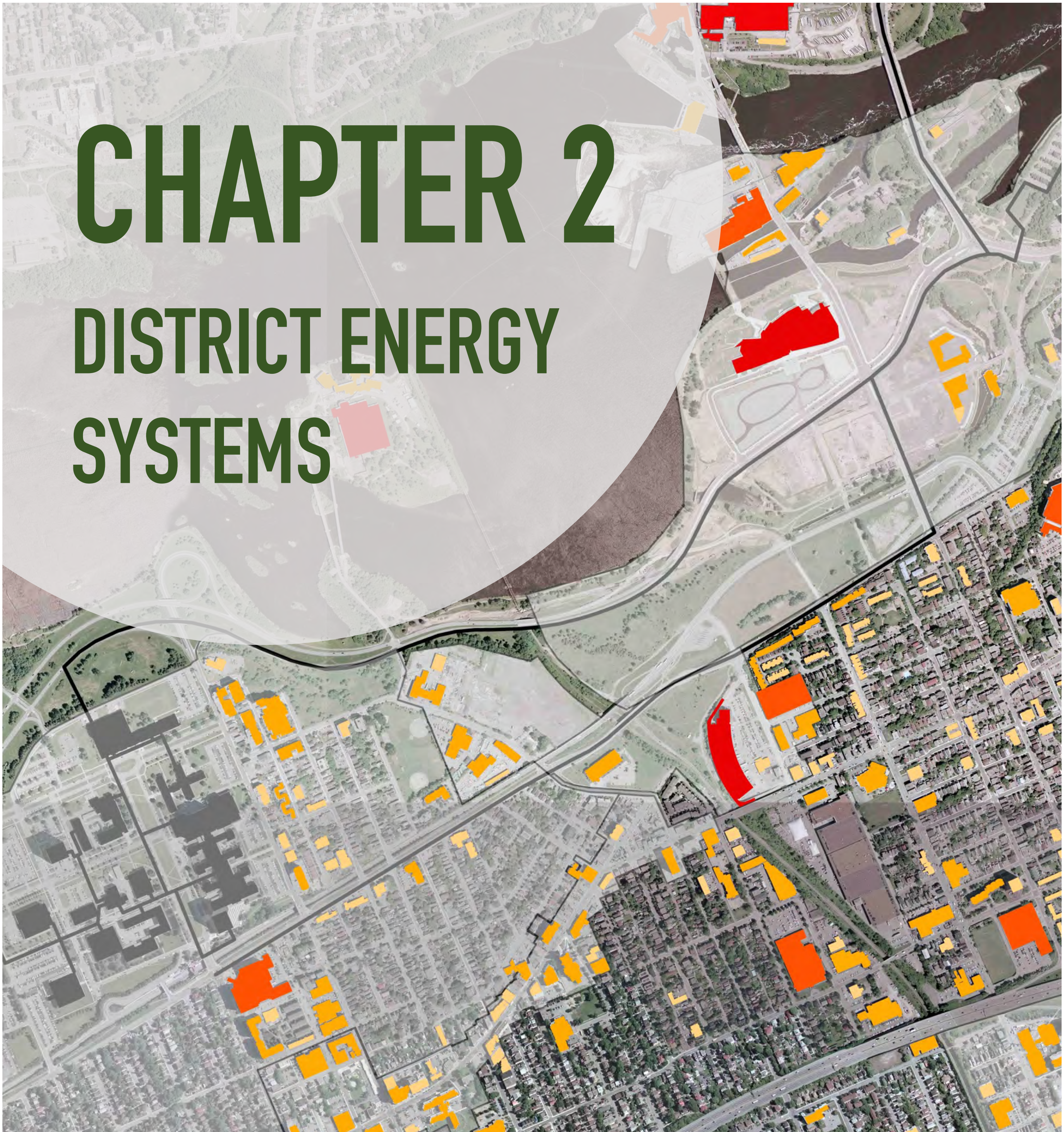
[11] The Canadian Press. (January 2016). "The future of work: mobile offices, more flexibility but temporary jobs." Retrieved from http://www.cbc.ca/news/business/workplace-trends-office-1.3386128

[12] Confederation Line light rail transit. Retrieved from https://thecanadianpress-a.akamaihd.net/graphics/2016/ottawa-urban-renewal/index.html

[13] City of Ottawa, Urban Design Guidelines for Low-Medium Density Infill Housing. Retrieved from http://ottawa.ca/calendar/ottawa/citycouncil/occ/2009/10-28/pec/5-ACS2009-ICS-PGM-0191%20-%20Low-Medium%20Density%20Infill%20Housing%20-%20Doc.%201.doc.pdf

CHAPTER 2

DISTRICT ENERGY SYSTEMS



SURP 824 PROJECT COURSE

2.0 District Energy Systems

2.1 How District Energy Works

A district energy system (DES) serves to distribute energy generated at a local, centralized location to buildings connected via a network of predominantly underground piping. Such a system can play a variety of roles, including supplying heating, cooling, and electricity. The most common role of such a system is providing space and water heating, which, in many cases, is coupled with cooling and/or electricity supply. In North America, this type of system is most often installed to serve the needs of a campus-type development (Figure 1), supporting high energy demand institutional or industrial uses. However, increasingly, North American cities are following the example of international cities in developing these systems for wider use in densely built-up areas where energy demand is high. Movement towards the use of DESs is due to the inherent efficiency of such a system that lends to all three main facets of sustainability – environmental, social, and economic.

Figure 1: UBC District Energy Utility Centre, The University of British Columbia.[1]

The concept of a DES in practice begins with a generation plant, or energy centre. These plants, of which there can be multiple in each system, are located centrally such that the network of distribution piping originating from them can satisfy the demand of a broad area. A given plant will house the infrastructure necessary to generate the energy output for distribution. In the case of heat generation, there are most commonly a series of boilers housed in the plant. These boilers can be powered by a variety of fuels, with the limiting factors being the technology selected, the type of heating distributed, and the relative cost of the fuels. In many cases the boilers are selected such that they can be powered by renewable fuels to enhance the sustainability of the system. Fuels like natural gas are a common starting point from which a transition to renewables can eventually be made once the proper resources are available and the infrastructure is in place. These boilers can act to produce low-temperature hot water (LTHW), high-temperature hot water (HTHW), or steam to distribute for heating, depending on the system requirements. Of these three options, it has been demonstrated that LTHW is the most efficient, as it has the lowest heat losses associated with conversion and distribution, as well as at the building level. Chilled water, on the other hand, is distributed for the cooling of buildings within a system. In many cases, the plants will house water chillers, often powered by steam or electricity, where in other cases the water can be chilled using a large nearby water body. The fuels selected to power the technology within the plants largely depends on the temperature of water being distributed, as the combustion of some fuels cannot produce enough heat to result in HTHW.

Once the water is heated or cooled, it is sent through the distribution piping to the connected buildings. The piping infrastructure is often installed underground, but can sometimes be located atop roofs and along bridges or other major infrastructure. The nature and size requirements of the piping depend on the temperature of the water being distributed. Where the piping connects to each building, there are two options: either the water cycles through an energy transfer station or the water moves directly into the heating or cooling system of the building. The former, being an indirect connection, is the most common. If an energy transfer station is used, the water from the DES either acts to heat or cool the water on the building side of the system inside the heat exchanger. From there, the newly heated or cooled water within the building circulates to serve the needs of the building. The water in the DES that has now given up some of its energy circulates back to the plant to either be re-heated or re-cooled and repeat the entire process, forming a closed-loop. In order to track the energy from the system used by a building, there is a metre connected to each energy transfer station. The entire simplified functionality of a DES is illustrated in Figure 2.

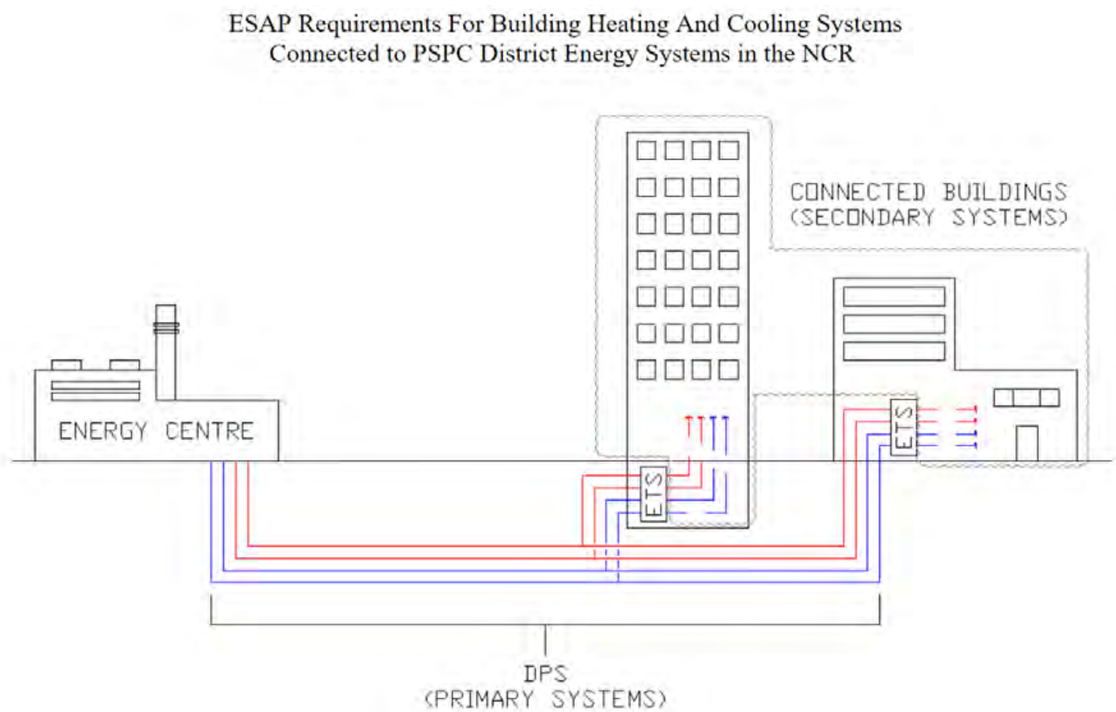


Figure 2: This figure illustrates the functionality of a DES. The water is heated or cooled at the energy centre, which is then circulated through the distribution piping to the energy transfer stations (ETS) in the connected buildings, and the resulting lower-energy water is then circulated back to the energy centre and the cycle is repeated.[2]

2.2 Benefits of District Energy

The benefits of DESs have been demonstrated across the globe through cost savings, convenience, energy security, adaptability, and reduced environmental impact. Because of the inherent efficiency of a centralized system and the advancing efficiency of individual boilers, heating and cooling costs for a given higher-density area have been reduced by up to 50%, which are savings experienced directly by the customers who are connected to the system.[3] Added benefits for building owners include a reduction in maintenance needs, reduction in space needed for heating and cooling systems in the building, and an overall increase in heating and cooling reliability. Maintenance is reduced because the operators of the DES maintain the entire network, most often including the energy transfer stations. Reliability is increased because of this and because there is typically more than one energy centre on a given system, which means that in the event one plant fails the others will continue to heat or cool the connected buildings. The efficiency of a DES also means that the environmental footprint associated with heating and cooling is greatly decreased. Beyond efficiency, the potential for these systems to be powered by renewable fuel sources, such as solar energy or biomass, results in significant reductions to both the emission of greenhouse gasses and particulate matter, which acts to both decrease the contributions to climate change and improve air quality. In these ways, DESs are sustainable solutions to meet the heating and cooling needs of diverse situations.

Overall, the main benefits of DESs include:

1. Cost savings for energy users and producers;
2. Reduction in upkeep, maintenance costs, and labour for building owners;
3. Improved reliability of heating and cooling systems due to external upkeep and built-in redundancy;
4. Reduction in space required within the building for heating and cooling systems; and
5. Lower environmental impact through energy efficiency and easier conversion to renewable energy sources.

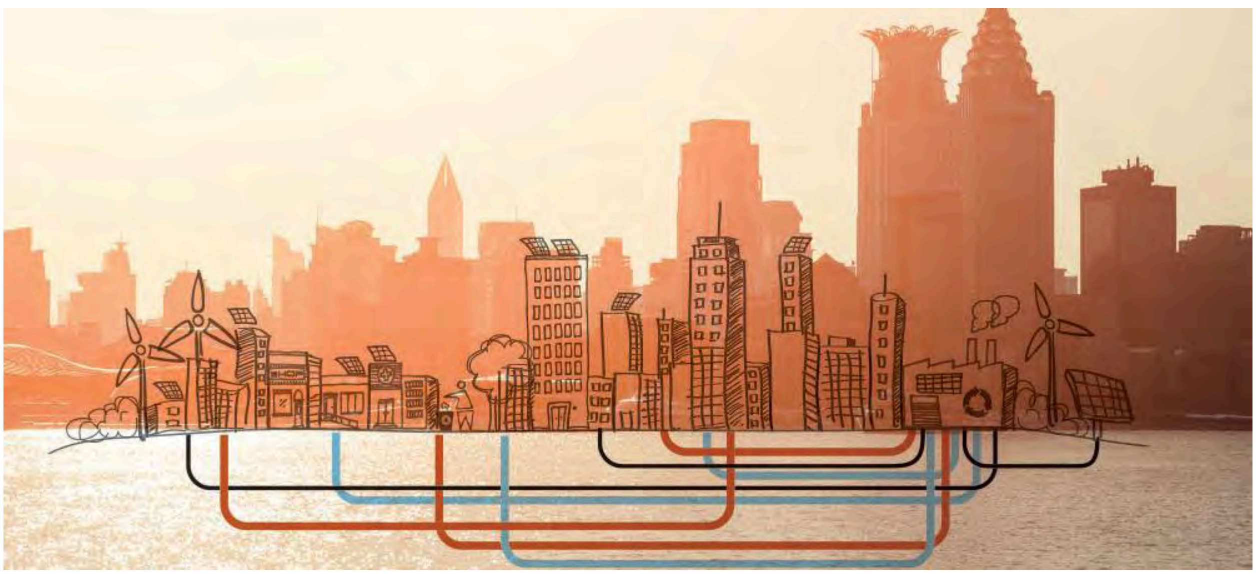


Figure 3: This figure illustrates the complexity and possible number of users in a district energy system.[4]

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[1] UBC District Energy Utility. Retrieved from thinkingthefuture.com/institutional/ubc-district-energy-centre-dialog/

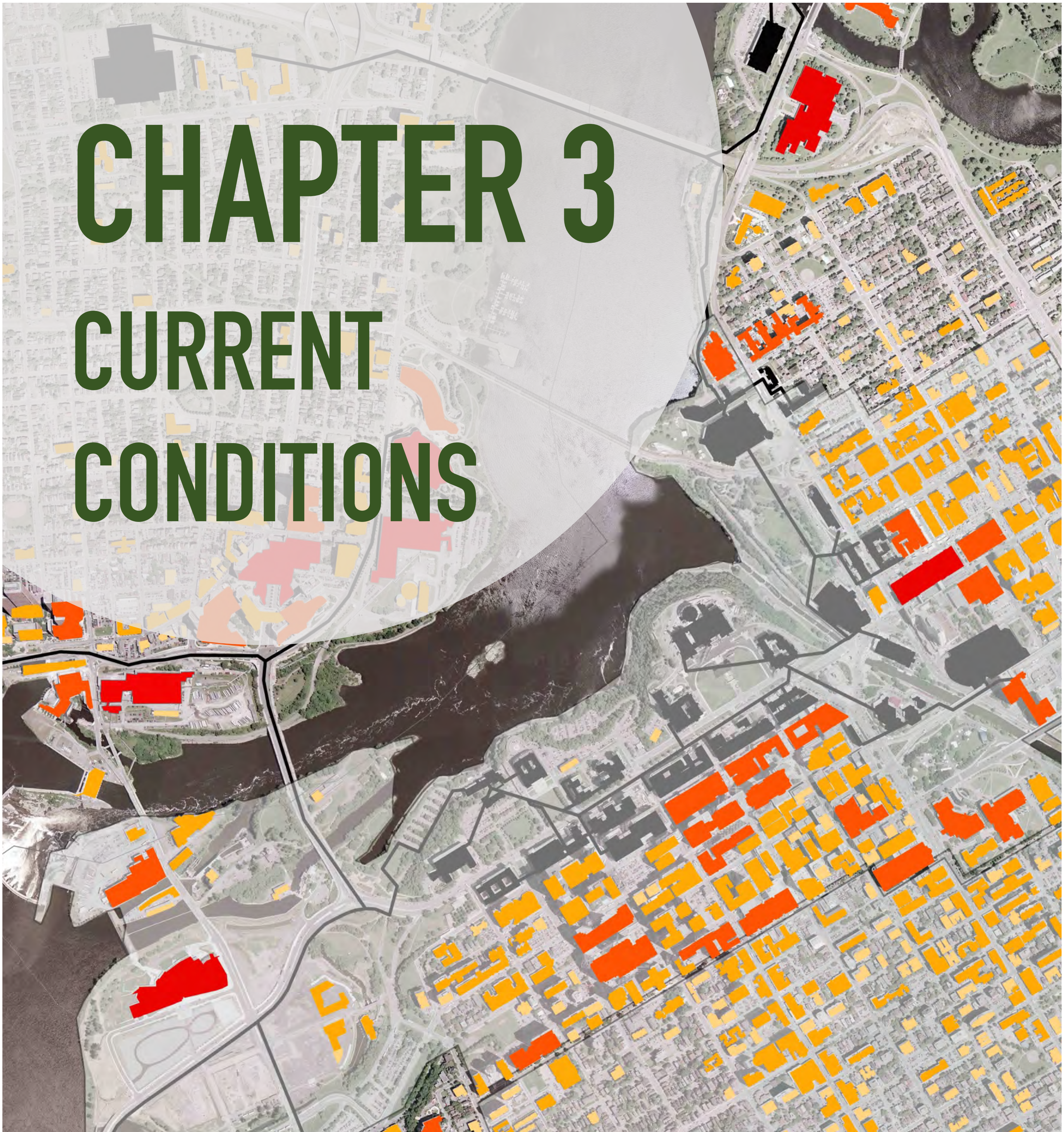
[2] Public Services and Procurement Canada. (2016). ESAP Requirements for Building Heating and Cooling Systems Connected to PSPC District Energy Systems in the NCR.

[3] District Energy in Cities Initiative. (n.d.). Why District Energy? Retrieved from http://www.districtenergyinitiative.org/why-district-energy

[4] District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy. United Nations Environment Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/9317/-District_energy_in_cities_unlocking_the_potential_of_energy_efficiency_and_renewable_ene.pdf?sequence=2&isAllowed=y

CHAPTER 3

CURRENT CONDITIONS



SURP 824 PROJECT COURSE

3.0 Current Conditions: District Energy in the National Capital Region

This section provides background information on the existing conditions of the district energy system (DES) in the National Capital Region (NCR), the planned upgrades of the Energy Services and Acquisition Program (ESAP), and the current government and policy context.

3.1 NCR DES Current System

Figure 1: This map indicates the locations and distribution zones of each CHCP in the PSPC DES, and includes the phase 1 piping to connect the Cliff Plant and Tunney's Pasture.

The existing DES in the NCR, which is owned by Public Services and Procurement Canada (PSPC), currently offers combined heating and cooling to approximately 80 federally-owned buildings within Ottawa and Gatineau. The PSPC DES includes five Central Heating and Cooling Plants (CHCPs), which were built between 1916 and 1958.[1] The CHCPs are positioned throughout the NCR, the locations and distribution zones of which are illustrated in Figure 1. Four of the plants are located in Ottawa and the fifth is in Gatineau.

Connections from the distribution system to the buildings exist in two forms throughout this DES. The heating functions, which is a supply of either steam or High Temperature Hot Water (HTHW), are either directly connected to the buildings, meaning the water circulated in the DES also circulates in the building, or indirectly connected through a heat exchanger within an energy transfer station. The cooling functions are predominantly directly connected to the buildings in the same way. A summary of the CHCP characteristics are shown in Table 1:

CHCP	Year Built	Type of Power	System Function	Number of Buildings Serviced	Additional Notes
Cliff Plant (Ottawa)	1916	4 steam boilers 6 electric chillers (2 at Dpt. of National Defense HQ	Primary	51 heating 41 cooling	• In 2009, all of the heating functions were moved from the Cliff Plant to a temporary steam boiler plant south west of this location on Fleet Street • Largest system with 6.5 km of tunnels and 2km underground piping • Services most of the parliamentary precinct
National Research Council (Ottawa)	1930	2 steam boilers, 4 electric chillers	Backup to Cliff Plant		
Confederation Heights (Ottawa)	1958	4 HTHW boilers, 5 electric chillers	Standalone	11 heating 9 cooling	• 2 km of tunnels and 350 m of underground piping
Tunney's Pasture (Ottawa)	1952	4 steam boilers, 5 electric chillers	Standalone	18 heating 16 cooling	• 1.4 km of tunnels • Serves federal campus • CHCP building has federal heritage status
National Printing Bureau (Gatineau)	1954	3 steam boilers, 4 electric chillers	Standalone	1 heating and 1 cooling	• Plant used to be connected to NRC and Cliff network via the MacDonald Cartier Bridge • CHCP building has federal heritage status

Table 1: A summary of the main characteristics of each of the existing CHCPs in the NCR. [2]

The current CHCPs are not meeting many of the necessary standards and thus need upgrades.[3] The PSPC DES is no longer functioning at its original high efficiency and the plants are near the end of their life-cycle, making them costly to maintain.[4] Because of this outdated technology, the system operates 25% less efficiently than the best in the industry. The current boilers are fueled by natural gas and oil, which contributes significant greenhouse gas emissions to the atmosphere.[5] The modernization and introduction of new technologies will enable the system to function more sustainably, both economically and environmentally.

3.2 Energy Services Acquisition Program (ESAP)

ESAP's modernization process consists of two phases: (1) modernization of the existing system; and (2) expansion and greening of the system. ESAP's modernization of the heating and cooling system within the NCR will achieve seven project objectives to create many benefits for the Government of Canada, including contributing to greenhouse gas (GHG) emission reduction targets, reducing costs, and increasing safety and reliability.[6] Seven objectives have been set by ESAP to direct the modernization of the DES:

1. Improving the Government of Canada's environmental performance;
2. Reducing the costs of heating and cooling operations;
3. Increasing safety and reliability of both the heating and cooling systems;
4. Utilizing the private sector's innovation, capacity and expertise;
5. Expanding the district energy infrastructure throughout the NCR;
6. Implementing an education platform into the new system; and
7. Designing the Cliff Plant into an Architectural landmark.

These objectives have also been used to inform the goals of this project.

3.2.1 Phase 1: Modernization

The main objectives of the first phase of ESAP's modernization process, which will run from 2017 to 2025, are upgrading the heating system to supply low temperature hot water (LTHW) instead of steam and to switch to electric chillers.[7] This will include the replacement of a variety of infrastructure, including building connections, 14 kilometres of piping, and technology in four of the CHCPs, which will increase the capacity of the system by 25%. During phase one, ESAP will be creating an interconnected network between the NRC, Cliff, Tunney's Pasture, and NPB CHCPs, as well as a connection across the Portage Bridge to Place du Portage.

ESAP is in the process of establishing a public-private partnership (P3) model to complete the modernization of phase one. The Request for Qualifications has closed and ESAP is currently preparing the Request for Proposals in order to select one private sector partner. The selected private sector partner will be responsible for designing, constructing, and financing the project on a 35-year contract.[8] The private sector partner will also be required to complete the conversion of the system to distribute LTHW, rather than steam, and to redevelop the Cliff plant into a landmark of the NCR.[9]

During phase one, ESAP will also be testing new carbon neutral fuels to replace the natural gas that currently powers the system.[10] Starting in the summer of 2017, the Government of Canada launched two pilot projects, which involve the installation and evaluation of alternate fuel sources within the DES, with the goal of determining the most reliable fuel for reducing the NCR's carbon footprint.[11] The two pilot projects will be implemented at the Confederation Heights CHCP as part of the modernization of the PSPC DES.[12] At this time, the pilot project includes two contracts for different types of fuels, which are biofuel and a wood chip biomass.[13] Both the use of biofuel and biomass will require the installation of new infrastructure in the Confederation Heights plant.[14]

3.2.2 Phase 2: Greening and Expansion

Based on the findings from the pilot projects, the most effective alternative fuel will be integrated into the functionality of a new biofuel or biomass plant in phase two. ESAP is anticipating phase two to begin in 2025, once the conversion of the heating system to LTHW is completed.[15] This section of the modernization process is estimated to reduce GHG emissions by 63%.[16]

It is during phase two that ESAP intends to look at expansion of the system to connect more buildings and areas onto the DES. In their calculations for total building energy loads after modernization, ESAP has factored in an extra 25% capacity. A building currently connected to the system has an average energy load of 1.38 megawatts. By our calculations, included in Appendix B, the 25% capacity will allow for approximately 23 additional buildings to connect to the DES heating network. The new bio-mass plant proposed will produce approximately 60 megawatts of additional capacity, which could support another 43 average-sized building connections. Upon completion of the modernization phase, ESAP has stated that its DES will be able to support up to 600 buildings.[17] From our understanding, this will require additional plants to be built and connected to the system over the long-term.

3.3 Government Context

With the PSPC DES being located within the NCR, there are several governmental jurisdictions and policies at play, including federal, provincial, and municipal, that must be considered for the potential expansion of the system. The Government of Canada, Province of Ontario, Province of Québec, City of Ottawa, and Ville de Gatineau are key stakeholders based upon the legislative framework of Canada. In Canada, legislative powers and responsibilities are outlined in the *Constitution Act (1982)* under which federal and provincial governments are delegated separate domains. The federal government's domain includes matters relating to the peace, order, and good government of Canada, including but not limited to criminal law, regulation of trade and commerce, and currency. [18] Each province is entitled to make laws in relation to direct taxation, property and civil rights, municipalities, administration of justice, licences, hospitals and other institutions, and other specified matters in, or for, the Province.[19] As such, municipalities are not directly issued power but are "creatures of the province" with all regulatory powers prescribed by the provincial government.[20]

This section summarizes the government context and an analysis of higher-level documents, policies, and plans that identify environmental and energy priorities relevant to the PSPC DES, as shown in Table 2. These documents, policies, and plans all directly influence how decisions regarding environmental sustainability and general land use are made in the NCR and contain policies that must be considered in the broader context of a DES.

	Government of Canada	National Capital Commission	Ontario	Québec	Ottawa	Gatineau
Level of Government	Federal	Federal	Provincial	Provincial	Municipal	Municipal
Legislation	-Constitution Act (1982)	-National Capital Act (1959)	-Constitution Act (1982) -Municipal Act (2001) -Planning Act (1990) -Municipal Code of Québec (2000)	-Constitution Act (1982) -Municipal Powers Act (2005) -Sustainable Development Act (2006)	-City of Ottawa Act, S.O. (1999)	-Charter of Ville de Gatineau (2001)
Environmental Policy	-Federal Sustainable Development Strategy (2016-2019) -Policy on Green Procurement (2006)	-Environmental Strategy (2009, currently being updated) -Plan for Canada's Capital (2017)	-Long Term Energy Plan (2017) -Go Green (2007) -Green Energy and Green Economy Act (2009) -Ontario's Climate Change Strategy (2015) -Cap and trade (2017)	-Politique énergétique 2030 (2016) -Government Sustainable Development Strategy (2008) -Plan d'action 2013-2020 sur les changements climatiques (2012) -New cap and trade system (2014)	-Environmental Strategy (2003) -Framing Our Future (2012) -Sustainability and Resilience Plan (2012) -Energy and Emissions Plan (2012) -Risk Prevention and Mitigation Plan (2012)	-Plan stratégique, (2016) -Plan d'action politique environnementale (2009)
Development/ Land Use/ Infrastructure Policy	Long-Term Vision and Plan (2007)	-Capital Urban Lands Plan (2017-2067) -Canada's Capital Core Area Sector Plan (2005) -Confederation Heights Sector Plan (2000)	-Ontario Energy Board Act (1998) -Provincial Policy Statement (2014)	-Loi Sur Hydro-Québec (1983)	-Official Plan (2016) -Secondary Plans -Zoning bylaw (2008) -Infrastructure Master Plan (2009)	Plan d'urbanisme de la Ville de Gatineau (2012) -Le plan de zonage (2005)

Table 2: Summary Table of the governing policy context for the PSPC DES.

3.3.1 Government of Canada

The Government of Canada is the administrative organization that oversees the operations of Canada's various departments, agencies, and other entities, such as crown corporations. The Government of Canada employs over 258,000 people and manages a budget of over $330-billion.[21,22] There is only a limited amount of government-wide policy that exists, as policy tends to be focused specifically on the ministry it impacts most directly. As the DES is currently owned by PSPC, a federal department, its operations are beholden to Government of

Canada policies. The policies that are most relevant to the PSPC DES are the Federal Sustainable Development Strategy, the Policy on Green Procurement, and the Long Term Vision and Plan.

Federal Sustainable Development Strategy

The Federal Sustainable Development Strategy is the main reporting tool and standard for sustainable development planning used by the Government of Canada. This strategy sets forward 13 priority areas to which all federal departments and organizations must adhere. Of particular relevance to the PSPC DES are the priorities of a "Low-Carbon Government," "Modern and Resilient Infrastructure," and "Clean Energy".[23] These priorities include an ambitious target of reducing GHG emissions from federal buildings and fleets by 40% below 2005 levels by 2030.[24] Beyond this self-imposed requirement, the PSPC DES is also supported through other policies in the strategy that support investing in green technology and green infrastructure, as well as making green infrastructure more accessible to Canadians.[25]

Policy on Green Procurement

The Policy on Green Procurement is a federal policy that is being implemented through PSPC. The intention of this policy is to advance the protection of the environment and support sustainable development by integrating environmental performance considerations into the procurement decision-making process. This is fundamentally tied to the PSPC DES project, as the redevelopment process should meet the performance considerations outlined in this policy. Particularly important is this policy's commitment to apply "more environmentally responsible planning…[and] use…in the federal government".[26] The way that this planning is integrated into the procurement strategy is through the redefining of the concept of "value for money" to include environmental considerations beyond cost, performance, availability, and quality.

Independent of these considerations, the policy also has the stated objective of seeking to "stimulate innovation and market development of, and demand for, environmentally preferred goods and services, making these available and mainstream for other sectors of society".[27] This will be a critical objective to the future expansion of the PSPC DES. Such an objective clearly expresses the desire of the Government of Canada to see green services, such as DES, being expanded and offered to as many Canadians as possible.

Parliamentary Precinct

As the Parliamentary Precinct is the seat of Canada's parliamentary system and a symbolic gathering place for Canadians, it is essential that the Precinct be preserved and enhanced. The Government of Canada's Long-Term Vision and Plan (LTVP) emphasizes the need for energy-efficient systems and state-of-the-art sustainable features to reduce Parliament's environmental footprint. Part of the LTVP consists of an extensive sequence of moves needed to allow Centre Block to be vacated and rehabilitated. Between 2006 and 2028, six building functions will be moved to allow this to be achieved, which include Valour Building, Wellington Building, West Block, Government Conference Centre, Centre Block, and East Block. The LTVP covers both the Parliamentary and Judicial Precincts, shown in Figure 2.

Environmental Sustainability is one of the goals of the LTVP, specifically regarding new development, renewal, and rehabilitation. District energy is specifically mentioned in the Energy Reduction section under Environmental

Sustainability. One strategy to help reduce energy demand is "implementing high efficiency river source district heating and cooling to supplement/replace Cliff Street Heating."

Figure 2: The Parliamentary and Judicial Precincts in Ottawa, which are both under the LTVP.[28]

Parts of Blocks 1, 2, and 3 facing Parliament Hill are to be redeveloped in order to establish a strong street wall along Wellington Street. The federally-owned buildings are required to have a "medium profile" in order to protect the visual integrity of the Parliamentary Lawn composition, with a specific set height limit of 108 metres above sea level for those buildings facing Wellington Street. In order to provide a building profile that steps away from Wellington Street, redeveloped buildings facing Sparks Street must not exceed 113 metres above sea level. In addition, buildings are to be built to the property lines to maintain a consistent vertical face along Wellington and Sparks Street.

The redevelopment of existing buildings on Sparks Street, and the preservation of at-grade retail space, will reinforce the revitalization of Sparks Street as an active urban space. Through the addition of the underground parking that will result from the redevelopment of Blocks 1, 2, and 3, one of the LTVP's goals to remove surface parking from the Precincts will be met.[29]

3.3.2 National Capital Commission

The *National Capital Act (1959)* governs the National Capital Commission (NCC), which is a crown corporation with a 15-member Board of Directors, including a chairperson and Chief Executive Officer, with representatives from Ottawa, Gatineau, and other regions of Canada. With an objective and purpose to ensure that "the nature and character of the seat of the Government of Canada may be in accordance with its national significance", the two main functions of the NCC are to coordinate development of federal lands through a development approvals process and to manage NCC-owned lands, which include over 1,300 buildings.[30] These buildings include the official residences, over 70 designated federal heritage buildings, and six national historic sites. The NCC has jurisdiction on federal lands within the 4,715 square kilometre area of the NCR, and is the largest land owner within this area, owning approximately 11% of the total land.

NCC policy documents are structured in a hierarchy of plans for the NCR with the Plan for Canada's Capital at the top, followed by master plans, sector plans, and design guidelines. The NCC Board of Directors has the exclusive authority to approve the Plan for Canada's Capital; master plans for the Greenbelt, Gatineau Park, and Capital Urban Lands; and sector and area plans in the Core area or on the National Interest Land Mass. For any Federal projects or work on public lands within the NCR, Federal Land Use, Design, and/or Transaction approval (FLUTA or FLUDA) from the NCC is required to erect, alter, extend, or demolish a building or change the use of public lands. For a project with an impact on protected views, which qualifies as Level 3, proposals are reviewed by the Advisory Committee on Planning, Design and Realty in a minimum eight-month review process, prior to being forwarded to the Board of Directors. The NCC can require changes to building characteristics, such as those related to building materials, height, massing, siting, and efficiency. The type of energy supply for a given building is out of the scope of NCC approval, meaning that there are no regulatory approvals for switching to renewable energy or consideration of the impact of energy supply in terms of GHG emissions or other environmental factors in the FLUTA/FLUDA process.[31]

As a component of the approval process for the PSPC DES project, the guiding policy of the NCC plays a central role in phase one and two of the ESAP plans. This role extends to the expansion of the PSPC DES on federal lands and the establishment of an expanded customer base that corresponds to buildings within NCC's ownership. Pertaining to the PSPC DES, the Cliff, Printing Bureau, and NRC plants are under the 2005 Canada's Capital Core Sector Plan and the Confederation Heights Plant is within the Confederation Heights Sector Plan. There is also an overarching document, the Environmental Strategy, that applies to all of the NCC, which is explored in more detail below.

Environmental Strategy

The Environmental Strategy, an NCC document that is currently undergoing review, focusses on reducing waste, enhancing biodiversity, preventing pollution, leading in environmental practices, and combating climate change.[32] This policy document identifies the goal of achieving carbon neutrality through increased energy efficiency and carbon emission reductions, which is supplemented by strategies to counterbalance carbon dioxide (CO_2) emissions that cannot be eliminated. There is a target to reduce GHG emissions from federal buildings and fleets by 40% by 2030. To this end, the NCC has undertaken retrofit programs and other initiatives. For example, all new buildings greater than 250 square metres constructed on NCC lands will be certified LEED Gold and all major renovations will meet LEED certification standards. Within the Environmental Strategy, implementing and supporting a district energy project is one idea of supporting GHG emissions targets; however, it is important to note the NCC is not focused on the planning of district energy, but more on how to use district energy as a tool to achieve the larger objective of reducing GHG emissions.

Plan for Canada's Capital

In order to create a 'people's plan' for the national capital, the Government of Canada carried out a widespread consensus-building exercise that included thousands of Canadians from across the country. The resulting Plan for Canada's Capital is a 50-year plan made up of three major pillars and 17 milestone projects to be completed by 2067. Some of the proposed work consists of advancing the greenbelt as a natural oasis, preserving and enhancing the Parliamentary Precinct, improving the trail networks for Gatineau Park, and redeveloping LeBreton Flats and the islands to enable a more thriving and connected city. Although the document is strategic and does not specifically mention district energy, there are potential opportunities for integrating some of the milestone projects with the existing or expanded DES. A key policy direction of the NCC is to promote design excellence, which includes projects that are, among other qualities, energy-efficient and include the use of renewable energies.[33]

Capital Urban Lands Plan

The Capital Urban Lands Plan plays a key role in creating high quality and meaningful places that are supportive of the capital's green and blue space network and a liveable capital region. This plan identifies major federal employment areas, including Tunney's Pasture, Confederation Heights, and the National Research Council, as well as the need to support non-employment uses within federal employment nodes. This plan provides more specific direction on opportunities for urban intensification and fostering design excellence with a mandate to protect the visual integrity and symbolic primacy of our national symbols and ensure development contributes to the capital. Further guidance is outlined in Canada's Capital Views Protection (2007), which is relevant to the Cliff Plant.

Canada's Capital Core Area Sector Plan

Canada's Capital Core Area Sector Plan recognizes that many federal buildings are nearing the end of their life cycle, are energy inefficient, and no longer meet current needs. This plan has a focus within the Parliamentary Precinct, as many functions of the parliament buildings are being or have been relocated into surrounding buildings. Detailed in the Parliamentary Precinct Long Term Vision and Plan, updated in 2007, there is a planning program, major capital program, recapitalization program, and building components and connectivity program for shifting building functions.[34]

3.3.3 Province of Ontario

The Province of Ontario has, through the *Planning Act (1990)*, delegated to municipalities its powers to govern over land use matters. Every municipality is required to be consistent with the Provincial Policy Statement (2014) (PPS) with respect to any planning matter.[35] As such, land use planning in any municipality in Ontario, including the City of Ottawa, is directed by the PPS to promote strong communities, a strong economy, and a clean and healthy environment. Other powers to regulate are issued through the *Municipal Act, S.O. 2001*.

Provincial Policy Statement, 2014

The PPS is supportive of district energy by promoting alternative energy systems, in general, under Section 1.6 Energy Supply, and by supporting energy conservation and efficiency under Section 1.8 Energy Conservation, Air Quality and Climate Change. More specifically, under Section 1.7 Long-Term Economic Prosperity, it is stated that "long-term economic prosperity should be supported by…promoting energy conservation and providing opportunities for development of renewable energy systems and alternative energy systems, including district energy".

Planning Act, R.S.O. 1990

Most notably, the *Planning Act (1990)* outlines land use controls by providing councils of municipalities authorization to adopt official plans and zoning bylaws. Official Plans contain broad goals, objectives and policies to direct change and establish procedures for land use approvals. Zoning bylaws are prescriptive documents that include site-specific use and siting restrictions of buildings and structures. The *Planning Act* also establishes the authority for municipalities to approve the subdivision of lands.

Municipal Act, S.O. 2001

The *Municipal Act (2001)* establishes municipal powers and spheres of jurisdiction. In Ontario, spheres of jurisdiction include lower-tier, upper-tier, and single-tier municipalities to establish a regional hierarchy of power. Specific powers are outlined pertaining to highways, transportation, waste management, public utilities, parks, parking, natural environment, health and safety, and licencing. It includes provisions for municipalities to participate in long-term energy planning, including considerations of energy conservation, climate change, and green energy.[36] By definition, heating and cooling systems, along with water, sewage, fuel, energy (excluding electricity), and telephone systems, that provide services for the public are considered public utilities. Municipalities have special rights to maintain public utilities that include permission to enter buildings, driveways, or highways without owner consent to install or maintain connections.

Green Policies

Ontario has a Climate Change Strategy, released in November 2015, aimed at reducing GHG emissions. This strategy has met the target of 6% GHG emissions below 1990 levels. The Long-Term Energy Plan for Ontario, entitled Delivering Fairness and Choice, balances affordability of electricity to consumers with providing a flexible energy system that is able to meet demand now and in the future. It provides a provincial strategy for how to meet demand and work to achieve provincial goals, including GHG emission reductions, while providing reliable service. In conjunction with the Climate Change Action Plan, Ontario's Five-Year Climate Change Action Plan (2016-2020) and previous plans, including Go Green Ontario, are committed to establishing a more sustainable energy future. They aim to reduce GHG emission rates from the 1990 levels by 15% by 2020 and 80% by 2050. This strategy includes conservation efforts, cap and trade of carbon, and renewable energy generation.

The Long-Term Energy Plan mentions district energy as a means for reducing GHG emissions and carbon-reliance in certain contexts. In doing this, the plan highlights three case studies where district energy has been applied successfully in Ontario. However, district energy is never given extensive consideration and is not included specifically in recommendations by the Province as a means for implementing wide-spread energy savings, GHG reductions, or any other associated benefits. The Five-Year Climate Action Plan, on the other hand, does not mention district energy.

Utilities and Pricing

The Ministry of Energy is the provincial authority that oversees electricity generation, transmission, and facilities in the Province of Ontario. It has legislative responsibility for the Independent Electricity System Operator (IESO), Hydro One, Ontario Energy Board, and Ontario Power Generation. Respectively, these agencies operate the wholesale electricity market, oversee the majority of transmission lines, act as a local distribution company in some areas, regulate natural gas and electricity sectors including pricing and service quality, and generate electricity from hydroelectric, nuclear, and fossil fuel stations.[37] Within the Province of Ontario, DESs are not regulated the same way as electrical utilities and therefore do not have price controls like those set for electricity.

District energy, unlike electricity, is not regulated by the Ontario Energy Board (OEB) under the *Ontario Energy Board Act (1998)*. However, there are circumstances when combined heat and energy systems sell and supply energy to the Independent Electricity System Operator, the organization operating Ontario's wholesale electricity market and ensuring procurement of energy supply. IESO contracts large facilities as well as smaller electricity generators under the FIT, which includes renewables with more than 10 kilowatt capacity, and microFIT, which includes renewables with less than 10 kilowatt capacity, programs enacted by *Ontario's Green Energy and Green Economy Act (2009).* The FIT and microFIT programs are being replaced with the Large Renewable Procurement program and net metering arrangements for smaller electricity generators.

The price structure of competing energy delivery systems affects the financial viability of district energy. Heating and cooling is commonly provided in commercial and residential settings through electricity or natural gas, where the latter is the principal energy source for 62% of households in Ontario.[38] The OEB sets rates for electricity and natural gas for some distributors and approves natural gas rates for others. Effective July 1, 2017, the current rates per kilowatt hour in Ontario for electricity are 6.5 cents Off-Peak, 9.5 cents Mid-Peak, and 13.2 cents On-Peak, which is monitored by smart metres tracking usage by the hour.[39] For natural gas, set rates, effective October 1, 2017 ranged from 10.558 cent/cubic metre for Enbridge Gas Distribution Inc. to 17.7694 cents/cubic metre for Natural Resource Gas Limited.[40] As natural gas is a traded commodity the price fluctuates on the market and Ontario adjusts natural gas prices four times per year.

3.3.4 City of Ottawa

The City of Ottawa, incorporated under the *City of Ottawa Act, S.O. 1999*, is governed by a City Council composed of the mayor and 21 other members. Its jurisdiction covers 2,796 square kilometres of the area south of the Ottawa River abutting the border of Ontario and Québec.[41] As an incorporated municipality within the Province of Ontario, the City is organized into the following departments:

- Transportation;
- Services;
- Service Innovation and Performance;
- Recreation;
- Cultural and Facility Services;
- Public Works and Environmental Services;
- Planning;
- Infrastructure and Economic Development;
- Emergency and Protective Services;
- Corporate Services;
- Community and Social Services; and
- Office of the City Clerk and Solicitor.[42]

These departments collectively cover a wide range of services, including fire, paramedic, roads, solid waste management, water, parks, community facilities, and transit.

The City of Ottawa is not directly in charge of utilities beyond water and sewer, such as electricity and heating/cooling. However, electricity within the City of Ottawa is distributed by HydroOttawa, also known as Hydro Ottawa Holding Inc., a private incorporated company wholly owned by the City of Ottawa.[43] The now disbanded local not-for-profit organization Ottawa Centre EcoDistrict had also developed a business plan for district energy in downtown Ottawa and had discussions with Hydro Ottawa, the City, and large and local developers regarding the designation of an EcoDistrict, an area in which sustainable development objectives are fully integrated into planning.[44] However, this EcoDistrict organization appears to no longer be functioning in Ottawa.

To guide decision-making for the City of Ottawa, there are five growth management plans under the Ottawa 20/20 Growth Management Strategy, including the Official Plan and Environmental Strategy. Within the Official Plan there are dozens of secondary plans, special policy areas, and transit-oriented development areas, all of which were considered in the land use analysis later in this report. In addition to these, the City of Ottawa has an energy and emissions Plan for the Canada's Capital Region, called Framing Our Future.

Ottawa 20/20 Growth Management Strategy Plans

Although the Official Plan of Ottawa does not directly mention district energy, the strategic directions outlined in the plan frame the City of Ottawa's position. In Strategic Directions Section 2.4.1 – Air Quality and Climate Change, there is focus on reducing emissions and adapting to climate change through support for sustainable growth management, renewable energy, and energy efficiency. The City of Ottawa is committed to reducing GHG emissions at the community level, which is supported in its Environmental Strategy, Air Quality and Climate Change Management Plan, and Energy and Emissions Plans. The Environmental Strategy includes energy-related initiatives to reduce GHG emissions and manage resources efficiently and effectively, including making buildings more efficient.

Framing Our Future

Framing Our Future: An Energy & Emissions Plan for Canada's Capital Region is part of the City's Sustainability and Resilience Plan that was created to guide decisions on major plans, policies, and programs and includes two sub-plans: the Energy and Emissions Plan and the Risk Prevention and Mitigation Plan. The Energy and Emission plan looks to reduce emissions from the building sector by 50% in Ottawa and 33% in Gatineau by 2060. A key directive in these plans is to promote low carbon and renewable energy supply. Low carbon, defined as energy production that reduces reliance on fossil fuels (oil, coal, and natural gas), directives coincide with a focus on making deep emission reductions and supplying energy from green, renewable sources. The Energy & Emission Plan and the Sustainability and Resilience Plan identify facilitating the development of a cost effective, low emission, high efficiency DES as a means of promoting low carbon and renewable energy supply and encouraging high performance buildings.

Infrastructure Master Plan

The City of Ottawa Infrastructure Master Plan was first drafted in 2003, and then updated in 2009. The purpose of the plan is to inform infrastructure planning directives for the City of Ottawa, particularly as they pertain to the planning horizon identified in the Official Plan. This takes the form of integrating the planning of water, wastewater, and stormwater infrastructure, and integrating growth planning with rehabilitation planning. In terms of identifying where expansion of the DES can be most easily integrated into the City of Ottawa's capital projects planning, this document serves as a guide for where and when large-scale infrastructure projects will be occurring. This in turn can allow DES expansion to "piggyback" on these infrastructure investments to minimize construction disruptions to the general public, while maximizing efficiency.

3.3.5 Province of Québec

The Province of Québec, through the *Municipal Powers Act (2005)*, has delegated powers to local municipalities in the areas of parks, local economic development, power development and telecommunications, environment, sanitation, nuisances, safety, and transportation.[45] Under the *Act* a municipality can regulate the use of the power it produces and may form partnerships with Hydro-Québec for the purpose, among other things, of producing electricity. The Municipal Code of Québec applies to every municipality and delegates its powers to municipalities to regulate land use planning and development.[46] It requires a strategic vision statement for cultural, economic, environmental, and social development and in cases of regional county municipalities, must consider the statements of the metropolitan communities within its boundaries. In Québec, municipalities are governed differently than cities and towns, which are given powers under the *Loi sur les cities et villes* (*Cities and Towns Act*, R.S.Q. c-19). Older cities, like Gatineau, also have their own charters.

Green Policies

The Province of Québec has the "Politique énergétique 2030", which outlines the energy objectives of the Province through 2030. One of the main objectives is the transition to a carbon-free electricity grid. However, due to the make-up of the current electricity grid in Québec, which is almost exclusively hydro, the plan contains no references to district energy, as heating and cooling by electricity in homes is already carbon-free. The Province of Québec's Energy Strategy sets out objectives for strengthening energy security, maintaining low cost power, promoting economic development, and empowering First Nations.[47] One of the key objectives is to finance energy efficient retrofits for individuals, industries, institutions, companies, and municipalities. The Sustainable Development Strategy 2015-2020 is the framework document for public service to follow when framing its actions. The Plan d'action 2013-2020 also outlines GHG emission reduction from 1990 levels by 20% by 2020 as a goal.[48] Part of Québec's strategy for reducing GHG emissions, is their cap-and-trade system which requires business with emissions over 25,000 metric tons of carbon dioxide to participate in purchasing allowances over the set annual emission cap.[49]

Utilities and Pricing

In Québec, Under the *Hydro-Québec Act (1983)*, Hydro-Québec is mandated as a government corporation to supply power within the Province.[50] Electricity rates are regulated by the Régie de l'énergie, an agency responsible for the distribution and transmission of electric power. Similar to Ontario's microFIT program for smaller electricity generators, there is a net metering option for customers with a maximum generating capacity of 50 kW when they use renewable energy generation. This can include wind, solar, hydroelectric, geothermal, or bioenergy, and allows customers to bank surplus energy generated to be applied toward grid consumption.

Although the rate structure is based on type of use, it includes a daily fixed charge (40.64 cents) or monthly fixed charge ($6.09) plus 5.77-5.82 cents per kWh for the first 33 kWh/day and 8.77-8.92 cents per kWh for the remaining consumption. It also includes a monthly charge of $4.59 per kW in excess of base billing demand in summer and $6.21 per kW in excess of base billing demand in winter.[51] Electricity prices are significantly lower in Québec than Ontario, particularly for On-peak electricity, which is weekdays from 11am-5pm in summer and 7am-11am and 5pm-7pm in the winter.[52] 66% of households in Québec use electric baseboards as their main heating system with electricity as the main energy source, making the natural gas market less influential in the energy decisions of customers.[53] Natural gas itself is not sold at a profit in Québec and has several distributors that are allowed to profit on distribution of natural gas, the largest being Gaz Metro. Gaz Metro offers a fixed rate at 12.996 cents/cubic metre effective October 1, 2017 or variable rate pricing. There is a cap-and-trade emission allowance price of an additional $3.501 cents/cubic metre.

3.3.6 Ville de Gatineau

The Ville de Gatineau was incorporated on January 1, 2002. The five municipalities in the Communauté urbaine de l'Outaouais, which are

Aylmer, Buckingham, Hull, Gatineau, and Masson-Angers, were amalgamated into the new single-tier Ville de Gatineau.[54] Gatineau is composed of 381 square kilometres of land bordering the Ottawa River directly facing the City of Ottawa.[55] With a population of 276,245 as of the 2016 census, Gatineau is the fourth-largest city in Québec after Montréal, Québec City, and Laval. As part of the Ottawa-Gatineau census metropolitan area, the Ville de Gatineau is part of a broader 1.3-million-person region.[56] The primary economic driver of the city is the civil service, with several large Government of Canada and Province of Québec departments and ministries headquartered in the city.

The Ville de Gatineau is administered by an 18-member Council and an elected Mayor.[57] As a single-tier municipality, Gatineau is commissioned with developing, implementing, and enforcing its own planning policy under the auspice of the Ministère des Affaires municipales, des Régions et de l'Occupation du territoire (Ministry of Municipal Affairs, Regions and Land Occupancy).[58] The plans most relevant to the PSPC DES project are the Plan Stratégique pour la Ville de Gatineau and the Plan d'Action Politique Environnementale.

Plan Stratégique pour la Ville de Gatineau

This strategic plan provides a high-level, 25-year horizon through which the Ville de Gatineau government outlines its priorities, objectives, and strategies for building itself into the future. The strategic plan highlights sustainable development as an integral piece of its future development strategy, and the plan challenges the city to adopt standards of development even higher than those laid out in Québec's *Sustainable Development Act.*[59] The strategies for doing so are broken down into four main "directions", of which the most relevant for the PSPC DES is "Direction A – Sustainable management of the natural and built heritage". Direction A.5 commits the government to fostering urban renewal in order to improve the quality of new developments, as well as their eco-efficiency. In conjunction with this, Direction A.6 implores the government itself to pursue initiatives for energy conservation and reducing the consumption of natural resources. These are the only two specific strategic direction policies that could directly apply to the PSPC DES project. However, when read as a whole, the strategic plan generally is very supportive of the technology and positive benefits of the DES, which is reflected in the municipality's zoning that must fit within the strategic plan's policy.

By promoting densification of activities and mixed uses, as well as the increased development of "urban villages", the Ville de Gatineau hopes to manage urban growth and other development related issues in The Strategic Plan. Québec's *Sustainable Development Act (2006)* and its related strategy provide Gatineau with an excellent opportunity to integrate its own principles on sustainable development and climate change. The *Act* also provides an outlet to strengthen unique aspects of Gatineau's identity.

Plan d'Action Politique Environnementale

Gatineau's environmental action plan claims that "a greener city is in the palm of your hand," and commits itself to leading its residents to this greener city through multiple objectives.[60] First and foremost, the Ville de Gatineau seeks to show leadership in promoting environmental and sustainable causes and initiatives. This is important for the DES project, as this policy points towards a willingness to work with ESAP over the longer-term to ensure both act responsibly towards the environment.[61] Equally important is the second objective Gatineau lays out, "acting with a focus on sustainable development".[62] Under this objective, Gatineau proposes policy that encourages the adoption of innovative approaches to land use planning, maintenance, and management.

[1] Public Services and Procurement Canada (PSPC). (August 31, 2017). Request for Qualifications for the Energy Services Acquisition Program (ESAP) Energy Service Modernization RFQ # EP635-173247/B. Retrieved from https://buyandsell.gc.ca/cds/public/2017/09/11/414f470ce21c1ef9a57793627ff9e7b2/ABES.PROD.PW__NB.B011.E73350.ATTA009.PDF
[2] PSPC. (August 31, 2017).
[3] PSPC. (August 31, 2017).
[4] PSPC. (August 31, 2017).
[5] PSPC. (August 31, 2017).
[6] Smetny-Sowa, T. (2016). Energy Services Acquisition Program (ESAP) for the National Capital Area (NCA). Retrieved from http://www.rpic-ibic.ca/documents/2016_RP_NW/Presentations/RPIC_Presentation_2016_ESAP_EN.pdf
[7] Government of Canada. (2017). Government of Canada committed to modernizing the heating and cooling plants in the National Capital Region. Retrieved from https://www.canada.ca/en/public-services-procurement/news/2017/07/government_of_canadacommittedtomodernizingheatingandcoolingplant.html
[8] Public Services and Procurement Canada. (2017). Low carbon in the National Capital Region's buildings. Retrieved from https://www.tpsgc-pwgsc.gc.ca/biens-property/gestion-management/ecologisation-greener/esap-pase-eng.html
[9] Public Services and Procurement Canada. (2017).
[10] Government of Canada. (2017).
[11] Government of Canada. (2017).
[12] Government of Canada. (2017).
[13] Government of Canada. (2017).
[14] Government of Canada. (2017).
[15] Government of Canada. (2017).
[16] Government of Canada. (2017).

[17] Public Services and Procurement Canada. (2017).

[18] Historica Canada. (n.d.). *The Distribution of* Powers. Retrieved from http://www.thecanadianencyclopedia.ca/en/article/distribution-of-powers/

[19] Government of Canada. (n.d.). *The Distribution of Legislative Powers, Powers of the* Parliament. Retrieved from http://laws-lois.justice.gc.ca/eng/Const/page-4.html

[20] The Atlas of Public Policy and Management. (n.d.). *Municipalities as 'creatures of the provinces'*. Retrieved from http://portal.publicpolicy.utoronto.ca/EN/CONCEPTSANDTERMS/KLM/MUNICIPALITIESASCREATURESOFPROVINCES/Pages/default.aspx

[21] Government of Canada. (2016). *Population of the Federal Public* Service. Retrieved from https://www.canada.ca/en/treasury-board-secretariat/services/innovation/human-resources-statistics/population-federal-public-service.html

[22] Government of Canada. (2017). *Federal Budget* 2017. Retrieved from http://www.budget.gc.ca/2017/docs/plan/budget-2017-en.pdf

[23] Government of Canada. (2016). *Achieving a Sustainable* Future. Retrieved from http://fsds-sfdd.ca/downloads/FSDS_2016-2019_Final.pdf

[24] Government of Canada. (2016). *Achieving a Sustainable* Future. Pg. 9.

[25] Government of Canada, (2016). *Achieving a Sustainable* Future. Pg. 23, 28, 35.

[26] Government of Canada. (2006). *Policy on Green Procurement*. 6. Policy Statement. Retrieved from https://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/achats-procurement/politique-policy-eng.html

[27] Government of Canada. (2006). *Policy on Green Procurement*. 4. Context.

[28] Canadian Society of Landscape Architects. (n.d.). Parliamentary and Judicial Precincts Area: Site Capacity and Long Term Development Plan. Retrieved from http://www.csla-aapc.ca/awards-atlas/parliamentary-and-judicial-precincts-area-site-capacity-and-long-term-development-plan

[29] Public Works and Government Services Canada. (2006). Parliamentary and Judicial Precincts Area: Site Capacity and Long Term Development Plan.

[30] National Capital Act, Revised Statutes of Canada. (1985, c. N-4). Retrieved from http://laws-lois.justice.gc.ca/eng/acts/N-4/page-2.html#h-6

[31] S. Candow, NCC Representative, personal communication, September 22, 2017.

[32] National Capital Commission. (2010). *National Capital Commission Environmental Strategy: Building A Greener* Capital. Retrieved from http://s3.amazonaws.com/ncc-ccn/documents/NCC-Environmental-Strategy.pdf?mtime=20170420102504

[33] National Capital Commission. (2017). *The Plan for Canada's Capital, 2017-2067.* Pg. 74. Retrieved from http://ncc-ccn.gc.ca/our-plans/the-plan-for-canadas-capital

[34] Government of Canada. (n.d.). *Executive summary-The Long Term Vision and Plan Annual Report 2014-15*. Retrieved from https://www.tpsgc-pwgsc.gc.ca/citeparlementaire-parliamentaryprecinct/rehabilitation/vplt-ltvp/2014-2015/sommaire-summary-eng.html

[35] Province of Ontario. (n.d.). *Provincial Policy Statement, 2014*. Retrieved from http://www.mah.gov.on.ca/AssetFactory.aspx?did=10463

[36] Municipal Act, 2001, S.O. (2001, c.25). Section 147 (1) and (2). Retrieved from https://www.ontario.ca/laws/statute/01m25#BK161

[37] Province of Ontario. (September 26, 2016). *About the Ministry*. Retrieved from http://www.energy.gov.on.ca/en/about/

[38] Statistics Canada. (November 27, 2015). *Households and the Environment: Energy Use*. Retrieved from http://www.statcan.gc.ca/pub/11-526-s/2013002/part-partie1-eng.htm

[39] Province of Ontario. (November 2, 2015). *Smart Meters and Time-of-Use Prices*. Retrieved from http://www.energy.gov.on.ca/en/smart-meters-and-tou-prices/

[40] Ontario Energy Board. (n.d.). *Natural gas rates.* Retrieved from https://www.oeb.ca/rates-and-your-bill/natural-gas-rates

[41] City of Ottawa. (n.d.). *Economy and demographics.* Retrieved from http://ottawa.ca/en/city-hall/budget-and-taxes/financial-reports-and-statements/long-range-financial-plans/long-range-financial-plan-iii-part-1-and-part-2/economy-and-demographics

[42] City of Ottawa. (October 2016). *Organizational Chart*. Retrieved from http://documents.ottawa.ca/sites/documents.ottawa.ca/files/final_org_chart_en.pdf

[43] Hydro Ottawa Limited. (2017). *Governance Structure.* Retrieved from https://hydroottawa.com/about/governance/structure

[44] Ottawa Centre EcoDistrict Steering Committee (January 17, 2013*). Transforming the Core: The Benefits of an Eco-district Approach.* Retrieved from http://app05.ottawa.ca/sirepub/cache/2/womw1xb1eory30kcjzq5rjk2/84353102920170334294l8.PDF

[45] Municpal Powers Act. 2005. (c-47). Retrieved from http://legisquebec.gouv.qc.ca/en/showDoc/cs/C-47.1?&digest=

[46] Municipal Code of Quebec. (c-27). Retrieved from http://legisquebec.gouv.qc.ca/en/showDoc/cs/C-47.1?&digest=

[47] Gouvernemet du Quebec. (2006). *Using Energy To Build the Quebec of Tomorrow*. Retrieved from https://www.mern.gouv.qc.ca/english/publications/energy/strategy/energy-strategy-2006-2015.pdf

[48] Gouvernemet du Quebec. (2012). *Plan d'action 2013-2020 sur les changements climatiques.* Retrieved from http://www.mddelcc.gouv.qc.ca/changements/plan_action/pacc2020.pdf

[49] Gouvernemet du Quebec. (n.d.). *A brief look at the Quebec cap-and-trade system for emission allowances*. Retrieved from http://www.mddelcc.gouv.qc.ca/changements/plan_action/pacc2020.pdf

[50] Hydro Quebec. (n.d.). *Act, Regulations and Conditions of Electricity Service*. Retrieved from http://www.hydroquebec.com/about/who-are-we/corporate-governance/act-regulations-conditions-electricity-service.html

[51] Hydro Quebec. (April 1, 2017). *2017 Electricity rates*. Retrieved from http://www.hydroquebec.com/publications/en/docs/distribution-tariff/electricity-rates.pdf

[52] Ontario Energy Board. (n.d.). *Managing costs with time-of-use rates.* Retrieved from https://www.oeb.ca/rates-and-your-bill/electricity-rates/managing-costs-time-use-rates

[53] Statistics Canada. (November 27, 2015). *Households and the Environment: Energy Use*. Retrieved from http://www.statcan.gc.ca/pub/11-526-s/2013002/part-partie1-eng.htm

[54] Ville de Gatineau. (n.d.). *History of the Cities*. Retrieved from http://www.gatineau.ca/portail/default.aspx?p=histoire_cartes_statistiques/archives/histoire_villes&mc=s&q=history.

[55] Statistics Canada. (2017). *Ville de Gatineau Census* Profile. Retrieved from http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=2481017&Geo2=PR&Code2=24&Data=Count&SearchType=Begins&SearchPR=01&B1=All

[56] Statistics Canada. (2017). *Focus on Geography Series, 2016: Ville de* Gatineau. Retrieved from http://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=505

[57] Ville de Gatineau. (2017). *Mayor and Councillors*. Retrieved from http://www.gatineau.ca/portail/default.aspx?p=la_ville/conseil_municipal

[58] Affaires municipals et Occupation du territoire Québec. (2017). Retrieved from https://www.mamot.gouv.qc.ca/

[59] Ville de Gatineau. (2016). *Strategic* Plan. Retrieved from http://www.gatineau.ca/portail/default.aspx?p=la_ville/administration_municipale/plan_strategique&mc=s&q=plan%20s

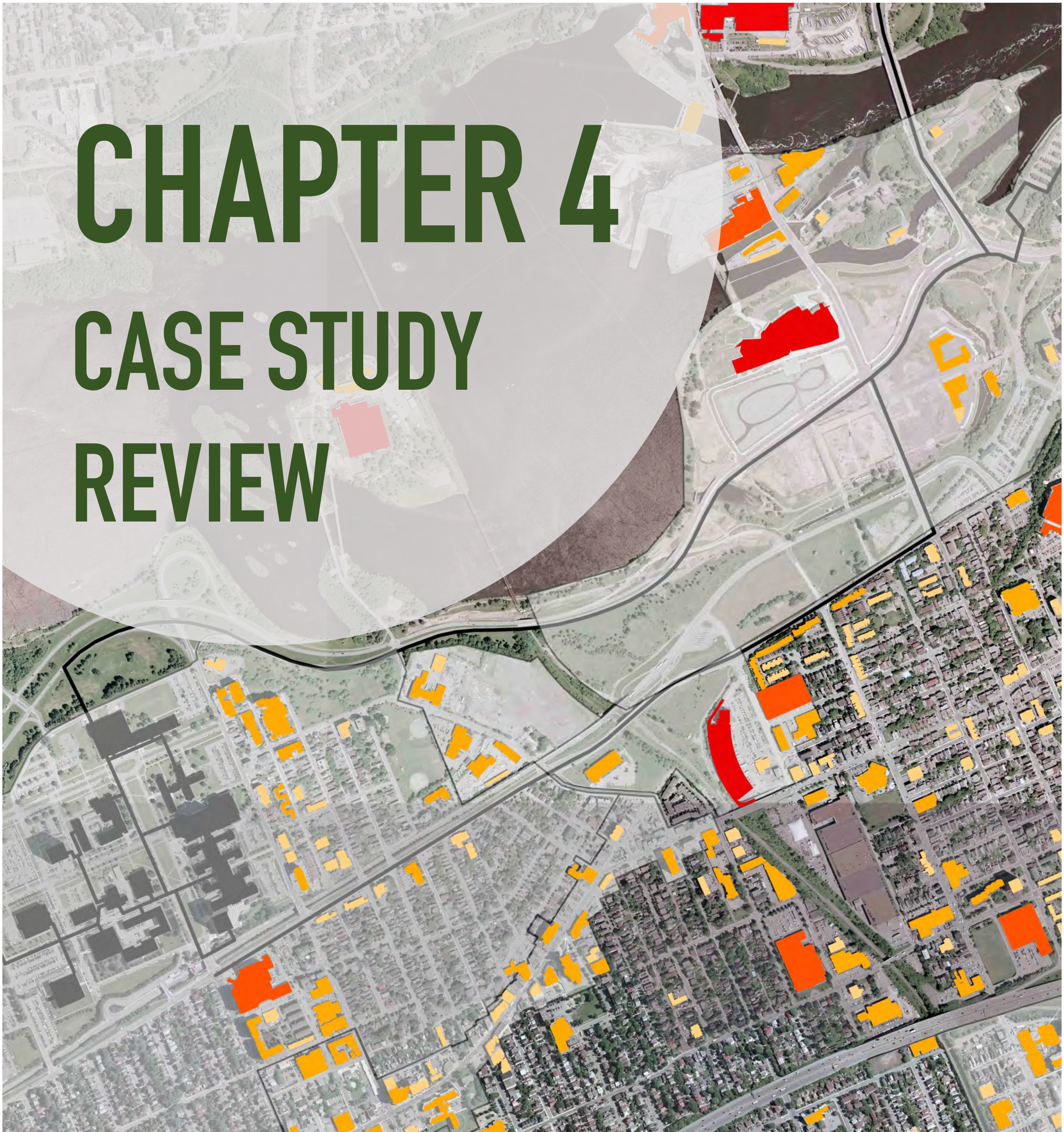
[60] Ville de Gatineau. (2012). *Gatineau's Environmental Policy*. Pg. 2. Retrieved from http://www.gatineau.ca/docs/la_ville/administration_municipale/politiques_vision/politique_environnementale.en-CA.pdf

[61] Ville de Gatineau (2012). *Gatineau's Environmental Policy*. Pg. 12.

[62] Ville de Gatineau (2012). *Gatineau's Environmental Policy*. Pg. 12.

CHAPTER 4

CASE STUDY REVIEW



SURP 824 PROJECT COURSE

4.0 Case Study Review: Lessons for Successful DES Expansion

4.1 Method of Review

This section provides a summary of the lessons learned from a series of 18 case studies of district energy systems from a variety of geographic locations. Based on the challenges and innovations in the case studies, the information in this section has been organized into three thematic areas: land use and expansion, growing client base, and system governance.

The first theme, land use and expansion, serves to highlight the importance of land use planning and the associated tools in the establishment and expansion of a district energy system (DES). The second theme, growing the client base, focusses on the importance of reaching out to potential clients and includes a summary of some of the best practices in securing new connections. The third theme, system governance, acts to pinpoint both the challenges and benefits associated with a variety of governance models. These three themes naturally grew out of the case studies and were used to systematically categorize the data to serve the objectives of this work. Though this strategy was selected, it should be noted that all three of the themes overlap significantly, particularly with respect to certain subthemes, such as timing and phasing, that are constant throughout.

The selected case studies incorporate a mixture of some of the most successful and unsuccessful DESs found within Europe, Canada, Australia, and the United States. Some systems were selected based on their innovative business models or their vast client base, whereas others were selected for having gone bankrupt and experiencing challenges. Others still were selected for their extensive planning frameworks or even their similarity to the NCR DES. Regardless of the reason, each of the studies selected offers valuable learning opportunities. This section delves solely into the key lessons learned, but a more expansive look at each of the case studies is provided in Appendix C along with all the sources of information. The case studies completed include the:

- Aberdeen, UK Combined Heat and Power System
- Bunhill, Islington, UK District Energy System
- Burlington, ON Community Energy Plan
- Burnaby Mountain, BC District Energy Utility
- Charlottetown, PEI District Energy System
- Denmark District Energy System
- Duluth, MN District Energy System
- Gibsons, BC District Energy Utility
- Guelph, ON District Energy System
- Île-des-Chênes, MB District Energy System
- Nashville, TN District Energy System
- North Vancouver, BC District Heating System
- Paris, FR District Energy Evolution
- Princeton University, NJ District Energy System
- Southeast False Creek, BC District Energy System
- St. Paul, MN District Energy System
- Sydney, AUS Trigeneration Master Plan
- Vingåker, SWE District Energy System

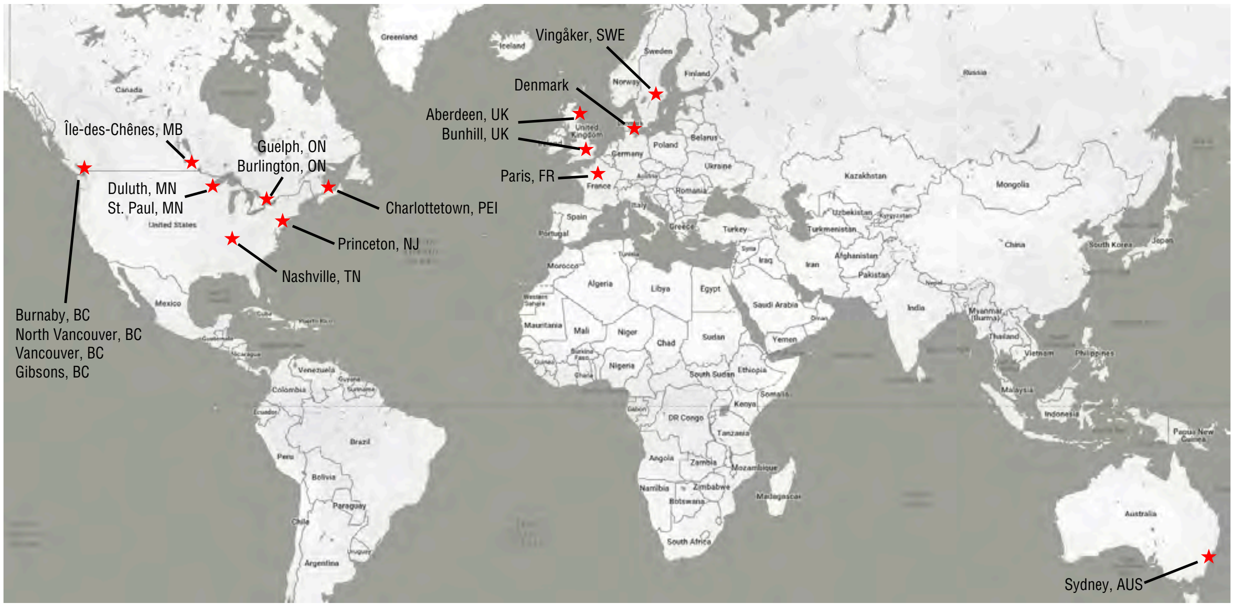


Figure 1: Selected district energy case studies around the world.[1]

4.2 Land Use and Expansion

Potential user demand for a DES is inherently connected to the mix of land uses, density levels, and the concentration of buildings within the service area. In developing a plan for future expansion of a system, a key first step is to determine future growth areas as they pertain to these characteristics. Given that the development types and patterns of urban environments are unique to the local context, it is important to carry out well-constructed growth studies to give stakeholders a firm understanding of their potential future market, employ community planning, and phase appropriately.

4.2.1 Determining Growth Areas

Overall, the case studies seem to suggest that the best growth areas for DES expansion are those with a high density and those with a large mix of users.[2] This is because the energy demand of different land uses peak at different times. When a variety of land uses is combined this creates a more stable energy demand profile throughout the day, allowing for the overall DES to function more efficiently.[3] A specific example of this lies in the ongoing expansion of the system in Aberdeen, United Kingdom (see page 98). They began their system with a small pilot project that served solely residential users. Though the system proved to successfully achieve their social goals, the efficiency and environmental benefits were limited due to the homogeneous load, which did not allow them to run their generators all year. In setting up subsequent systems, they experienced much more success by diversifying the connections to include larger users, such as sports facilities. In this way, residential energy demands, which peak in the mornings and evenings, were balanced with other loads that peak during the day.

An important best practice for determining where expansion should occur is carried out thorough demand feasibility studies, which are discussed further in Section 4.3 - Growing Client Base. Taking steps including population projections, local policy analyses, and a review of development proposals are worthwhile first steps in order to gain an accurate image of what the service area will look like in the future. One of the most common tools used to delve into a more detailed feasibility study is heat mapping. This is a valuable process to undertake in determining the areas where heating demand already exists in a city. However, relying solely on the conclusions from this type of analysis can be dangerous, as was experience in the case of the DES in Guelph, Ontario (see page 117). Though they fully mapped and prioritized areas within the city based on current and projected quantitative demand, they did not combine this with ensuring large, anchor users would actually connect to provide the base load requirements for a financially and environmentally feasible system. This lead to failure, initially. Figure 2 shows an example of the heat mapping carried out in planning the Guelph DES.

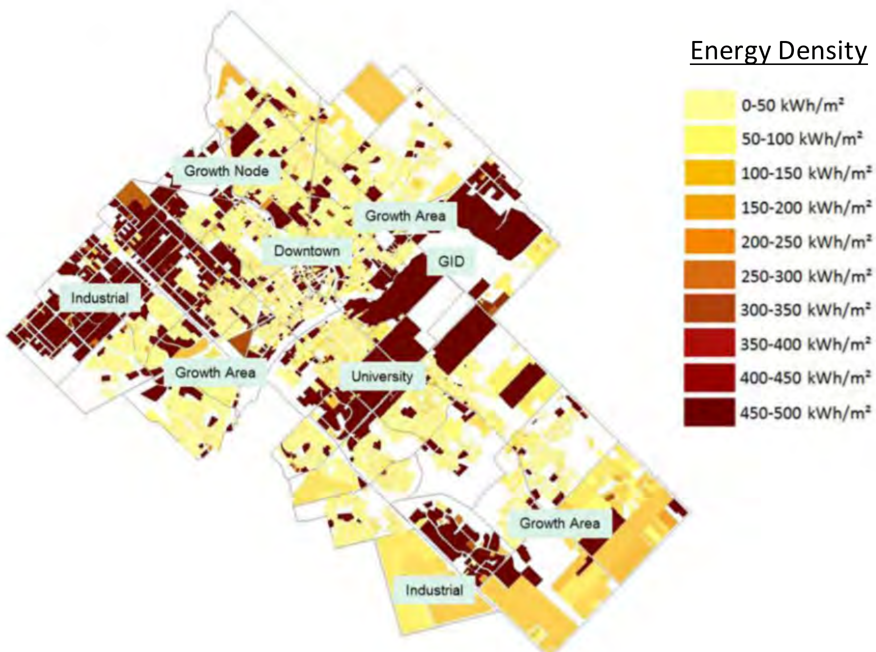


Figure 2: Heat mapping for Guelph, Ontario. Maps like this were used to determine the areas where a DES would be most feasible.[4]

These feasibility analyses are best carried out at an early stage of planning, as they will support decision making throughout the remainder of the project. For example, the City of Burlington, Ontario (see page 103) carried out detailed land use analyses in an initial Community Energy Plan prior to any detailed investigation of how a district energy system could be developed in the community. The Burlington analysis included growth projections, future development potential, and an analysis of existing stock which supported the identification of district energy as a solution to local goals. These early analyses fed into an iterative planning process that resulted in DES feasibility analyses of increasing complexity, ultimately identifying key areas for expansion that were feasible both technically and financially.

Though the City of Sydney, Australia (see page 138) does not currently have a DES installed, it has taken proactive steps toward identifying areas for future installments of decentralized energy systems across their local government area (LGA). Sydney has recognized the immense environmental benefits of trigeneration, a technology that takes cogeneration, which is the simultaneous production of electricity and the exploitation of waste heat from the generation process to supply heating and hot water needs, a step further by converting heat supply to cooling through a heat-driven cooler. In 2010, the City of Sydney had five trigeneration plants in operation; however, these have been installed privately to solely serve the needs of a given building. The Decentralized Energy Master Plan, prepared in 2013, has set the ground work for installing large trigeneration plants in areas that are of high density and high energy demand. Spatial diagnostics were performed using the City's land use and floor space data, which was analyzed against metred electricity and gas consumption data. This process helped to map areas in the City with the greatest energy and thermal demands. Within the LGA, the City used this information to identify four "Low Carbon Infrastructure Zones", shown in Figure 3, which are areas best suited to DES installation for financial reasons. In these areas, an additional 15 large trigeneration plants will be installed with decentralized energy piping networks that connect residential, office, and institutional buildings. The City of Sydney is hoping to have these networks in place by 2030.

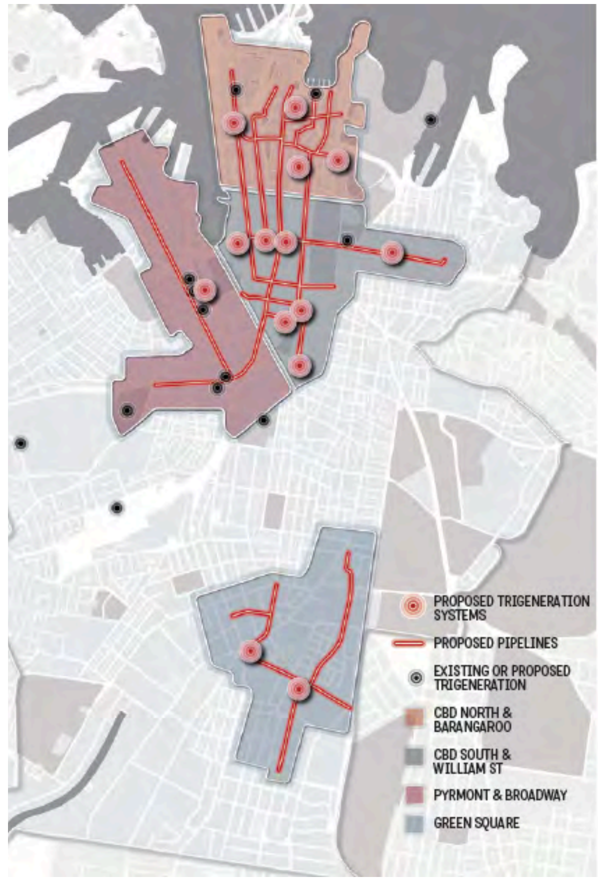


Figure 3: Low Carbon Infrastructure Zones across the City of Sydney. [5]

4.2.2 Community Planning and DES Expansion

The application of land use planning tools can be a powerful method to stimulate DES expansion and adoption. Partnering with local authorities can lend to leveraging planning processes that are not otherwise available. This can make the operations and expansion of a DES more financially viable and simple to complete.

Paris, France (see page 127) has generated an impressive level of DES adoption by clients through the establishment of density bonuses. These relaxed restrictions on building height, size or unit count have been used to leverage a switch to renewable energy or higher energy efficiency standards in new developments. Given that developers stand to gain considerable profit from density bonuses and DES adoption as a method to meet the requirements, bonuses have been a strong incentive to adopt the system. As a result, new developments have resulted in large expansions in current DES networks.

Various other municipal planning tools can also be taken advantage of early in the development and expansion of a DES in order to lead to long-term success. In Guelph, Ontario the company planning the system worked closely with the city planners in order to ensure easements for the future DES piping network were in place in areas where new developments were being planned, allowing for much more timely and easy expansion. In Duluth, Minnesota (see page 112), on the other hand, the discussions leading up to the system expansion have included the idea of working with the city planners and local authorities to change the building code to optimize new building design, particularly with respect to the heating and cooling systems, to fit well with the DES and improve the overall efficiency. The update of the Duluth system has also been heavily coordinated with infrastructure updates planned by the municipality. By working with the municipality and timing the expansion so that it aligns with the reconstruction of one of the main streets in the downtown, they will experience significant cost savings.

Partnerships with municipalities to assist in the encouragement and, even requirement, of connections to the system can be used to broaden a client base. For example, the City of North Vancouver (see page 125) passed a bylaw near the beginning of the expansion of the DES that requires all new and retrofitted developments over 1000 square metres to connect into the system. In this case, the corporation operating the system also prepared detailed guidelines for developers on what is required of them to connect and what will be provided.

Beyond the planning tools available, planning for sustainability is an additional area where district energy can be integrated into community planning efforts. DESs are increasingly being regarded as a viable solution to reach environmental sustainability goals by reducing greenhouse gas (GHG) emissions. Efforts by cities to plan for the installation of a DES are proliferating across the globe. Local municipalities have a strong role to play in encouraging the development of DESs. Municipalities can develop Community Energy Plans (CEP) to set out goals, targets, and strategies to lay down the groundwork for areas where a DES could be implemented, as was done in the City of Burlington's CEP (Figure 4).

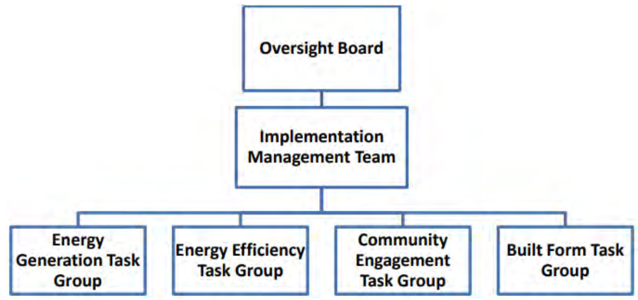


Figure 4: The governance organizational structure for the Burlington Community Energy Plan.[6]

Similar to the City of Burlington's CEP, the City of Sydney, Australia has developed a Decentralized Energy Master Plan. This master plan not only establishes strategies by which the City can achieve GHG emission reduction targets, it also integrates land use planning with energy planning. After having conducted land use analyses to see where the highest energy demands exist across the city, the Master Plan outlines a series of enabling actions that integrate energy planning with land use planning. These enabling actions push for coordination with utility providers to identify which buildings need life cycle upgrades, working with municipal planning departments to develop land use policy tools for incentivizing connections to DES, and streamlining federal, state, and municipal environmental planning policy documents. As a result, the Decentralized Energy Master Plan is important for guiding the installation of DESs. It recognizes that urban form is highly connected to energy consumption, making it necessary to integrate energy planning and land use planning.

Though partnering at the local level is hugely beneficial, strong policy direction and support from upper levels of government are important, particularly during the early stages of installing a DES. Strong and clear policy from the outset allows for municipalities to plan accordingly. It is vital to ensure that the DES meets the broader environmental goals of the region and evolves effectively as these goals become increasingly ambitious. If the methods used to generate energy for the DES fail to evolve to meet environmental targets, they may contribute to broader environmental degradation. For example, district energy installations in Paris, France were created in the 1920s in reaction to serious air pollution concerns by centralizing heat production to replace coal and wood fired heating in individual buildings. However, the system currently still utilizes a considerable amount of coal and oil in heat and power production. In order to meet rapidly increasing environmental goals and standards, the leaders of the Paris systems have developed a strategy to rapidly increase the use of renewable fuels. By advancing the system to use cutting edge technology, DES will turn once again into a solution for environmental issues in Paris.

4.2.3 Timing and Phasing

Considerations for timing and phasing are required for all aspects of DES expansion. The utilization of land use planning tools at the outset of system expansion strengthens the prospect of future success. For expansion in urban areas, as discussed in Section 5.2.1, it is also vital that the initial phases of a project of this kind include extensive research to identify areas where interested potential users are located. In addition, a critical first stage in any proposal to install or expand a DES is to host public consultations to better educate the public and to establish a transparent relationship between all stakeholders.

Early stakeholder engagement and partnerships can ultimately lead to the establishment of mechanisms that later act to support system expansion. For example, the Simon Fraser University Community Trust utilized information gained from other stakeholders involved in its Burnaby Mountain District Energy Utility (BMDEU) (see page 105) project to establish strong development standards that aided in the future success of the system. The Trust held off on physical expansion of their DES throughout the first stage of the project and instead worked on passing stringent environmental requirements in cooperation with the municipality. These environmental requirements ultimately worked to make DES connection more attractive for private developers and acted to increase efficiency levels a future system could obtain.

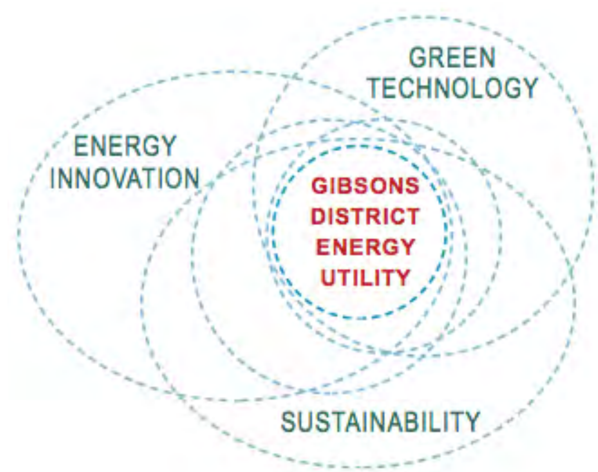


Figure 5: Energy innovation, green technology and sustainability were the driving forces behind the formation of the Gibsons district energy system. These important forces represent the values of the town and what they want to see in their planning.[7]

Clearly phased implementation strategies are often prepared to establish a practical timeline for achieving the objectives of a project. The Gibsons, British Columbia DES (see page 105) is an example of a new development using district energy from the very beginning. The Town of Gibsons created a geo-exchange district energy system for a new neighbourhood development project (Figure 6). The system uses heat from in the earth to heat and cool buildings in the Parkland community. Gibsons is working with developers to connect all the residential, commercial, and public buildings in the area to the system over time (Figure 6 & 7). In order to achieve their goals, the project was broken down into distinct phases. The first phase, which is now complete, included expansion of the DES throughout a particular residential section of the neighbourhood, whereas the remaining phases will extend to the rest of the neighbourhood and the adjacent commercial properties, including a shopping centre and a hockey arena. In this way, the phasing was established such that the newly constructed buildings would be connected first.

Figure 6: Town of Gibsons location and phasing of their district energy system infrastructure.[8]

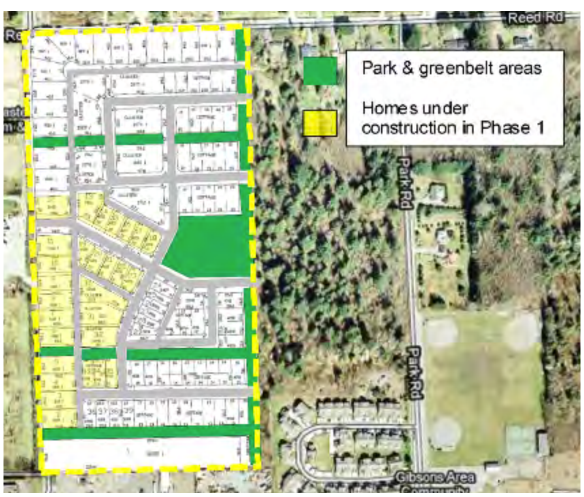


Figure 7: Phase 1 housing connections to the Gibsons district energy system.[9]

This type of systematic expansion based on demand can ultimately lead to the success or failure of a system. Installing too large of a system early on can lead to significant financial barriers and overall inefficient function. The initial failure of the DES in Guelph, Ontario was a result of plans to install two large combined heat and power plants from the beginning without sufficient commitment from customers. Leading up to installation, it became clear that the plans were not sustainable, forcing the cancellation of the large plants, which limited the overall DES size. Reflecting on what happened, the city now understands that starting small and incrementally growing the system when needed would have led to the financial and environmental sustainability that they did not achieve with their strategy. They have even discussed how attempting expansion of their currently modest system again in the future could experience success by taking over the operations of existing under-utilized boilers to share the capacity more widely. Cooling could also be limited to an as-needed basis to save and simply use the heating infrastructure by installing steam or hot water driven chillers on site.

The City of North Vancouver is an excellent example of this type of systematic growth. Based on their feasibility studies, the utility company chose to install a series of mini-plants in the basements of buildings connected to the system. This way, less infrastructure is needed, and the system remains flexible in adding new mini-plants when the demand is sufficient. Targeting building connections immediately adjacent to the existing system lends well to this method and is an inexpensive way to leverage more income for further expansion.

In recognition that installing a DES will take place over several years, it is important to account for room for innovation. As time progresses, newer and more efficient technologies will become available. This means that to save capital over the life span of the system, it will be important to install versatile infrastructure and technology. For example, movement towards using renewable fuels is prominent, so a system that can use multiple energy sources is of high value. Denmark (see page 109) recognized this from the beginning and has, over several years, converted coal plants to natural gas plants that are adaptable to use other sources of energy, such as woodchips, straw, and other biofuels. This was done over the course of three distinctly planned phases, which lead to much less upfront expenditure than an entire retrofit would have.

4.2.4 Lessons Learned

There are many lessons learned from the case studies relating to the theme of Land Use and Expansion. Below is a summary of these lessons divided by subtheme.

Determining Growth Areas

1. The best growth areas for the expansion of a DES are those that are high density and have a mix of lands uses. These areas result in higher district energy efficiency through sufficient demand and a mix of energy demand cycles, resulting in a more level overall energy demand profile.
2. In order to achieve a maximally efficient DES, anchor users, which are those with consistently high demand, are vital to connect.
3. Detailed land use analyses and demand feasibility studies are both necessary to guide the planning stages of a DES. This will ensure that the areas of high demand where interest in connecting to the system exists are being targeted.
4. These combined processes can be achieved using a myriad of methods, including population projections, local policy analysis, development proposal reviews, heat mapping, and stakeholder engagement.

Community Planning and DES Expansion

1. Partnering with local authorities to access planning tools can make the expansion much simpler and financially viable. These processes and tools are wide ranging and include incentivization of connections through density bonuses, establishing easements for future piping, optimizing building requirements to support connection, coordinating with other infrastructure projects to reduce costs, and implementing bylaw requirements for connection.
2. Partnering with local authorities to prepare a CEP or DES Master Plan will help to guide expansion into the future while integrating land use planning and energy planning.
3. The promotion of sustainability and connections to the system can be leveraged by partnering with not-for-profit organizations with goals that align with the DES project. This partnership can also act as a platform for educating stakeholders and the general public about the DES.
4. The system should be planned to meet broader environmental goals, such as those established by higher levels of government. This requires that the plans be continually assessed and updated in order to continue to meet goals as they become increasingly ambitious.

Timing and Phasing

1. Engaging with stakeholders from the very beginning will ultimately result in the development of a system that is attractive for a breadth of customers and will ensure that all key players have the information they need.
2. Clearly planned phasing of both initial development and expansion will help in achieving the overarching goals of the project in a systematic and timely manner. Flexibility should be built into the phasing to account for innovation and newer technologies.
3. Pursuing the connections of new developments while they are being planned is best prioritized. When available, these

buildings generally represent easier connections that will otherwise be lost opportunities.

4. Systematic and flexible expansion based on demand will ultimately result in a more sustainable system from the beginning. One aspect of this is to target connections immediately adjacent to the existing infrastructure to leverage income for further expansion. Another option is to limit cooling services to onsite hot water driven chiller that use the heating infrastructure where necessary.

4.3 Growing Client Base

The success of an expanding DES is intrinsically tied to ensuring that the client base is also growing. Ultimately, this will initially require that the leaders identify potential clients based on their proximity to the infrastructure, energy demand, and interest in connecting. Though these are the fundamental drivers, clients are sometimes attracted simply from an environmental sustainability standpoint, but all will be interested in how connecting will affect their bottom line. With all factors considered, marketing the system is ultimately how potential clients will learn about the option to connect in the first place.

4.3.1 Identifying Potential Clients

Given the upfront costs of connecting to a DES, targeting users at the new construction stage is vital to achieve a stable client base growth rate. Targeting sales towards existing buildings is important, but is largely confined to attracting users who are in the process of replacing heating and cooling systems at the end of their life cycle. Outside of this small window of opportunity, building owners will likely be reluctant to assume the cost of replacing systems that are already paid for and are in good repair. New construction, on the other hand, presents the lowest cost of DES adoption, particularly in the case of innovative renewable technology.

The City of Vancouver is a prime example in illustrating that new developments are the strongest candidates for installing a DES to help mitigate high upfront capital costs upon installation. The City of Vancouver has ambitious targets to become the Greenest City in the world by 2020. One of the City's objectives under this plan is to emit zero carbon. The City started moving towards this goal by seizing the opportunity to install a DES in Southeast False Creek (SEFC) (see page 132), a development otherwise known as Olympic Village. The successful implementation of the SEFC DES has set strong precedent for seeking out areas in the City where a DES could be installed. Currently, the city is mapping potential future sites, shown in Figure 8, and has recognized that areas being developed to support high density and a mix of land uses are prime candidates for installing a DES, like the Neighbourhood Energy Utility (NEU) at SEFC. The City, however, has acknowledged the high upfront capital costs of installing a DES in this development. To mitigate installation costs the City staged the construction of the DES with installed floor area, which included delaying installation of the most capital-intensive portion of the project to the end of the district's build-out once a certain demand threshold was achieved. In this way, the City was able to offset costs associated with the installation of the DES.

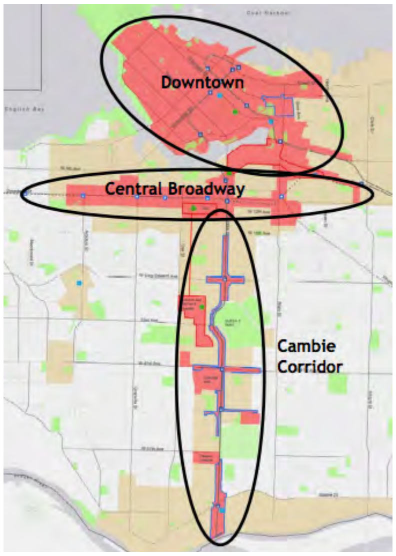


Figure 8: Areas that are best for DES, as identified by the City of Vancouver.[10]

Figure 9: The Cogeneration Energy Plant in St. Paul, Minnesota.[11]

Seeking out solutions to decrease up-front capital costs are important to ensure that a DES can be successfully expanded. Cities that take an integrated planning approach to installing a DES have seen reduced installation costs and have been able to more easily extend their DES to new users. The City of St. Paul, Minnesota, for example, has worked closely with the transportation, urban planning, and energy sectors, which allowed them to expand their DES at a lower cost. In 2010, a new Light Rail Transit (LRT) line was being installed, which the City took advantage of during the construction phase. By doing this, they easily expanded their DES by another 11 kilometres along the LRT line to a new large industrial client. This expansion has offered the opportunity to incrementally expand the customer base in that area by gradually connecting them into the system. As this example illustrates, integrated energy planning is a vital tool that encourages the expansion of a DES, as was discussed in Section 4.2.1. It is important to have open lines of communication between multiple sectors within a city in order to effectively take advantage of new developments, such as the LRT in St. Paul, and optimize the expansion of a DES to reduce installation costs.

Given that potential energy savings scale with the amount of energy being used, DESs stand to appear more attractive to potential clients with larger energy needs. Building owners of industrial sites or large commercial and residential buildings have the potential to shave a significant amount off of their operational budget by adopting a DES connection. In the City of North Vancouver, the analyses carried out by city staff indicated the best suited users to connect would be large buildings of any use type, including multi-family residential, municipal, commercial, and office. Often, many large developments already have their own internal DES, which provides a new kind of opportunity to establish partnerships. The Aberdeen, United Kingston and Charlottetown, Prince Edward Island (see page 108) systems have both experienced success in partnering with the local universities in updating their existing systems to connect surrounding users and eventually connect to the broader system.

District energy companies in Paris, France have also developed innovative mechanisms for targeting key users. Given low demand for residential cooling, the local cooling DES "Climespace" targets institutional and commercial users including museums, such as the Louvre. To maintain demand during the winter months, special users with year-round cooling needs, such as data centres, are targeted as a baseline client base. The district heating and power generation company in Paris, La Compagnie Parisienne du Chauffage Urban (CPCU), also targets key users for adoption of new technology. Given that innovative generation systems, like geothermal, are difficult to install in areas with high levels of historical development, the CPCU targets areas of new development for their expansion.

4.3.2 Financial Tools for Client Attraction

The primary consideration of most building owners and operators in deciding whether or not to connect to a DES is the financial cost of doing so. This is particularly the case when attempting to attract private landowners, who are predominately tied to the profit motive. Therefore, when expanding a DES it is necessary to ensure that base pricing is competitive with alternative energy sources. Following that, DES operators may wish to utilize various financial incentives that make the system more attractive for prospective clients.

At a basic level, the only way to encourage connections effectively without requiring them will be to ensure that the rates and service levels are competitive and stable. The North Vancouver system has been able to achieve competitive monthly rates sold as a package that not only includes heating, but also includes the fuel, maintenance, and operations, which are all inherent pieces of the district energy model. Their rates have remained low due to both their effective expansion strategies and the use of the most economical fuel sources.

On the other hand, it is important to ensure that the desire for competitive rates does not impact the financial feasibility of the DES itself. This can be a large concern for expanding systems, particularly with those that are managed or regulated by a public body with the ability to set rates. By setting rates too low, the system can quickly become financially infeasible as price inputs change. If limited pricing flexibility is added into the mix, DES operators can be hamstrung and unable to avoid bankruptcy. The Vingåker case study demonstrates this risk. Financial models need to be constructed with a realistic and conservative business mentality, as a system intended to operate over many decades will almost certainly encounter many changes in input costs and stakeholder needs throughout its existence.

In cases where DES is a new entrant to market, clients may be hesitant to become early adopters even if the financial benefit is clear. While education is an important tool to address this issue, DES operators may also wish to utilize financial incentives to draw in early clients. For example, financial incentives for installing geothermal energy technologies given by the Province of Manitoba have spurred an increase in the construction of these energy system. The province is providing financial support for the installation of geothermal technology in the form of tax credits and grants. Through these mechanisms, existing and new homes can receive up to $5,000 and commercial buildings can receive up to 15% of their system's value in financial support, whereas DESs are eligible for an incentive up to $150,000 and receive refundable tax credits up to 15% of the cost. These incentives have led to the creation of geothermal systems from single house projects to DES projects throughout the province.

Île-des-Chênes, Manitoba has used these provincial incentives, as well as other grants, to create a DES. The rural town in the Municipality of Ritchot developed a plan to use geothermal energy to heat and cool the local hockey area, but the high initial investment required made the project infeasible for the town. Île-des-Chênes decided to incorporate the fire hall and the new community centre into the project and create a small DES network. Île-des-Chênes was able to secure both federal and provincial funding and move forward with this project. The system has reduced energy usage by 60% and energy costs by 40% for the connected buildings, demonstrating how upfront financial incentives for the operators will later benefit the customers.

Similar to the NCR, St. Paul, Minnesota was faced with the challenge of retrofitting old buildings and making district energy appealing to existing property owners. Because the majority of the concern over connecting to the system was the high up-front costs for building owners, the city decided to come up with financial incentives that relieved this financial burden. St. Paul established an Energy Reinvestment Revolving Loan Fund to offset the cost of converting buildings to be able to connect to the DES. This fund was established by the St. Paul Foundation, at the request of the mayor of St. Paul, to assist non-profit customers paying for building retrofits. It was funded by $2.6 million in grants and long-term loans from a variety of foundation and corporate donors. This financial support helped to secure clients in the early phases, which in turn lead to the successful growth of the DES.

4.3.3 Attracting Clients for Environmental Sustainability

While the influence of pricing on attracting clients is undeniable, it may also be possible to attract specific clients by promoting the environmental attributes of a DES. This is particularly the case with governmental and institutional building owners that have a mandate for environmental sustainability. In many cases, government agencies and departments have specific targets to reach in order to reduce their environmental footprint. It is important for DES operators to target these potential clients with sales tactics that promote the ability to reach targets and meet mandates by connecting the DES.

An excellent example of this lies in the case of Paris, France. The district heating and power company in Paris has committed to targeting public buildings as potential clients. This strategy is largely linked to the fact that connecting into a DES can significantly advance progress towards meeting government mandated environmental targets. This ties back to the idea that a DES is best planned with broad policy objectives in mind, particularly those are upper levels of government.

In terms of environmental sustainability, innovative approaches to de-carbonizing have been successful in Islington, United Kingdom (see page 101). During the first phase of DES expansion, the Bunhill Heat and Power network has been able to reduce energy poverty by significantly reducing the price of heat and power. In turn, the cheaper and cleaner sources of heat and power have attracted a broad client base, currently serving over 850 homes, two leisure centres, and a new residential development. The Bunhill Heat and Power centre not only reduced carbon dioxide emissions by 60%, but it also now provides a source of affordable heat and power. Plans for the second phase of the Bunhill Heat and Power network include the construction of another energy centre and an expanded network of piping to capture heat from the tube network in London. This expansion uses a heating supply that would otherwise be wasted and will allow expansion and connection to an additional 454 homes, with the potential to supply an additional 1,000 homes. The existing, planned, and potential heating networks in and around Islington are illustrated in Figure 10. The use of the heat generated from London's tube network is an environmentally sustainable source and will help further reduce energy prices and carbon dioxide emissions. While the environmental benefits of Bunhill Heat and Power network are substantial, the network is also socially sustainable and has helped to close the energy poverty gap that previously plagued the area.

Figure 10: Map showing existing, planned, and potential heating networks in and around Islington.[12]

4.3.4 District Energy Marketing

In markets where DES is new or uncommon, potential clients may be reluctant to join the system as an early adopter, even if the financial and environmental benefits are clearly advertised. In many cases, potential clients may not be aware that DES is an option that applies to them. To remedy this, attention needs to be given to spreading information about the benefits of joining the system, where the system is planned to expand, and who can connect to it.

While local governments are significant players in advocating for district energy, not-for-profit organizations also play a pivotal role in educating the public on district energy. A great example of this is the movement around EcoDistricts that has spread across the globe. EcoDistricts are areas within a city that promote sustainable development whether it is installing bike share programs, electric vehicle charging stations, educating the public on green technologies, or working closely with city builders to create sustainable development frameworks. St. Paul, Minnesota for example, is a certified EcoDistrict and is a platform for educating the public on the benefits of district energy. Educational programs have been created to teach the public about the benefits of district energy, heat recovery, combined heat and power, and other advanced technology. Establishing an EcoDistrict acts as a catalyst for promoting connection to a DES, growing the client base, and is a tool for educating the public.

While developing educational resources, it is important to pay specific attention to transparency in practices and protocol. Establishing clear, easily understandable operations is perhaps one of the most attractive characteristics the operators of a DES can embrace in their daily functions. Those that choose to connect will want to know precisely what they are signing up for, which is why a platform for all information related to the function, players, rates, and services associated with the system is important.

Publishing the benefits to individual customers, the community at large, and the environment all in the same place will provide clarity with respect to the advantages of this type of system in the long-term sustainability of a city. In the case of the City of North Vancouver District Heating System, the corporation established by the city to operate the system maintains a user-friendly web page that elaborates on all aspects of the system from updates on governance dynamics to advantages of the system to how customer rates are calculated. In this way, not only does such a platform encourage connections, but it serves as an information source for current customers.

Nashville, Tennessee (see page 122) secured the support of the citizens for their DES through a public information project. Metro Nashville worked with the consulting firm Gershman, Brickman and Bratton to create broad awareness of the project. Together, they also established a brand for the project by designing a logo to include on all documents related to the DES. Additionally, they released information on DESs, generally, and why they are important to incorporate into Nashville's downtown core, specifically.

Developing strong social capital around the project ultimately leads to the support and connections necessary for successful function of the system from the beginning. Such is the case for Charlottetown, Prince Edward Island in their unwavering success. The leaders have engaged fully with stakeholders and the public from the beginning, which has ensured everyone has a base knowledge of the system and has opened a line of communication for continual marketing. By using local energy sources, their marketing is tailored to the community in contributing to the local economy, assisting municipal waste management, and further stabilizing consumer rates, on top of the standard marketing schemes. The social capital for the system in Aberdeen, UK was built slightly differently by showcasing a pilot project. With the objective for the system to combat fuel poverty in the city, a lot of skepticism existed about how this not-for-profit scheme would experience success. The small pilot project system demonstrated that the governance structure functioned well, and that the system was reliable and improved living conditions, which spurred further support moving forward.

Public perceptions of the governance structure and operators of the system might also come into play. In many cases, a private company is mandated with the operation of the system. In others, such as the City of North Vancouver, the city established an arms-length corporation to operate the heating system. Regardless of the selected partnerships and governance, the perceptions and uncertainties linked to the method is vital to consider when looking forward to seeking future connections into the system.

4.3.5 Lessons Learned

There 13 lessons learned from the case studies relating to the theme of Growing the Client Base. Below is a summary of these lessons divided by subtheme.

Identifying Potential Users

1. New development areas offer opportunity to easily secure new clients. The developers need to be contacted during the planning phases to ensure that they will integrate connecting to the DES into their development.
2. Integrated energy planning, in the form of partnering with local authorities and developers, allows for the opportunistic expansion of the system. Aligning expansion with other projects may allow the system to expand to clients that would otherwise not be reached in a financially viable way.
3. Partnering with large developments or campuses that already have an internal DES can allow for the leveraging of valuable infrastructure. In some cases, it is possible to establish these partnerships with the intention to update and expand their existing system to also serve the surrounding area.

Financial Tools for Client Attraction

1. Ultimately, competitive monthly rates to other energy sources is the driving factor in securing new connections to a DES.
2. Financial incentives to reduce the upfront investment for building owners to retrofit their buildings to connect to the system will greatly assist in securing new connections to a DES. This will generally make it a more accessible amenity.
3. A realistic, conservative, and flexible financial model needs to be in place for the economic sustainability of a DES. In this way, it is important from a business perspective that monthly rates are competitive, but not too low.

Attracting Clients for Environmental Sustainability

1. By initially ensuring that the system will act to support government environmental objectives, securing the connection of government buildings will be much easier. Part of this will be establishing lines of communication from the beginning.
2. Ultimately, competitive rates, both upfront and monthly, will be the biggest factor in securing new connections. However, this can be supplemented with the environmental sustainability benefits in order to initially attract clients.

District Energy Marketing

1. The best marketing strategies are those that are transparent about all aspects of the system. These aspects include governance, operations, rate, benefits, and more. The most effective method to communicate this information continually is to establish some sort of education platform, which often manifests as a website.
2. Branding the system by designing a logo and incorporating common wording and imagery can increase the recognizability of the system and, therefore, the overall awareness of it.
3. Public and stakeholder engagement from the beginning and on an ongoing basis is important to ensure that everyone has the information they need.
4. Advertising the benefits to the local community, rather than solely relying on marketing broad environmental benefits, can help to build social capital. These local benefits might include job creation, use of local energies, and the reduction of fuel poverty.
5. Carrying out an upfront pilot project to showcase that the system is reliable, and the

governance model is functional will help to attract reluctant clients moving forward.

4.4 System Governance

There is certainly no ideal governance model for a DES. Rather, the factors at play in each given situation must be considered to establish the best system. This section delves into both the challenges and benefits of a variety of governance models. The importance of citizen engagement and consultation as well as reviewing the local policy context are both discussed as building blocks for success. Finally, the discussion shifts to successful operations and what that means from a governance standpoint.

4.4.1 Establishing a Governance Model

As a DES evolves and expands, the number of involved stakeholders naturally increases. This is particularly true in cases where multiple levels of government, as well as private firms, are involved. The result is that there is a complex layering of regulatory systems and stakeholder needs. A well-organized and streamlined governance model is essential to navigating this complexity and ensuring that all stakeholders have their demands met while maintaining system efficiency.

Given that every DES is fundamentally tied to the local context, there is no "one size fits all" governance model. Rather, the governance model decided upon needs to be tailor-made to suit the stakeholders involved in the project. This requires a unique framework to be developed for all the potential stakeholders present to negotiate and collaborate as a system evolves. While this can be a daunting task in situations with a complex array of public and private stakeholders, case study examples provide a recipe for success.

At the outset of planning for long-term system evolution, a critical step is the positioning of one key stakeholder as a leader to create an institutional framework for future negotiation and cooperation on the system. As exemplified in the BMDEU case study, this is particularly important in cases with a layering of public and private stakeholders with different needs, mandates, and regulatory systems. The BMDEU project was able to bring together the municipality, university, and a variety of private sector interests within a provincial regulatory framework in a large part due to the efforts of the Simon Fraser University (SFU) Community Trust that took a leadership role in bringing all the parties together under a single institutional framework for collaboration.

As mentioned in Section 4.2 – Land Use and Expansion, BMDEU demonstrates another key element in effective DES governance: establishing a complementary local regulatory system well in advance of rolling out any physical expansion. Based on concerns from stakeholders, the SFU Community Trust held off on physical expansion and instead focused on laying the foundation of sustainability through innovative local bylaws and development standards put in place in cooperation with the local municipality. This work demonstrates forward-looking and transparent governance that clearly accounts for the needs of additional stakeholders, while making rational decisions about the long-term phasing of the project.

When moving forward with physical expansion, it is vital to ensure that the organization structure – both in high-level governance and in a business model – operate in a commercially viable way. In the BMDEU example, a privately-operated utility body selected by the SFU Community Trust was chosen as an ideal system, as it brings in commercial experience necessary to market and sell the system to consumers, while maintaining the high-level governance input needed to meet the Trust's mandate. In the case of the North Vancouver DES, an arms-length corporation was established by the municipality to run the system along with the guidance, in the form of a contractual agreement, of an experienced district energy operator during its initial years.

Similar to North Vancouver, the Aberdeen, United Kingdom combined heat and power system has been developed and managed by a city council arms-length company called Aberdeen Heat & Power (AH&P). Unique to Aberdeen, however, is that this company is entirely not-for-profit, with a mandate of providing affordable heating to the social housing owned by city council. In this way, full capital costs for AH&P have needed to be covered so that the burden is not placed on the occupants, which has been largely achieved through government and fuel grants. To ensure stability for the company and the system, two main mechanisms are in place. First, AH&P has a 50-year framework agreement with city council requiring that city council selects the housing to be served by the system, AH&P installs and maintains the necessary infrastructure, and council thereafter owns the infrastructure installed within their buildings. Second, a wholly owned subsidiary of AH&P, called District Energy Aberdeen Limited (DEAL), was established to retail the services of AH&P to private customers. In this way, AH&P remains not-for-profit in serving the needs of social housing and public buildings, but gains resources from DEAL to maintain low prices and update infrastructure.

Energy sectors within each Canadian province fall under differing rules, regulations, and acts. As such, this will influence the choice of appropriate governance model for any DES project. In Vancouver, British Columbia for example, the City itself is regulated under the Vancouver Charter. Under the Charter the City of Vancouver is able to establish their own utility governance structure, which is what was done at the SEFC development. The City set up the NEU, which is governed by the Energy Utility System By-law No. 9552. This bylaw specifies that the NEU is owned and operated by the City, which holds the right to sell the utility to the private sector in the future if the public would be better served by a private utility company. In addition, the bylaw gives the City authority to implement mandatory connection policies to the SEFC DES. New developments within the boundaries of the SEFC and rehabilitation projects over $95,000 located in the vicinity of the SEFC boundary are currently required to connect to the system.

4.4.2 Citizen Engagement and Consultation

Public engagement and consultation for DESs not only act as catalysts for discussion, they also serve to educate the public on the economic, social, and environmental benefits of district energy. As the case studies illustrate, it is crucial to recognize the necessity in doing public outreach and fostering proactive dialogue with the public as this helps to ensure buy-in from stakeholders.

In the SEFC case study, public consultation played a significant role in the City of Vancouver's decision to use the conversion of heat from raw sewage as the main energy source for the DES. However, the City faced the challenge of mitigating the public's concern over the location and aesthetics of the SEFC Energy Centre and the potential negative externalities associated with it. Through several rounds of public consultation and design charrettes, the City decided to install the energy centre underground and have the above ground portion used as a public education tool. An additional component to the Energy Centre was the idea to include an artistic component to the emissions stacks. Local artists were commissioned to provide a design that would transform the system's emissions stacks into a community landmark. The design chosen is meant to instill a human quality to the system by representing a human hand. At the tip of the five 'fingers' LED fixtures are used to represent the 'fingernails' of the hand, which change colours to represent the amount of energy being produced by the system, shown in Figure 11. Through extensive public consultation, the City was able to successfully integrate a sustainable technology that serves the needs of the neighbourhood. It is important to point out that the City recognized that implementing new technologies requires a great deal of public education.

Figure 11: The Southeast False Creek Energy Plant at night.[13]

The City of Burlington, Ontario provides another example of the benefits of comprehensive community engagement. Burlington framed the development of their Community Energy Plan with a series of core principles, including meaningful public engagement. Throughout the planning process, stakeholder advisory committees were created to guide the identification of goals and future actions, bring together information from a range of stakeholder perspectives, and provide a framework for collaboration. Public outreach efforts were held including online discussion forums and energy sustainability contests for local students.

Reaching out directly to both current and potential customers can also play a huge role in expansion. For example, to assist in the expansion of the system in Aberdeen, United Kingston, the city council facilitated a workshop for local and federal government officials, developers, and local businesses to discuss the current and potential challenges and opportunities. This helped to identify the areas on which to focus to attract more connections to the system, such as more clarity in the financial and technical supports available for developers. The initiation of an awareness campaign also stemmed from this meeting, for which the main objective is for all of the leading stakeholders to have consistent and accurate messaging to share with the customers. To ensure community involvement is continual, the Aberdeen system has a board of directors that includes volunteers from a diversity of backgrounds, two of which are elected, and has a provision for tenant members.

4.4.3 Reviewing the Legislative and Policy Context

Strong policy direction from all levels of government related to the project is extremely important to ensure the success of a DES. Clear policy from the outset allows for municipalities to plan accordingly. As discussed in Section 4.2.1, district energy works best in dense urban areas with a mix of land uses, for which feasibility analyses, include a thorough review of policy directives, is necessary.

The Danish federal government has been the key driver in the success of Denmark's DES. In recognition of the negative environmental impacts of importing and using oil as a prime source of energy, the Danish government enacted legislation to initiate the planning framework for DESs in their country. The *Heat Plan Act of 1979* required municipalities to map the existing energy demand, heat supply, and energy used throughout their jurisdictions. The information that was collected by this research was thereafter sent to the regional authorities to formulate a summary of the heating methods and level. This allowed for the regions to create heat plans, which set focus on the necessary steps on how and where to install district energy.

The Denmark example illustrates that strong and coherent policy must first be set in place to give local authorities guidance for transitioning towards district energy. In addition, the political environment plays a crucial role in the success of implementing policy. The objectives set out by upper-levels of government with respect to district energy are crucial. To expand a DES, the first stage should involve all levels of government achieving a mutual understanding on the importance of establishing policy that sets a clear and transparent direction for transitioning to district energy.

Policy support can also exist for other objectives related to the system. The *Affordable Warmth Strategy* in Aberdeen, United Kingdom has acted to give footing to their socially-oriented combined heat and power system. This document is based on studies indicating that the extensive social housing owned by the city council was very poorly heated, with tenants living in discomfort during the cooler months. Based on this from the beginning, the main objective of the system has been to provide affordable heating and it has successfully removed hundreds of people from their former fuel poverty.

4.4.4 Ensuring Successful Operations

Throughout the expansion of a DES, ensuring stable and effective operations is an absolute necessity. Effective management is required to ensure that the system operates smoothly, safely, and in a manner that delivers a quality product to clients.

Princeton University in New Jersey (see page 129) has developed a flexible DES to heat and cool the campus. The university created a system that can use multiple types of fuel to power the system and is able switch between them on a daily basis (Figure 12). The system is based on getting the cheapest source of fuel and meeting the needs of the campus. The university produces solar energy and has gas and steam turbines in the power plant to power the system. The system also allows for purchased grid power to run the system. The grid power is typically purchased overnight when the prices are at their lowest and stored in a thermal energy storage system to be used at peak price times. The operators are trained to determine when to use each fuel source and when to use imported energy to ensure the system remains reliable, safe, and financially attractive.

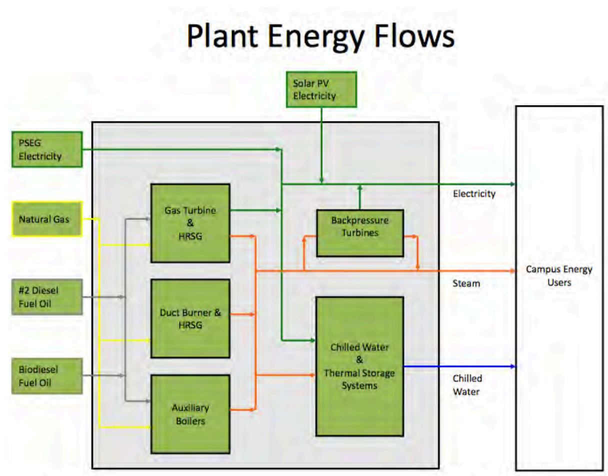


Figure 12: The four sources of energy for Princeton's district energy system to provide heating and cooling to the university campus.[14]

Two decades ago, Nashville, Tennessee was operating an unreliable, inefficient, and costly waste-to-heat energy system at the end of its life-cycle that led to 40 forced operation shut downs every year. In the early 2000s, Nashville installed a new DES to heat and cool the downtown core (Figure 13), which has had only one forced operation shut down over 15 years of operation. The system's reliability has been a driving factor attracting new clients to connect to the system.

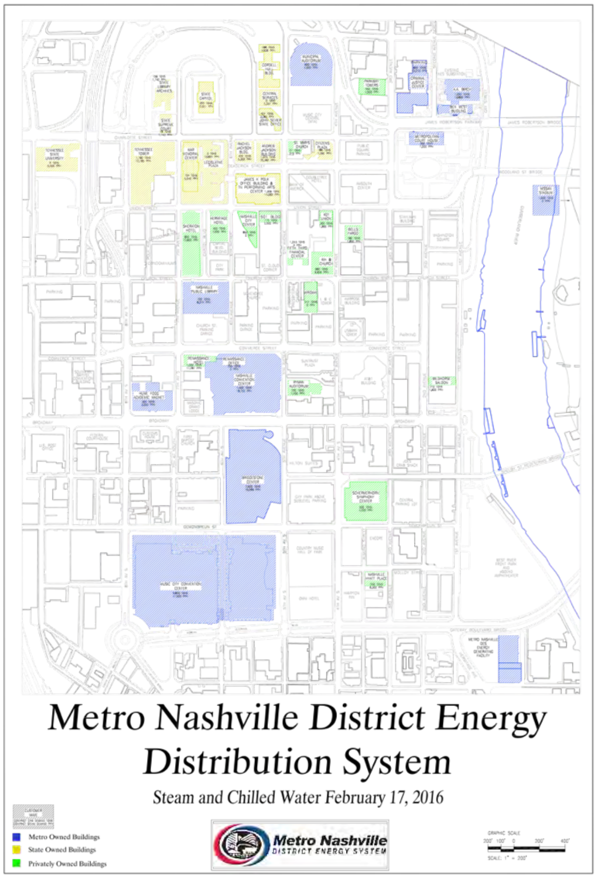


Figure 13: A map of Nashville showing the type of buildings connected to the district energy system and their location.[15]

Another addition that can contribute to successful operations is the capacity to produce power supplying heating and cooling. In the successes of the Charlottetown, Prince Edward Island system, their cogeneration capacity serves exclusively to provide their internal energy needs. Any excess power is produced is then sold to the grid, acting as additional income. Aberdeen, United Kingdom has a similar system, but sells the power to some of their customers directly as well. In this case, and many other similar cases, the heat produced from the generators supplying the power is captured and used for the heating network, which contributes to efficiency increases.

As discussed in section 4.3.2 Financial Tools for Client Attraction, the financial model selected is another key consideration for successful operations. Key contracts need to be created in a manner that allows flexibility in rates and contains clear processes for renegotiation. As demonstrated in the Vingåker DES (VDES), simply following typical procurement procedures may lead to absolute failure of the project and potential bankruptcy of private partners. The DES business model needs to be constructed with a realistic and conservative business mentality, as a system intended to operate over many decades will almost certainly encounter many changes in input costs and stakeholder needs throughout its existence.

However well-constructed, systems also need to take into account the potential for failure in their regulatory framework. Failure to do so can lead to lengthy politicized battles, as was the case in the VDES case study after bankruptcy proceedings. Provisions need to be established to ensure continuity of services for customers, and the transfer of infrastructure in the case of stakeholder insolvency.

4.4.5 Lessons Learned

There are 11 lessons learned from the case studies relating to the theme of System Governance. Below is a summary of these lessons divided by subtheme.

Establishing a Governance Model

1. Positioning one key stakeholder as a leader greatly simplifies the establishment of a clear institutional framework for negotiations and

cooperation between all players. Working transparently with all key stakeholders in this way to share information and establish a regulatory framework is the first step in long-term system evolution.

2. A variety of public, private, and public-private partnership models have experienced success. Ultimately, the most important outcome is that clear governance and business models are established.
3. Governance and business structures should be created in a way to ensure long-term financial sustainability and efficiency of service. It is critical to ensure an organizational structure with expertise not only in physical infrastructure creation, but also in commercial service provision.

Citizen Engagement and Consultation

1. Building both public education and engagement into the selected governance model will help to both secure support for the system and to shape the system to serve the desires of the public. This can take on many forms, such as public meetings and workshops.
2. Stakeholder advisory committees can serve to formalize the input of the key players on an ongoing basis and to ensure that their perspectives are being incorporated into decisions.

Reviewing the Legislative and Policy Context

1. Legislation, strategic-level policy, and local policy should all be reviewed for direction and guidance in both carrying out specific actions and establishing general objectives.
2. In the long term, clear policies that are supportive of DES are valuable for the sustainability of the system. Even supportive
3. policies, such as those related to reducing fuel poverty, are important to consider and embrace.

Ensuring Successful Operations

1. By remaining flexible to use different fuels, the economic and environmental efficiency of the system can grow over time.
2. Ensuring that operations are reliable and unwavering will both help to keep existing customers and attract new clients based on the positive reputation of the system.
3. In core areas where delivery of energy services is critical, business models must be created conservatively with an aim to insulate customers against service interruptions.
4. Contracts and partnerships need to carefully and conservatively predict input costs, allow flexibility in renegotiation along clear parameters, and include transparent processes in the case of financial insolvency or organizational restructuring.

4.5 Summary of Lessons Learned

Many lessons on a variety of topics were derived from the 18 case studies completed for this work, all of which were considered in establishing the land use analysis methodology and, ultimately, the recommendations for the expansion of the ESAP DES. Table 1 acts to summarize the key lessons learned from these case studies. The lessons not discussed in this section are included in Appendix C along with additional information about each case study.

Land Use & Expansion	Growing Client Base	System Governance
Determining Growth Areas 1. The best growth areas for the expansion of a DES are those that are high density and have a mix of lands uses. 2. Anchor users are vital to connect. 3. Detailed land use analyses and demand feasibility studies are both necessary to guide the planning stages of a DES.	**Identifying Potential Users** 1. New development areas offer an opportunity to easily secure new clients. 2. Integrated energy planning allows for the opportunistic expansion of the system. 3. Partnering with large developments that already have an internal DES can allow for the leveraging of valuable infrastructure.	**Establishing a Governance Model** 1. Positioning one key stakeholder as a leader to establish institutional framework 2. The most important outcome is that clear governance and business models are established. 3. Governance and business structures should be created in a way to ensure long-term financial sustainability and efficiency of service.
Community Planning and DES Expansion 1. Partnering with local authorities to access planning tools can make the expansion much simpler and financially viable. 2. Partnering with local authorities to prepare a CEP or DES Master Plan will help to guide expansion into the future. 3. The promotion of sustainability and connections to the system can be leveraged by partnering with not-for-profit organizations with goals that align with the DES project. 4. The system should be planned to meet broader environmental goals, such as those established by higher levels of government.	**Financial Tools for Client Attraction** 1. Competitive monthly rates are the driving factor in securing new connections to a DES. 2. Financial incentives to reduce the upfront investment for building owners will greatly assist in securing new connections to a DES. 3. A realistic, conservative, and flexible financial model needs to be in place for the economic sustainability of a DES.	**Citizen Engagement and Consultation** 1. Building both public education and engagement into the selected governance model will help secure support for the system. 2. Stakeholder advisory committees can serve to formalize the input of the key players on an ongoing basis.

Land Use & Expansion	Growing Client Base	System Governance
Timing and Phasing	**Attracting Clients for Environmental Sustainability**	**Reviewing the Legislative and Policy Context**
1. Engaging with stakeholders from the very beginning will ultimately result in the development of a system that is attractive for a breadth of customers. 2. Clearly planned and flexible phasing of both initial development and expansion will help in achieving the overarching goals of the project in a systematic and timely manner. 3. Pursuing the connections of new developments while they are being planned is best prioritized. 4. Systematic and flexible expansion based on demand will ultimately result in a more sustainable system from the beginning.	1. By initially ensuring that the system will act to support government environmental objectives, securing the connection of government buildings will be much easier. 4. The environmental sustainability benefits can help to market the DES to attract clients.	1. Legislation, strategic-level policy, and local policy should all be reviewed for direction and guidance. 4. In the long term, clear policies that are supportive of DES are valuable for the sustainability of the system.

Land Use & Expansion	Growing Client Base	System Governance
	District Energy Marketing 1. The best marketing strategies are those that are transparent about all aspects of the system. 2. Branding the system by designing a logo and incorporating common wording and imagery can increase public awareness of the DES. 3. Public and stakeholder engagement from the beginning and on an ongoing basis is important to ensure that everyone has the information they need. 4. Advertising the benefits to the local community can help to build social capital. 5. Carrying out an upfront pilot project to showcase that the system is reliable, and the governance model is functional will help to attract reluctant clients moving forward.	**Ensuring Successful Operations** 1. By remaining flexible to use different fuels, the economic and environmental efficiency of the system can grow over time. 2. Ensuring that operations are reliable and unwavering will both help to keep existing customers and attract new clients. 3. Business models must be created conservatively with an aim to insulate customers against service interruptions. 4. Contracts and partnerships need to carefully and conservatively predict input costs.

Table 1: Summary table of the key lessons learned from the 18 case studies.

[1] Map of 18 district energy case studies looked at around the world

[2] Zhou, Y., Li, Z., & Tao, X. (2016). Urban mixed use and its impact on energy performance of micro grid system. Energy Procedia, 103, 339-344.

[3] Church, K. (2007). Is District Energy Right For Your Community? Part 1: The Concept. Municipal World. Retrieved from http://www.biomassinnovation.ca/pdf/Report_NRCAN_DistrictEnergy_Nov2007.pdf

[4] Envida Community Energy. (2013). District Energy Strategic Plan for the City of Guelph. Retrieved from: http://guelph.ca/wp-content/uploads/011514_DistrictEnergyStrategicPlan_web.pdf

[5] City of Sydney. (2013). Decentralized Energy Master Plan. Retrieved from http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0007/193057/Trigeneration-Master-Plan-Kinesis.pdf

[6] City of Burlington. (2014). Pg. 19-20.

[7] Energy innovation, green technology and sustainability were the driving forces behind the formation of the Gibsons district energy system. These important forces represent the values of the town and what they want to see in their planning. Town of Gibsons. (2014). Geo-exchange Utility. Retrieved from http://www.gibsons.ca/geo-exchange-utility

[8] Town of Gibsons location and phasing of their district energy system infrastructure. Ed Lohrenz. (2011). Gibsons, BC District Geothermal Energy System. Retrieved from http://www.geoptimize.ca/uploads/2/2/3/6/22361732/gibsons_district_systems.pdf

[9] Phase 1 housing connections to the Gibsons district energy system. Ed Lohrenz. (2011). Gibsons, BC District Geothermal Energy System. Retrieved from http://www.geoptimize.ca/uploads/2/2/3/6/22361732/gibsons_district_systems.pdf

[10] City of Vancouver. (September 25, 2012). Policy Report Environment- Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines. Retrieved from http://vancouver.ca/files/cov/neighbourhood-energy-strategy-and-energy-centre-guidelines-committee-report.pdf

[11] The Cogeneration Energy Plant in St. Paul, Minnesota. Retrieved from http://www.districtenergy.com/2015/10/district-energy-st-paul-plans-elimination-of-coal-for-heating-system/)

[12] Islington Council. (n.d.). Bunhill Heat and Power: Case Study. Retrieved from https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=ae95be02-aefe-0f9c-456e-e98c32d506b8&forceDialog=0

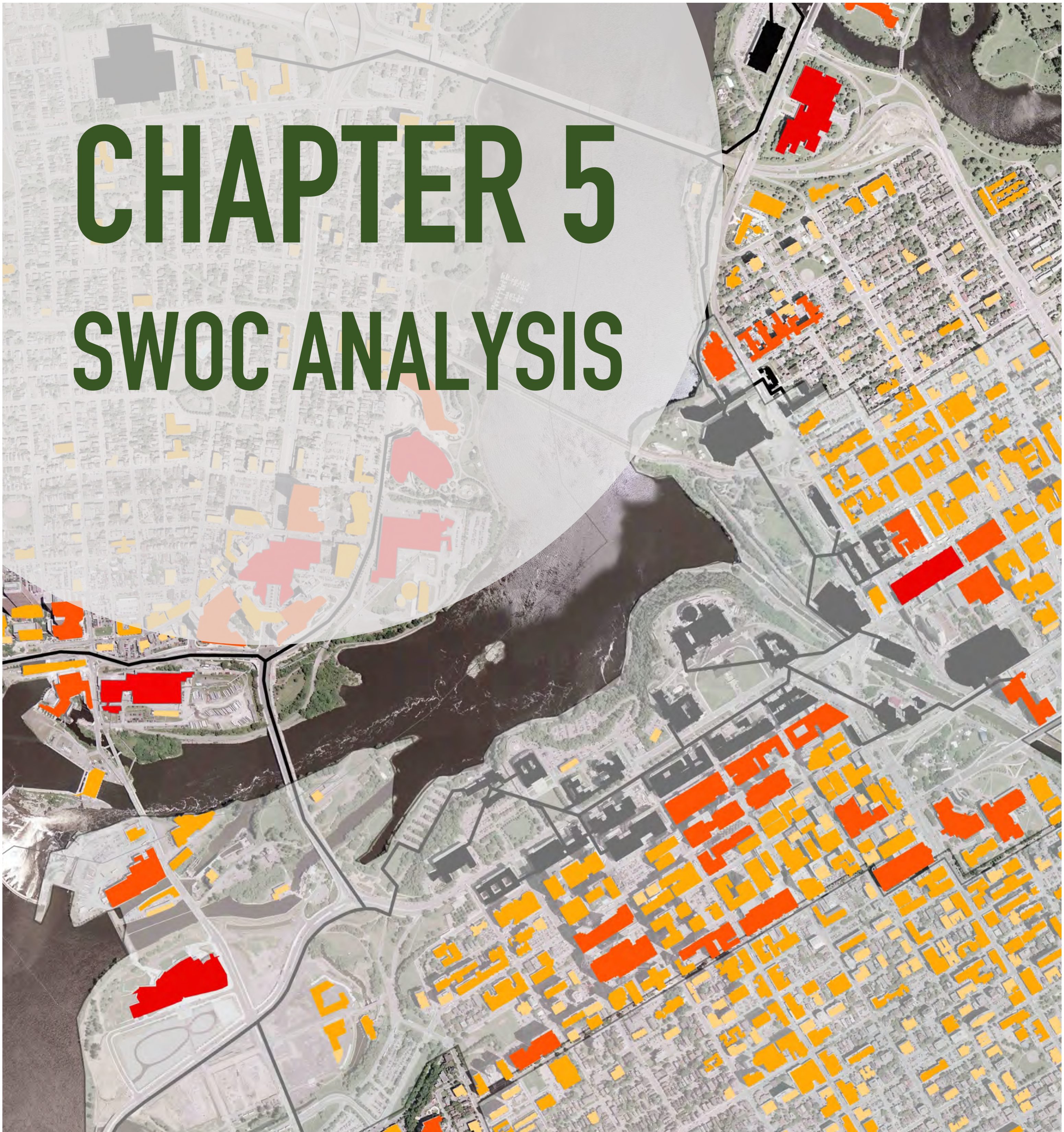
[13] CDm2 Light Works. (n.d.). Southeast False Creek Energy Centre Stacks. Retrieved from http://www.cdm2lightworks.com/project/southeast-false-creek-energy-center-stacks

[14] The four sources of energy for Princeton's district energy system to provide heating and cooling to the university campus. Edward Borer. (April 2013). Energy Efficient Infrastructure for More Resilient Local Economies. Retrieved from http://www.eesi.org/files/050813_Borer.pdf

[15] A map of Nashville showing the type of buildings connected to the district energy system and their location. Metro Government of Nashville & Davidson County, Tennessee. (2017). DES System Descriptions. Retrieved from http://www.nashville.gov/District-Energy-System/Technical-Information/System-Descriptions.aspx

CHAPTER 5

SWOC ANALYSIS



SURP 824 PROJECT COURSE

5.0 SWOC Analysis

With an understanding of the existing district energy system (DES), within its current context, a Strengths, Weaknesses, Opportunities, and Challenges (SWOC) Analysis was conducted for the expansion of the Public Services and Procurement Canada (PSPC) DES in the National Capital Region (NCR). This analysis includes considerations of policy, anticipated growth, and the Energy Services and Acquisition Program (ESAP) plans. Using the lessons learned from the case study analyses, the SWOC is organized by the three themes established in the case study review: land use and expansion, growing client base, and system governance.

5.1 Land Use and Expansion

STRENGTHS	WEAKNESSES	OPPORTUNITIES	CHALLENGES
• By the end of phase 1, an entirely modernized system with interconnected plants will be in place • The DES already has anchor users (Government of Canada buildings) and is situated near other potential federal connections • The modernized system will produce less greenhouse gas emissions and reduce energy loss • The modernized system will have the capacity to make use of renewables, which ESAP is already trialing • The system infrastructure connects to both Ottawa and Gatineau, and will provide a connection between Cliff and Tunney's Pasture CHCPs	• There have been missed opportunities for connections to the existing system • Because there is an existing system, there is less flexibility for expansion or changing the current large-plant DES model • Both Tunney's Pasture and NPB CHCPs are Federal Heritage buildings, which require additional permission/justification to modify • Expansion of the system in highly developed core areas is costly and disruptive • There is potential conflict with view-planes and national character with the prominent location of the Cliff Plant	• There is capacity and will from Government of Canada to expand existing DES • There is opportunity to connect to new high-density and mixed-use developments and new anchor users • The existing P3 will provide incentive for the private partner to expand the system in ESAP phase 2	It will be a challenge to implement policy changes at all levels in a timely manner: • To capitalize on existing political support for environmental objectives • To capitalize on the infrastructure being built in phase 1 and 2 of ESAP, including the connection to Tunney's Pasture

Table 1: Strengths, weaknesses, opportunities, and challenges table for the land use and expansion theme.

5.2 Growing Client Base

STRENGTHS	WEAKNESSES	OPPORTUNITIES	CHALLENGES
• ESAP phase 1 and 2 will include an educational component and generate more public awareness about DESs and their benefits • Several plants are located in the highest density core of the NCR including mixed-use areas, and planned growth areas which are well suited for connecting	• The DES situated near University of Ottawa's existing campus DES, which may compete for users or limit expansion • ESAP is focused on public awareness instead of marketing to potential customers • There have been missed internal opportunities for DES connections • Different measures of density for DES and traditional Land Use Planning (units per hectare versus buildings per hectare) • Fragmented access to information and poor communication are internal barriers between Government of Canada departments	• The completion of ESAP phase 1 and 2 can be used to stimulate interest around DES, and market system to potential users • The DES is located in built environments and areas with land use policy conductive to high density, which are supportive of DES usage	It will be a challenge to overcome barriers to connecting to the system, including: • The large upfront costs of connecting to the system • The lack of knowledge about a DES's environmental benefits and life cycle cost savings • Other competing energy opportunities, such as cheaper Quebec hydroelectricity, the University of Ottawa DES, and Zibi DES • Some developers require services for both heating and cooling in order to connect

Table 2: Strengths, weaknesses, opportunities, and challenges table for the growing client base theme.

5.3 System Governance

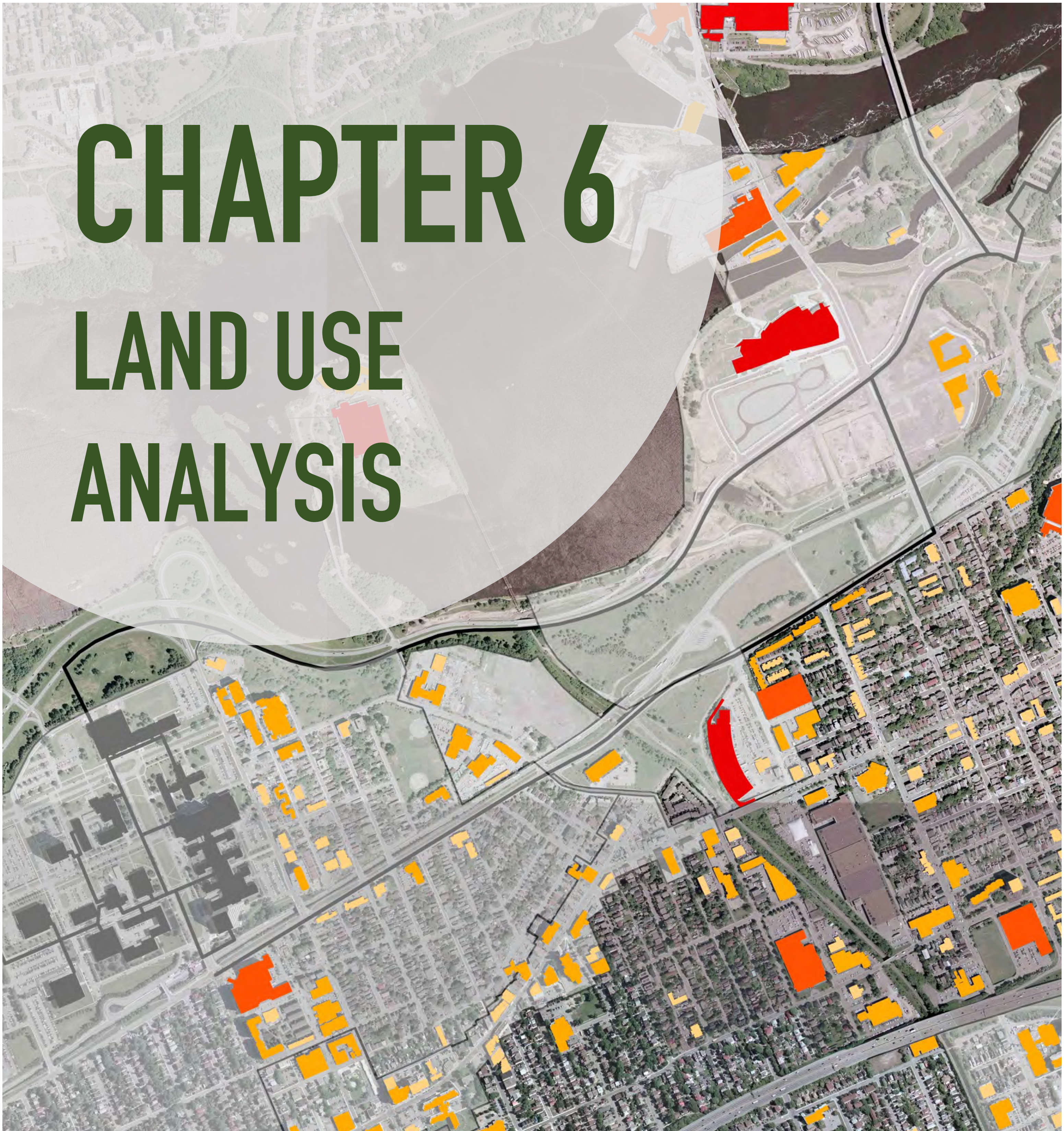
STRENGTHS	WEAKNESSES	OPPORTUNITIES	CHALLENGES

• The Government of Canada "green" priorities incorporate and support DES
• Ontario's Provincial Policy Statement directly supports DES
• All key stakeholders have "green priorities" of some form and are supportive of environmental goals
• ESAP has an established team of expertise on DES technology and infrastructure
• ESAP has prioritized private sector involvement and innovation
• The modernized DES will provide cost savings for the Government of Canada over time
• There is existing economy of scale with multiple, high capacity and well-positioned CHCPs
	• Projects beyond ESAP Phase 1 and 2 are subject to changing Government of Canada priorities
	• Any DES infrastructure on Federal Land is subject to review by the NCC, which does not specifically promote DES
	• There is no identified business model for the delivery and expansion of the DES
		• ESAP is well positioned to take a leadership role in initiating expansion of the DES and bringing together stakeholders
		• Building upon ESAP staff expertise to implement a world-class, integrated DES
			• Ensuring flexibility and room for innovation during expansion
			• Political climate and context will be different in 35 years upon completion of ESAP Phase 1 and 2
			• ESAP will need to overcome barriers for collaboration and communication with Provincial and Municipal governments to take leadership on DES in the NCR. This includes overcoming:
			  ◦ Differing environmental priorities and needs across all stakeholders
			  ◦ City of Ottawa interests in ownership and management of a shared DES
			  ◦ Difference in language between energy and land use requirements for density and mixed-use
			  ◦ Lack of communication and buy-in amongst stakeholders
			  ◦ The bureaucratic processes for inter-provincial, federal, and municipal projects

Table 3: Strengths, weaknesses, opportunities, and challenges table for the system governance theme.

CHAPTER 6

LAND USE ANALYSIS



SURP 824 PROJECT COURSE

6.0 Land Use Analysis: Conceptualizing DES Expansion in the NCR

To evaluate the feasibility of expanding a district energy system (DES) in the National Capital Region (NCR), it is essential to understand what the future growth trends in the region might look like. The following sections provides an overview of growth planning policies in each municipality and upcoming urban redevelopments that will have a considerable influence on growth in the region. This section explores the expansion potential of areas for two key elements: (1) supportive land use policy and (2) supportive built environment conditions. From the lessons learned in the case studies, it was concluded that DES is best supported by a mix of uses, high density and concentration of buildings, and anchor users with high energy demands. The purpose of this land use analysis is first to identify areas with land use policy that supports a mix of uses and intensification of density and built form. Then, this analysis serves to identify areas within those areas that demonstrate potential for a high concentration of users from planned new development and from existing built form. The following section acts to build a land use analysis framework that lends to the identification of areas best suited for the expansion of the Public Services and Procurement Canada (PSPC) DES in the NCR.

6.1 Data and Limitations

Using the above framework, data was compiled and displayed using Geographic Information System (GIS) software, ESRI ArcMap 10.5. A description of the data used for the land use analysis, including sources and processing description is included Appendix D. The data used or created for the land use analysis included:

- PSPC DES pipes, plants, and connected buildings, as well as the planned expansion of the existing system through the Energy Services Acquisition Program (ESAP);
- Ottawa Official Plan mixed use areas;
- Ottawa Community Design plan areas;
- Ottawa Secondary Plan Areas;
- Ottawa transit-oriented development areas (600 metres);
- Gatineau transit-oriented development areas (700 metres);
- Existing Buildings;
- Roads;
- New development areas of Tunney's Pasture, LeBreton Flats, Zibi, and Place de Portage; and
- Aerial images.

The team was unable to access accurate GIS data for:

- Location of Federal buildings;
- Building ownership;
- Building HVAC lifecycle replacements;
- Building energy usage;
- Building square footage; and
- Land parcels.

The land use analysis was limited in nature, due to the lack of available data. To approximate energy consumption, first floor building footprint was mapped because this was the information available. In order to map this data, buildings footprints were used starting at 547 square metres. This size was selected because it is the smallest building footprint of users currently connected to the PSPC DES. Buildings between 547 and 1,000 square metres were grouped together, as 1,000 square metre minimums were recognized in the case studies as supportable for DES. Buildings between 1,000 and 5,700 square metres were grouped, as 5,700 square metres constitutes the mean building footprint of current PSPC DES users. A break at 11,400 square metres demonstrated twice the mean.

The analysis would have been strengthened by using actual building square footage. It is assumed that larger buildings, i.e. buildings with a large footprint or square footage, have higher energy demands, and this assumption formed the basis of analysis. It would be even more accurate to map heating and cooling demand specifically, instead of the proxy of building size, as the energy demand for heating and cooling is based upon the user, type of use, and building characteristics including building materials, age, and type of HVAC system. There may be opportunities for information sharing in the future to obtain data regarding energy usage from the utilities, as well as building size and usage from land assessments. Further analysis, similar to ESAP's feasibility study previously conducted for the Downtown, would then be needed to identify the likelihood of users willing to connect to the system. This would be dependent upon building compatibility for DES connection and timing of replacement of HVAC systems for existing buildings, in addition to the potential for new development, either infill or greenfield.

6.2 Supportive Land Use Policy

From the case studies and policy analysis, it was determined that supportive land use policies in the NCR include transit-oriented development areas, mixed-use areas, and secondary plans that encourage a high concentration of buildings and users and/or tall buildings, as shown in Figure 1 and Appendix D.

6.2.1 Ottawa Official Plan High Density and Mixed-Use Nodes

The City of Ottawa's Official Plan (OP) Schedule B identifies several areas as "mixed-use" nodes and corridors, shown in Figure 1. These are areas that have been identified as strategic locations on the City's rapid-transit network and lie adjacent to major roads. They act as focal points of activity, both within their respective communities and within the larger municipal structure. Moreover, these areas are important as they represent the places where the City is expecting and encouraging higher density and a mix of commercial and residential uses. In the context of our study area, these areas include Tunney's Pasture, Confederation Heights, the Preston Street corridor, and the University of Ottawa Lees Campus area. The lands identified in the Official Plan are subject to certain increased standards and requirements relative to the rest of the City, including but not limited to:

- A minimum built-out job density exceeding 5,000 jobs per mixed-use area;
- The mandatory creation of a Community Design Plan prior to development;
- Mandatory medium or high-density minimums for all residential development;
- Mandatory highest-density nodes within 400 metres of transit stations; and
- Mandatory implementation of active transit principles beyond what is otherwise required

6.2.2 Ottawa and Gatineau Transit Oriented Development

The City of Ottawa has prioritized high density mixed use development surrounding transit stops. The City of Ottawa's OP contains policy supporting improved urban design and land use intensification in areas near rapid transit stations, with residential and mixed-use development permitted up to 30-storeys, or 90 metres, and a minimum permitted density of 350 residential units per net hectare. While these density figures and height maximums range between station areas depending on the relevant secondary plans, they are all supportive of upzoning lands within a 600 metre radius of the station relative to other surrounding areas. The target density range is approximately 200 to 400 combined jobs and residents per gross hectare within each Transit-Oriented Development (TOD) area.[1]

The *Plan d'Urbanisme de la Ville de Gatineau 2012*, also promotes TOD areas, which are defined as a 700-metre radius from each of their Rapibus stations. While none of these stations are in immediate proximity to the downtown Hull area where the National Printing Bureau (NPB) CHCP is located, this intensification strategy is still worth noting for how it may potentially induce development further away from the current DES network. Development within this 700-metre radius has been upzoned relative to other areas in Gatineau in order to allow for greater densities and mixes of use in the areas immediately abutting these stations.

6.2.3 Ottawa Secondary Plan Areas

The City of Ottawa's OP contains many secondary plans, some of which pre-date amalgamation and others that have been developed since the unified City of Ottawa was created in 2001. All secondary plans within the City of Ottawa's core area were reviewed, with a focus on determining how supportive each plan was for expansion of district energy. The total number of plans reviewed was 16, which are listed in Table 1 as either containing policies supportive or unsupportive of the land uses necessary for successful DES expansion. The policies deemed unsupportive were mostly due to the distance between the plan area and the existing DES. Many also lack the requisite density and energy demand to successfully support the DES in the early stages of expansion. Many of these plans also prioritize preserving the existing character of the neighbourhoods they regulate, and few provided infill at a scale that would create a proper energy demand for DES. All of these secondary plan areas, both supportive and unsupportive, along with the community design plan areas, transit areas, and mixed use policy areas, are shown in Figure 1 and Appendix D relative to the existing and planned DES infrastructure in the NCR.

Out of all of these individual plan areas, it was determined that six were supportive of mixed use and high density in the specific areas near the district energy piping, including the Central Area Secondary Plan, the Centretown Secondary Plan, Scott Street Secondary Plan, NCC LeBreton Flats vision, Tunney's Pasture Master Plan, and Confederation Heights Secondary Plan. It is generally assumed that these policy areas would be supportive of the density and mix of uses required to support DES. These plans primarily dictate the density and scope of development, are all TOD focused, except for parts of Centretown, and set radii of 600 metres from major transit stations that permit greater levels of intensification.

Supportive Plans	Unsupportive Plans
• Central Area Secondary Plan • Centretown Secondary Plan • Scott Street Secondary Plan • Confederation Heights Secondary Plan • Tunney's Pasture Master Plan • LeBreton Flats Area Plan	• Alta Vista/Faircrest Heights/Riverview Park Secondary Plan • Bayview Station District Secondary Plan • Carleton Heights Secondary Plan • Hurdman Secondary Plan • Montreal Road District Secondary Plan • Old Ottawa East Secondary Plan • Preston-Champagne Secondary Plan • Richmond Road/Westboro Secondary Plan • Riverside Park Secondary Plan • Tremblay, St. Laurent, and Cyrville Secondary Plan • Wellington Street West Secondary Plan

Table 1: The Secondary Plans of Ottawa sorted as either supportive or unsupportive of the land uses necessary for successful DES expansion.

The supportive policy areas were further refined by excluding areas without the potential for continuous connectivity with the DES piping within supportive policy areas (i.e. no leap frogging between areas). A short list of supportive policy areas was created, as shown in Figure 2 and summarized in Table 1. These areas include the Scott Street Secondary Plan, Tunney's Pasture Master Plan, Bayview Station Secondary Plan, Rendezvous LeBreton Master Plan, Central Area, and Centretown. Although Confederation Heights allows tall buildings and is a TOD area, it was not included in the map, due to the isolated nature of the DES network in relation to known development pressures.

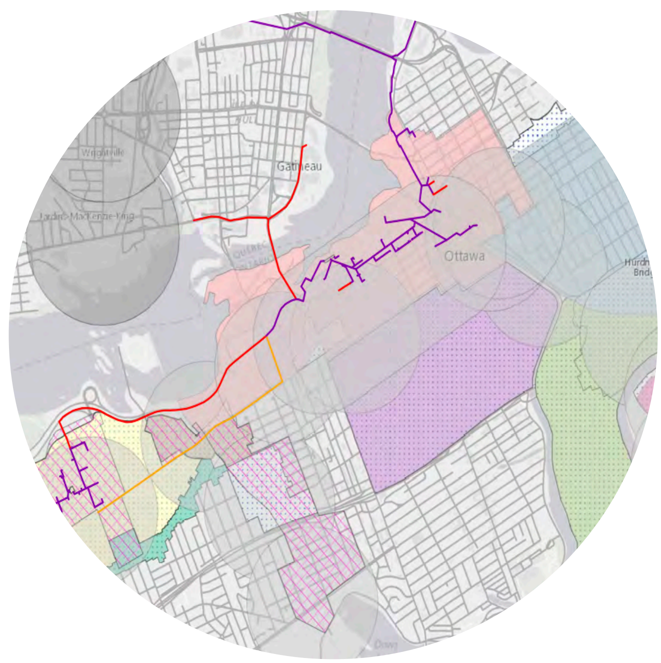


Figure 1: This map shows all of the transit areas, mixed use policy areas, secondary plan areas, and community design plan areas relative to the existing and proposed PSPC DES infrastructure (full map in Appendix D).

Location	Secondary Plan	TOD	Mixed Use Supportive	Tall Buildings	High Building Concentration
Downtown	**Central Area Secondary Plan**	✓	✓	✓	✓
Sparks Street Spur	**Centretown Secondary Plan**	Partial	✓	Partial	✓
Tunney's Pasture	**Scott Street Secondary Plan**	✓	✓	N/A	N/A
Tunney's Pasture	**Tunney's Pasture Master Plan**	✓	✓	✓	✓
LeBreton Flats	**Central Area Secondary Plan**	✓	✓	✓	✓
Confederation Heights	**Confederation Heights Secondary Plan**	✓		✓	

Table 2: A summary of the characteristics of the policies deemed supportive of DES expansion.

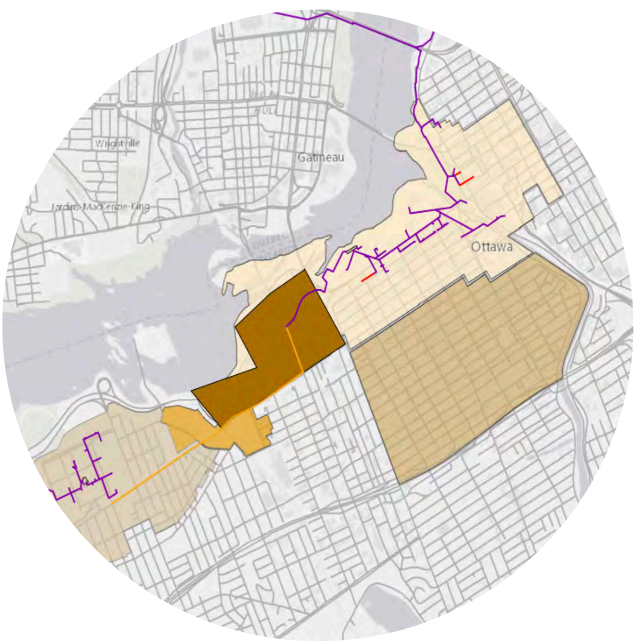


Figure 2: This map shows policy areas deemed supportive of DES expansion included in Table 2 (full map in Appendix D).

6.3 Supportive Built Environment

The second part of the land use analysis included the identification of supportive built environments within the area identified in Section 6.2 - Supportive Land Use Policy. Because connection to DES is considered at two development stages, which are at time of building for new construction and at time of undertaking HVAC system upgrades at the end of their lifecycle or redevelopment stage for existing buildings, potential growth areas for new development and existing clusters of large buildings for existing development were identified.

Supportive built environments, for the purpose of this analysis, were areas closest to the DES piping that contained a high concentration of buildings with building footprints equal to or larger than existing users, and areas with anticipated growth that is expected to produce a high concentration of buildings.

6.3.1 Potential Growth Areas

Areas where it is likely for new construction to occur based upon known large developments were identified, which is shown in Figure 3 and in full, in Appendix D. These large developments are discussed in further detail in Section 1.2.2.2 - New Development. Based on the SWOC analysis, there are various challenges to growing the client base in these locations, which are summarized in Table 3. Zibi is providing their own DES and therefore, would not require outside heating and cooling services. LeBreton Flats has significant potential. There have been discussions of providing both heating and cooling services to this development by the PSPC DES, which is something the developer of LeBreton Flats has identified as necessary for the connection to be possible. However, timing of service availability is crucial to coordinate with timing of new construction, and any construction that occurs before DES connections are available will likely be lost as a potential client until end-

Figure 3: This map shows identified new development areas (full map in Appendix D).

of-lifecycle system upgrades are required. The evaluation of potential growth areas demonstrates that, in addition to supportive land use policy and built environment, coordination with stakeholders is vital to expanding the client base, as there are a multitude of factors that determine a client's interest to DES connection. Tunney's Pasture and LeBreton Flats are considered to have good potential for expanding the client base, dependent on the availability and capacity of cooling services.

Area	Mixed Use	High-Rise	Supportive Client Base	Potential for Expanding Client Base	Challenges
LeBreton Flats	Yes	Yes	Conditional upon cooling availability	Conditional	Timing; Planned pipes do not include cooling system
Zibi	Yes	Yes	No	Poor	Developing their own private DES
Tunney's Pasture	Yes	Yes	Unknown	Good	Capacity of existing cooling system; Multiple owners

Table 3: A summary of the characteristics and challenges of the identified new development areas.

6.3.2 Existing Buildings

The second priority after new development is the opportunity for "infill" development of the DES when buildings currently abutting the network reach the point in their life-cycle when they must completely upgrade their heating and cooling systems. Engaging with private interests in high-energy use industries or buildings about connecting to the DES during these lifecycle projects will become a crucial element of expanding the user base.

An evaluation of existing buildings with a minimum footprint equal to or greater than the smallest current DES user visually reveals areas with concentrations of large buildings, which is mapped in Appendix D. This analysis revealed that the greatest concentration of large buildings is found in Place du Portage in Gatineau, downtown Ottawa, and the Byward Market within the Central Area, a stretch along Bank Street and Elgin Street into Centretown, Carleton University, University of Ottawa, and various business parks. Although, there is a concentration of large buildings, each area has its own challenges and potential client base for supporting DES, as summarized in Table 4. For example, within Ottawa's business parks, these areas were not located close to the DES system and did not provide opportunities for a mix of uses. Areas with a high concentration of large buildings within identified supportable policy areas are shown in Figure 4.

Area	Mixed Use	High-Rise	Supportive Client Base	Potential for Expanding Client Base	Challenges
Central Area	Yes	Yes	Yes - Federal buildings and feasibility study	Good	Building compatibility and heritage
Bank Street Spur	Yes	Yes	Unknown	Good	Building compatibility, heritage
Elgin Street Spur	Yes	Yes	Unknown; Municipal buildings would require renewable energy	Good	Renewable energy required for municipal buildings to connect
Place du Portage	Yes	Yes	Yes – Federal buildings	Poor	Low electricity costs in Québec; limited new development in area
Business Parks	No	No	Unknown	N/A	Not close to pipes and no mix of users
Carleton University	Yes - Student Residences & University Buildings	Yes	Unknown	Fair	Limited expansion potential to other users
University of Ottawa	Yes	Yes	No	Poor	Operates own system; seeks to remain independent

Table 4: A summary of the characteristics and challenges of the identified areas with a high concentration of large buildings.

Figure 4: Map of the large buildings within the policy areas deemed supportive of DES expansion (full map in Appendix D).

To provide further depth to the analysis, the density of buildings within secondary planning areas were documented, as summarized in Table 5. Because the secondary planning areas are large and include areas such as open space, parks, and natural features, the concentration of buildings for the area as a whole is less than what is considered to be supportable for DES. A building concentration of 55 buildings per hectare has been identified as a minimum standard for supporting district energy in a previous study.[2] This demonstrates that further analysis within supportable secondary planning areas is required to identify target areas with appropriate concentrations of buildings. To benefit from users with high energy demands, targeting areas with the highest percentage of large buildings would be beneficial.

Secondary Plan	Hectare	Large Buildings	Total Buildings	% of Large Buildings	Large Buildings per Ha	Buildings per Ha
Montreal Road	19.14	59	460	13%	3.08	24.03
St Laurent TOD	120.47	36	497	7%	0.30	4.13
Tremblay TOD	100.94	30	63	48%	0.30	0.62
Sandy Hill	182.89	114	494	23%	0.62	2.70
Central Area	299.75	180	547	33%	0.60	1.82
Old Ottawa East	162.84	32	2159	1%	0.20	13.26
Alta Vista/Faircrest/Riverview	690.20	91	6876	1%	0.13	9.96
Bank Street	93.09	56	267	21%	0.60	2.87
Riverside Park	424.76	40	3150	1%	0.09	7.42
Carleton Heights	295.80	50	3033	2%	0.17	10.25
Confederation Heights	200.00	16	118	14%	0.08	0.59
Preston-Champagne	37.38	24	354	7%	0.64	9.47

Secondary Plan	Hectare	Large Buildings	Total Buildings	% of Large Buildings	Large Buildings per Ha	Buildings per Ha
Bayview	30.13	15	57	26%	0.50	1.89
Scott Street	30.13	40	1849	2%	1.33	61.37
Centretown	212.02	222	2919	8%	1.05	13.77
Richmond Road	270.85	91	2258	4%	0.34	8.34
Wellington Street West	27.94	44	364	12%	1.57	13.03
Hurdman TOD	67.53	10	52	19%	0.15	0.77

Table 5: Building concentrations within Secondary Plans

Key Priority Areas for DES Expansion in the NCR

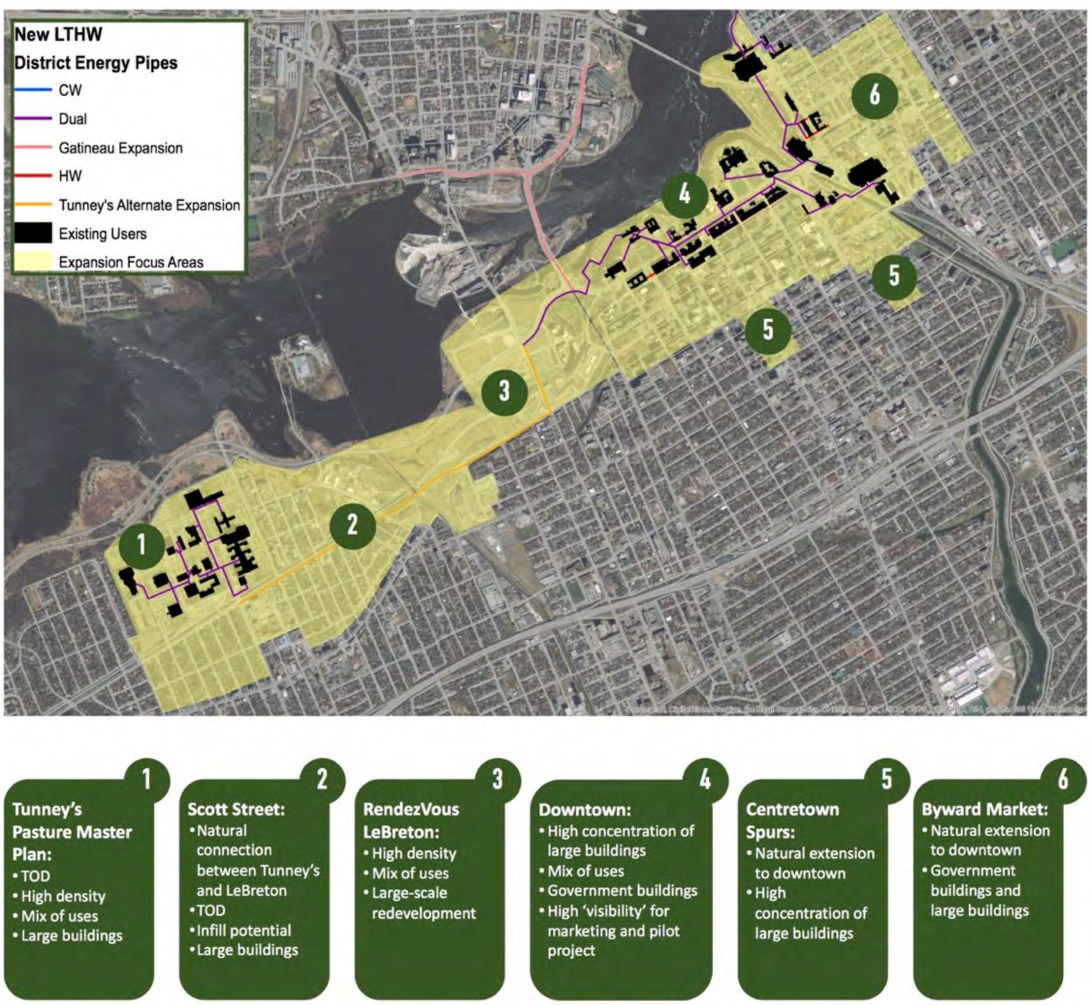


Figure 5: Key priority areas for DES expansion in the NCR as identified through the land use analysis from west to east, in no prioritized order (full map in Appendix D).

Area	Mixed Use	High-rise	Supportive Client Base	Potential for Expanding Client Base	Challenges
Central District	Y	Y	Y - Federal buildings and feasibility study)	Good	Building compatibility and heritage
Sparks Street Spur	Y	Y	Unknown	Good	Building compatibility, heritage
Elgin Street Spur	Y	Y	Unknown; Municipal buildings would require renewable energy	Good	Renewable energy required for municipal buildings to connect
LeBreton Flats	Y	Y	Y – if cooling in addition to heating is supplied	Good	Timing
Tunney's Pasture	Y	Y	Y	Good	Capacity of existing cooling system; Multiple owners

Table 6: A summary of the key characteristics and challenges of the key priority areas for the expansion of the PSPC DES in the NCR.

6.4 Discussion

There are several considerations in evaluating where efforts to expand the client base should be focused for the PSPC DES. This land use analysis has identified areas with land use policy that supports general considerations of district energy, including a mix of uses and compact built form. It has also identified potential users for new and existing development, generally. However, further analysis is required to provide comprehensive recommendations of potential users to target. As mentioned previously, an analysis with energy demand information, rather than solely building footprint, would be the most accurate. An alternative to energy demand is the identification of buildings by square footage to assess multi-storey buildings. In addition to these general users, lessons learned from the case studies demonstrate the importance of identifying anchor users and coordinating with stakeholders. Within the context of this DES, a phasing strategy for expanding the client base is required, as there are other factors for consideration. Further actions and studies required include:

Preparation Stage

- Identification of Federal buildings near DES, including expected timing of lifecycle upgrades and compatibility with DES
- Incorporation of stakeholders into dialogue to overcome barriers like limited servicing in LeBreton Flats, timing of construction, and benefits of the alternate route connection
- Knowledge sharing with stakeholders to collaborate on making new development or redevelopment 'district energy ready'

Planning Stage

- Heating and cooling demand mapping, based on building square footage and usage assumptions or building energy consumption averages to identify most economical piping spurs
- Identification of anchor users, early adopters, and government partners within areas supportive of expansion
- Further studies to determine appropriate phasing of expansion based on user demand and plant capacity

6.4.1 Phasing

In terms of phasing expansion of the system, the greatest opportunity lies in ESAP's intent to connect Tunney's Pasture to the Cliff/NRC network, as well as to expand across the Portage Bridge to Place du Portage. These expansions provide the opportunity to connect some of the largest new developments occurring in the NCR, and it is at the new-build stage where connection to a DES is the easiest and most attractive for owners.

The LeBreton Flats development is situated along the proposed two routes for the Tunney's Pasture connection. This redevelopment represents a generational opportunity for ESAP to connect potentially an entire master-planned community. Should ESAP choose the expansion option that skirts along the LeBreton Flats lands instead of running through them, a spur line should still be run to the development. If this is not possible, infrastructure could at least be left in place that would easily allow such expansion in the future. Similarly, the Place du Portage expansion provides an opportunity for the DES to expand into the Gatineau market. While the economic situation in Québec with its cheap hydroelectricity makes it a more difficult market for the DES to compete in, there are still considerable amounts of future large-scale residential developments proposed just beyond Place du Portage. It should be noted that there is more concentration of proposed buildings on the Ottawa side in areas supported by transit, providing more opportunity for private users than in Gatineau. Should private users in Gatineau be targeted for connection, the price of electricity reduces the likelihood of connection to high-rise buildings with an economy of scale that makes DES financially viable. Priority must be given to the largest-scale development opportunities in the NCR. Since a mixed-use user-base is important for maximizing the efficiency of the DES, the residential components of the developments proposed for Tunney's Pasture and LeBreton Flats, in particular, present once-in-a-generation opportunities for developing the DES to its maximum potential.

Collaboration, in the near term, with stakeholders is essential to take advantage of these new development opportunities.

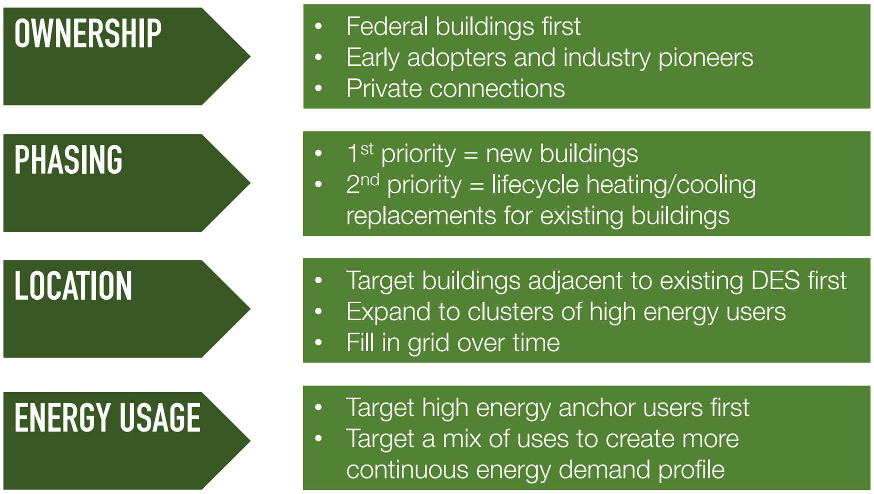


Figure 6: The four factors establishing the land use assessment framework.

6.4.2 Infrastructure Costs

One of the most significant limiting factors to expanding a DES is the cost associated with installing new piping. There are many large buildings and high energy users in the NCR, which are best suited for connection to the DES. However, the financial costs to connect to the system increase proportionally as the distance increases. The land use analysis, therefore, assumed that connections closest to the piping were preferred over connections that were further away. Furthermore, piping extensions that have the potential for multiple users is preferred to stand-alone building connections, with the exception for prime anchor users.

ESAP has previously undertaken a cost analysis for expanding their DES, from which they determined the all-in construction costs for installing new piping. Costs vary, depending on the associated plant and type of service being delivered. These costs are detailed in Table 7. In comparison, a feasibility analysis of developing a DES in Courtenay, British Columbia was assessed at approximately $1,200 per metre in 2017 dollars.

Plant	LTHW Options			
	Cool Water		**Hot Water**	
	Tunnel ($/m)	**Buried ($/m)**	**Tunnel ($/m)**	**Buried ($/m)**
Cliff/NRC	$5,353	$2,897	$4,189	$3,381
Tunney's Pasture	N/A	$3,172	N/A	$2,501
Confed. Heights	$4,170	$3,958	$2,776	$3,532
NPB	$3,028	$2,956	$2,337	$2,057

Table 7: The cost calculated per metre for installing DES piping in the NCR. The cost depends on both service being delivered and the associated plant.[3]

6.4.3 Ownership

The primary focus in terms of client ownership entails ESAP ensuring all federal buildings within the identified buffer area are connected to the DES. These connections present the easiest opportunity to quickly establish forward momentum with the project, since the connection of federal buildings to the DES is firmly supported by the existing federal policy. This also presents an opportunity to establish a pilot project wherein operating costs can be documented, and a governance model can be showcased. A major benefit in targeting federal buildings first is that these can act to test the functionality of the system. This provides an opportunity to identify any challenges that may exist in both converting the system to low temperature how water (LTHW) and in connecting individual buildings. Undergoing this test with federal interests allows for the development of best practices that can then be shared and applied when interests outside of the federal government are seeking to connect to the system. This will in turn make these new connections as seamless and easy as possible, further benefitting the reputation of the DES and increasing its appeal beyond the federal government.

By targeting federal connections, this will also allow for the ESAP team to build stronger connections with federal partners in other departments who may have private, provincial, or municipal contacts who have interest in connecting to the DES. These can in turn become the early adopters and industry pioneers outside of the federal government who act as a bellwether that further develops confidence in the system from the private market.

6.4.4 Anchor Users

The priority of anchor users entails connecting major energy users adjacent to the existing network. Substantial office towers and high-energy users are located near the existing network in the downtown core of Ottawa, such as the Rideau Centre and several landmark hotels, as well as several large institutional buildings in Gatineau. When undertaking further analysis, anchor users should be identified and targeted as high-priority potential clients, including government buildings. This will entail substantial marketing and outreach, for which the federal building pilot project can demonstrate success.

6.4.5 DES Compatibility

Another layer of analysis within expansion areas is identifying buildings that are compatible to be connected to the DES. In support of this initiative, further policy can encourage making buildings ‘district energy ready’ to ensure a breadth of potential clients. Additionally, lifecycles of current systems will determine when potential users will come online. This also requires appropriate timing, since during upgrades is the only opportunity beyond new construction when connections are likely to be contemplated. Key to the long-term success and further expansion of the DES is the capacity to bring private customers online and to remove barriers, such as building incompatibility with the DES. Although this is identified as in the planning stage, this kind of awareness marketing should be occurring concurrently with the preparation stage. This way, when ESAP finishes connecting all federal buildings, it will already have developed a group of private property owners interested in connecting and on its way to ensuring that buildings are ready for conversion to DES when the timing is right. The opportunity to connect to these users is also of the utmost importance to ESAP because it will allow for a significant diversification of the base load throughout the day, especially if hotels and shopping centres are willing to connect. Currently, the DES experiences peak demand during the 9-5 working hours, as it almost exclusively services federal office buildings. By introducing users with peak energy demands that occur off-peak, this will allow ESAP to maximize the efficiency of the DES when it would otherwise be underutilized.

6.5 Results

The land use analysis framework that has been built in this section began with the identification of areas with land use policies that encourage DES supportive development. This includes much of the downtown core including the west end of the Byward Market, Tunney's pasture, LeBreton Flats, the area surrounding Carleton University campus, and TOD nodes in downtown Gatineau and Ottawa (Figure 5). The supportive policy areas were then focused to those that would support a continuous expansion of the piping system, contained or are close to new development areas, and included areas with high concentrations of large buildings. This process identified key priority areas as follows:

- Downtown – including a portion of the Central Area and the Byward Market;
- Centretown spurs down Bank Street and Elgin Street;
- Scott Street;
- Tunney's Pasture Master Plan; and
- RendezVous LeBreton.

The main characteristics contributing to the selection of each of these priority areas, as well as the associated challenges, are summarized in Table 6. It is recommended that the initial efforts for growing the client base be focused within the areas of interest noted above as a starting point, with recognition, generally, of phasing, infrastructure costs, ownership, anchor users, and DES compatibility. More specifically, the challenges associated with each individual area must also be considered. All of the detailed maps for this analysis are included in Appendix D.

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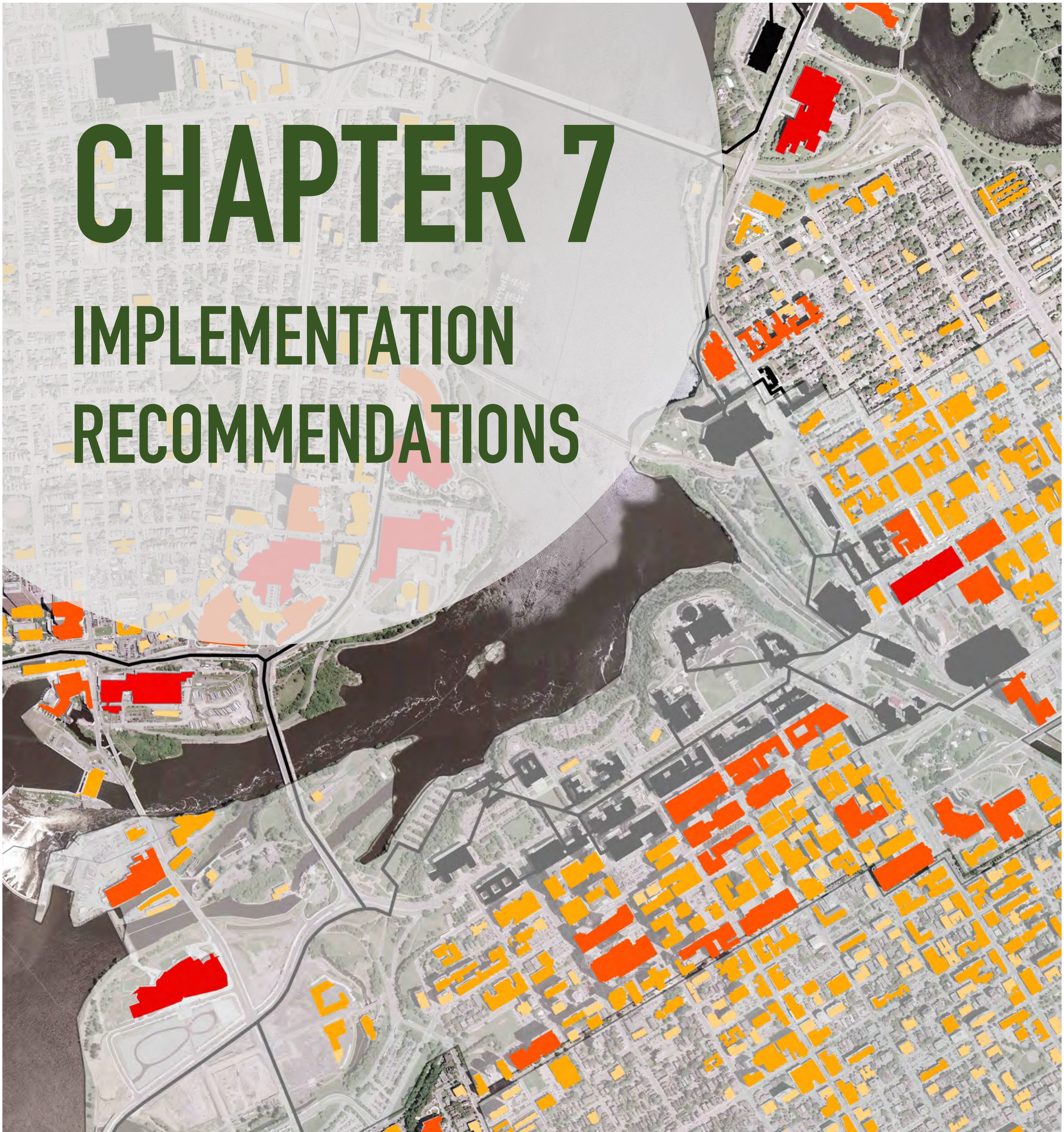
[1] City of Ottawa. (2014). Transit-Oriented Development (TOD) Plans. Retrieved from https://ottawa.ca/en/transit-oriented-development-tod-plans

[2] Energy Saving Trust. (2004). Community heating for planners and developers. Retrieved from http://www.communityplanning.net/pub-film/pdf/CommunityHeating.pdf

[3] FVB Energy (2016). "Feasibility Study for ESAP Technology Options: Final Report—2015 Base Cost Update—Revision 2".

CHAPTER 7

IMPLEMENTATION RECOMMENDATIONS



SURP 824 PROJECT COURSE

7.0 Implementation Recommendations: A Roadmap for Expansion

7.1 Overview

Based on the lessons learned from a comprehensive review of literature, case studies, and the urban context of the National Capital Region (NRC), this section of the report summarizes a number of recommendations generated for the expansion of the Public Services and Procurement Canada (PSPC) district energy system (DES). Whereas the earlier sections of this report survey themes of successful DES expansion and provide options based on land use analysis, the following recommendations are formatted as a roadmap setting out a long-term process for expansion.

Figure 1 and 2 displays an overview of the recommended steps for expansion. The three stages recommended for long-term expansion are:

- Preparation: including internal expansion and streamlining of the internal federal system and engagement with key stakeholders;
- Planning: including further analysis of conditions and the creation of a clear implementation strategy for expansion in the market; and
- Implementation: including the ongoing operation of the DES with an aim to continually expand and improve.

As an ultimate outcome, the DES in the NCR is envisioned as a sustainable and financially feasible product that delivers high quality service to clients while meeting the environmental goals of stakeholders.

7.2 Preparation

In the current state, the ESAP DES exists as a limited inward-facing service confined to federal buildings. To reach ambitious goals for expansion in the NCR, the system will need to transition into an outward-facing business with the organizational structure and capacity to deliver service to a range of clients external to the Government of Canada. The current state of the system represents a number of challenges given the shift needed to reposition as a public market entity. However, it also offers opportunities, including the existing infrastructure, strong staff expertise, and a long-term anchor tenant, being the federal buildings, which has the potential to grow further. The recommended first stage of expansion sets out two steps to leverage these opportunities to overcome challenges and prepare to introduce a DES that is well-equipped for sustainable expansion. These first two steps are: connecting federal buildings and engaging key stakeholders.

7.2.1 Connect Federal Buildings

As the first step, we recommend the connection of additional federal buildings and the streamlining of existing operations. At the time of this report's publication, the PSPC DES is connected to just over 80 buildings with a potential capacity to support approximately 23 additional buildings on its heating network after modernization of the interconnected system. Positioned in the core of the NCR, the Government of Canada owns a significant number of buildings within range of the existing DES service area, with public data noting over 1,500 structures nearby.[1]

This context represents a significant opportunity. The expansion of the current system to include federal building linkages to the maximum extent possible would offer two major benefits. First, this would allow for the establishment of a large and stable anchor client grid. Second, this would lead to the creation of a comprehensive pilot project to generate financial data and energy use metrics capable of proving the benefits of the system to future clients. If successful, the completion of this step would result in clear and accurate information demonstrating the environmental and economic benefits of connecting to the DES, effectively building public confidence and offering a basis for honest and effective marketing, as shown in Figure 1.

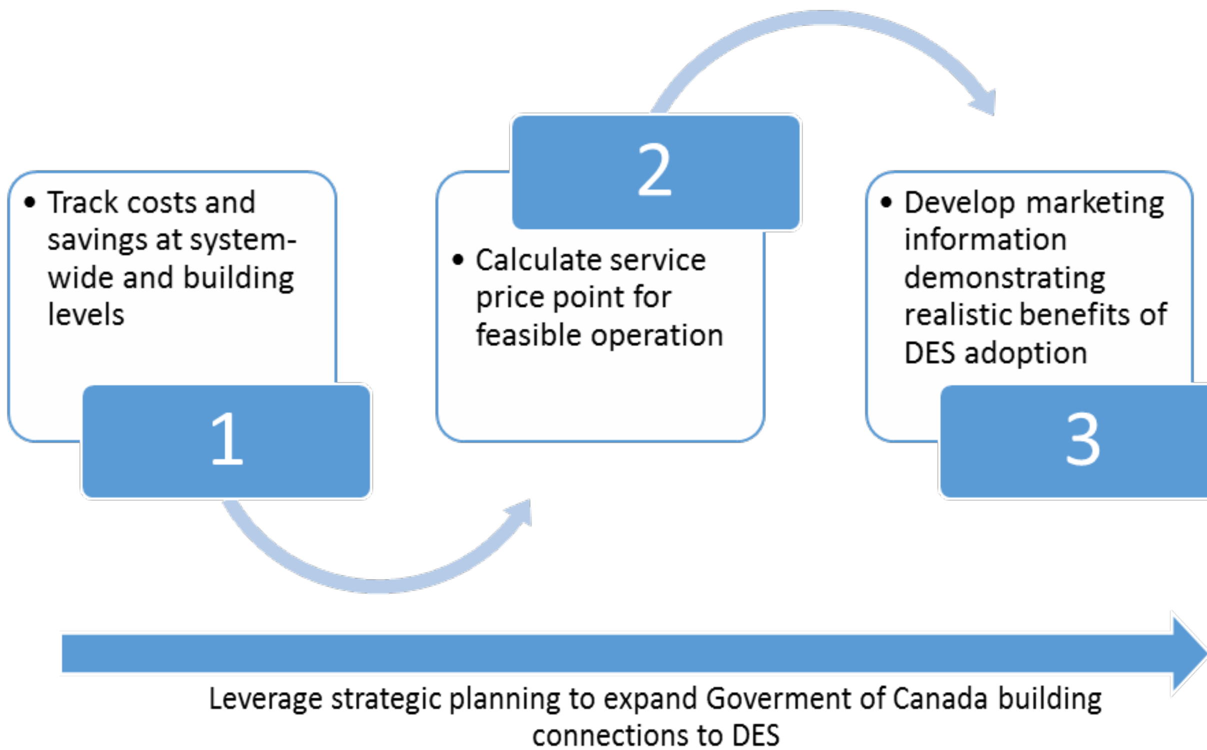


Figure 1: Strategic plan for DES expansion diagram.

Roadmap for Expansion

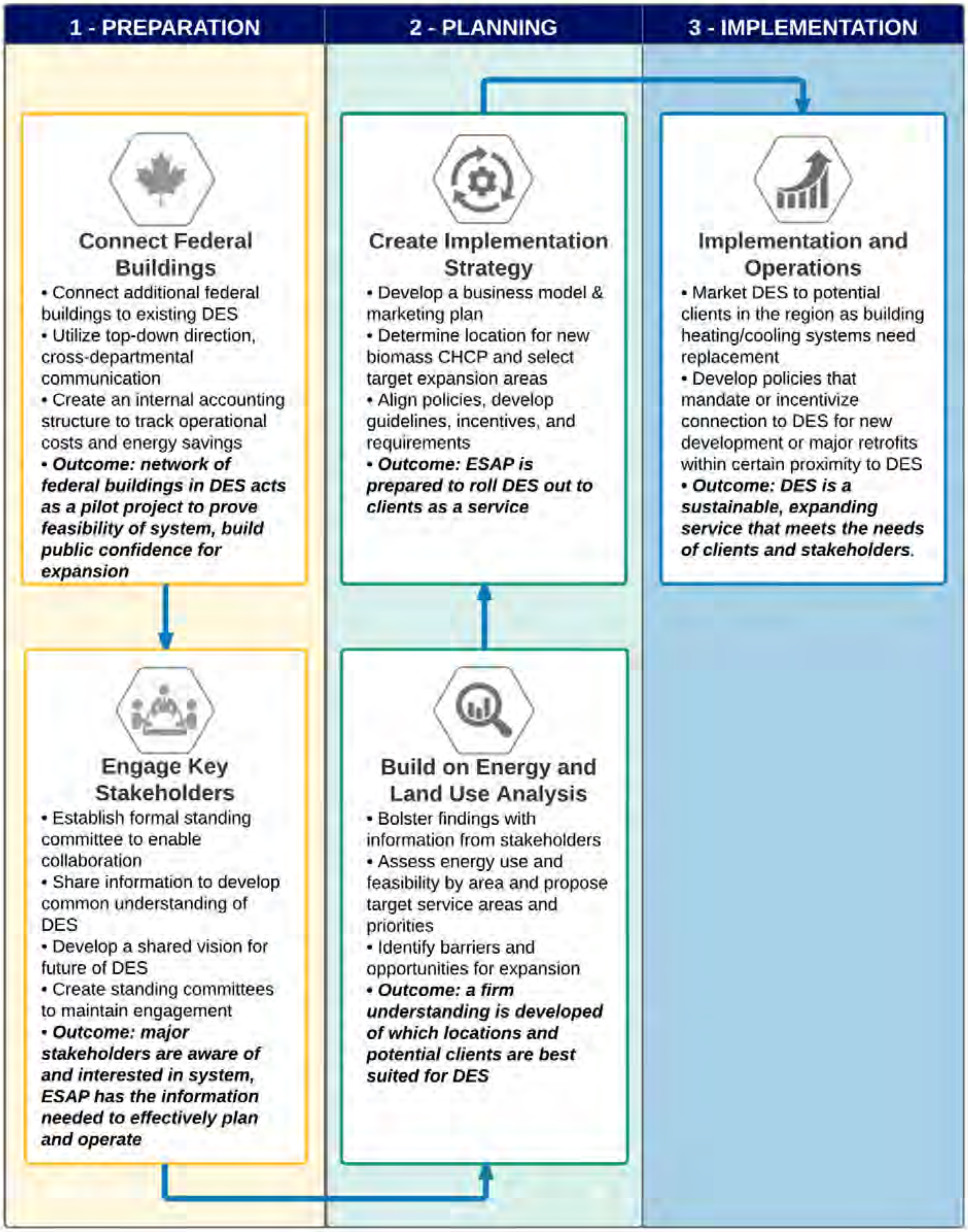


Figure 2: An overview of the recommended steps to be taken for a successful expansion of PSPC's DES.

In order to achieve this outcome, two key initiatives are required within Government of Canada operations. The PSPC DES needs to adopt a clear accounting structure that tracks operational costs and savings on both a system-wide and building-by-building basis. To expand the DES into external market service provision, ESAP will require a realistic idea of the price levels necessary to operate as a financially feasible business. On the flip side, prospective customers will require confidence in the benefits they stand to experience from connecting to the system. Once a transparent accounting structure is developed to track costs and savings, ESAP will be able to calculate a price point for financially feasible operations. This will allow for the development of marketing information that demonstrates the benefits of DES adoption, instilling public confidence in the system and attracting clientelle.

Alongside the establishment of a transparent accounting structure, we recommend that ESAP leverage top-down governmental direction to enable the connection of additional federal buildings. Given that the reduction of greenhouse gas (GHG) emissions and overall environmental footprint is a clear government-wide mandate, connection to the PSPC DES is a powerful opportunity that should be taken advantage of. While it may not be realistic to immediately transition all Government of Canada buildings within the service area given various lifecycle positions of heating and cooling machinery and equipment, a significant number may be good candidates. All new buildings planned for construction as well as those undergoing major rehabilitation work are obvious targets for system connection. In order to achieve this result, clear top-down direction will be required at a strategic level. By utilizing direction from a leader involved in multiple departments, such as the Treasury Board of Canada, and cross departmental communications at a strategic level, the Government of Canada stands to achieve a landmark example of environmental sustainability and cost savings.

Together, the expansion of Government of Canada building connections to the DES and the establishment of a clear and transparent accounting structure will result in a sustainable pilot system demonstrating a successful business model, which will be an attractive product to potential clients. The PSPC DES will be equipped with a stable, long-term anchor client comprising the federal building grid, as well as the information needed to instill public confidence in the benefits of the system and attract future clients from a wider market.

7.2.2 Engage Key Stakeholders

While the establishment of a financially feasible pilot system through Government of Canada building connections is a key step in laying the foundation of DES expansion in the NCR, it will not offer all the information needed for successful external market expansion. At the point of going to market, the PSPC DES will require significant buy-in from a range of stakeholders that transcends average product marketing given the large investment and significant policy changes necessary to enable connection. These stakeholders do not solely include potential clients. Policy shifts at the provincial and municipal levels as well as promotion from environmental and business-related non-governmental organizations can be integral to ensuring operational success. Serious and ongoing engagement efforts are necessary to achieving these goals and ensuring a successful market expansion. The current Ministerial Mandate letter for PSPC provides support for such efforts, urging “meaningful engagement” with stakeholders “including business, organized labour, the broader public sector, and the not-for-profit and charitable sectors".[2]

In order to carry out meaningful engagement, we recommend the creation of a formal standing committee to help guide DES expansion efforts. The creation of a formal committee would lend credibility to the process, helping to build stakeholder confidence and attract participants. Furthermore, the establishment of a formal committee creates the opportunity to ensure the confidentiality of information shared in the process. As the honest and transparent sharing of information is integral to developing a cohesive and effective plan for DES expansion, developing a medium to carry out this process without concerns regarding public disclosure or conflict of interest is a valuable opportunity. The Government of Canada has a long history of similar stakeholder engagement with diverse stakeholder committees, such as the Supplier Advisory Committee within PSPC.

It is vital to include a wide range of stakeholders in the process in order to best establish a collaborative framework for DES expansion. Potential stakeholders range from municipal and provincial governments, to potential private sector clients, to advocacy and program delivery non-governmental organizations. While the goals and interests of these organizations are disparate, it is essential that all stakeholders are brought to the table and afforded an opportunity to share perspectives and provide input on system expansion. DES expansion is a unique issue in that it offers the opportunity for true win-win results transcending governmental, non-governmental, and industry needs. As demonstrated through case studies, a well-functioning DES has the potential to achieve ambitious environmental goals and alleviate social issues, while simultaneously offering cost savings attractive to private sector and governmental building owners and operators, alike. By bringing a diverse cross-section of stakeholders together for meaningful engagement, it is possible to develop a shared vision to achieve these goals, resulting in a compatible and streamlined policy environment, strong public confidence and awareness, and an expansive roster of potential future clients.

While the creation of a steering committee to guide the high-level planning of DES expansion is a vital step at the outset of the process, continual engagement is recommended to maintain the collaborative and transparent flow of information between ESAP and the involved stakeholders. Case studies of successful DES expansions have proven the value of continual engagement with sub-committees for ongoing tasks, such as implementation and operations, as well as the value of public engagement for ongoing success. The creation of such committees can aid in overcoming challenges, innovating to higher levels of success, and building public confidence in the program. For example, ongoing partnership between the DES manager, industry, and municipal governments can lead to the creation of innovative land use policies that make DES adoption both more financially attractive and successful in reaching environmental targets. Partnerships with non-governmental organizations can also prove fruitful, with environmental organizations assisting in promoting the value of the program to the public, and industry associations promoting to potential private sector clients.

7.3 Planning

By the completion of the preparation stage of DES expansion, ESAP should have a well-functioning grid that services federal buildings, a strong accounting structure providing a realistic service price point for sustainable operations, and a clear vision for expansion developed in collaboration with project stakeholders. These factors form the foundation for actual implementation of an external-facing DES that is equipped for expansion. Recommended actions in the second stage will build upon this foundation to create a detailed action plan to guide the full market roll-out of the system. It aims to turn the high-level strategic planning and preparation of stage 1 into a concrete plan for implementation. Two initiatives are included in stage 2: building upon existing energy and land use analyses to identify specific areas and clients for expansion, and establishing a business strategy to guide ongoing operations.

Factors for targeting clients for DES:

OWNERSHIP
- Federal Buildings First
- Early adopters and industry pioneers
- Private Connections

PHASING
- 1st Priority = new buildings
- 2nd Priority = lifecycle heating/cooling replacements for existing buildings

LOCATION
- Target buildings adjacent to existing DES first
- Expand to clusters of high energy users
- Fill in grid over time

ENERGY USAGE
- Target high energy anchor users first
- Target a mix of uses to create more continuous energy demand profile

Figure 3: The four factors establishing the land use assessment framework.

7.3.1 Build Upon Energy and Land Use Analysis

Section 6.0 - Land Use Analysis of this report provides a number of detailed options for expansion based on the decision-making factors listed in Figure 3. Using currently available information, we have established a ground level framework to identify opportunities for targeted expansion in this report (Figure 3). Through information gained from stakeholder engagement and the internal restructuring and expansion in the recommended preparation stage of the expansion process, this framework will have the potential to be developed into a much more comprehensive analysis targeting specific buildings and building owners as clients as shown in Figure 4.

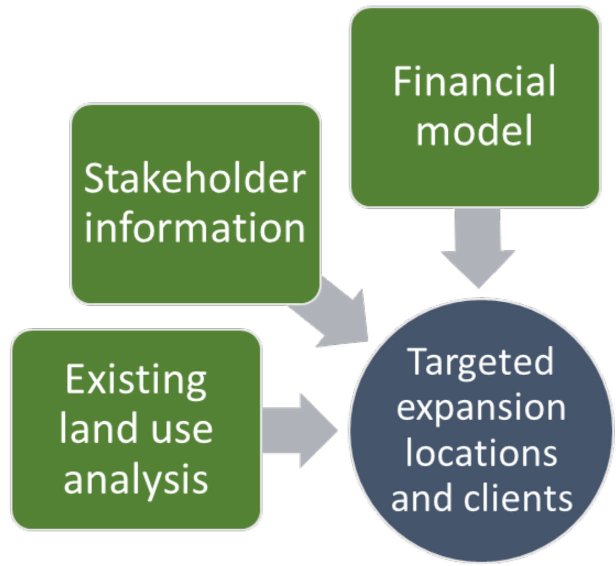


Figure 4: Recommended inputs to target expansion locations and clients.

As a first step, we recommend that ESAP consolidate all the information gained from municipal and private stakeholders regarding energy use and building lifecycle stages to bolster existing analyses. Then the findings should be combined with the financial model previously developed based on accounting methods for the federal building grid. This information will provide a clear image of the areas that stand to gain the most financially and environmentally from expansion, and the operational cost of this expansion.

7.3.2 Create Implementation Strategy

We recommend that a clear action plan in the form of an implementation strategy be created to guide the rollout of the DES to external clients. This step involves three key initiatives: aligning policies at the federal, provincial, and municipal levels; determining final locations for physical plant expansion; and establishing a marketing strategy and sales model. As an end result, ESAP should have an effective and efficient business plan containing clear organizational goals and milestones needed to ensure a successful market entry (Figure 5).

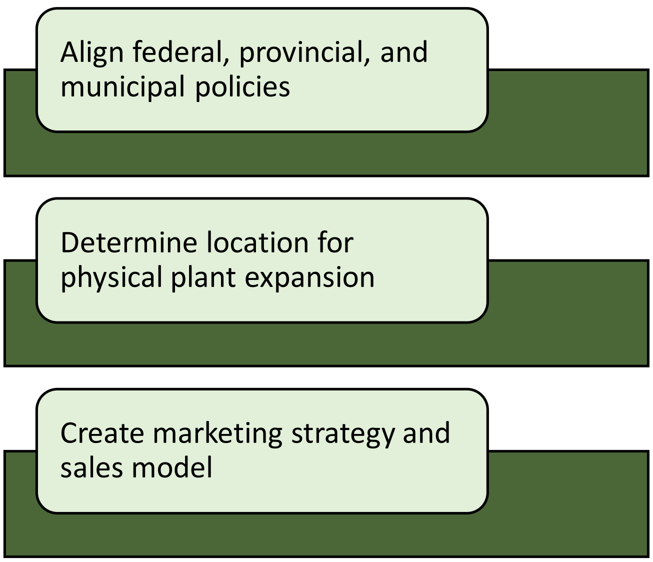


Figure 5: Three key initiatives of the recommended implementation strategy.

Throughout the stakeholder engagement process, it is imperative to share policy roadblocks and opportunities that may impact DES expansion. For example, municipal land use policies have the capability to make or break a system by defining density levels and a mix of uses that either promotes DES success or hinders it. Additional tools such as density bonuses or mandatory connection requirements can also be instrumental in success. We recommend that ESAP continue to maintain a formal working relationship with provincial and municipal representatives through this stage to identify areas of policy alignment necessary to overcome roadblocks and seize opportunities.

In addition, locations will need to be selected for physical plant expansion. This includes the placement of the planned biomass central heating and cooling plant (CHCP) and any potential future plants that may be warranted through future expansion. The location of these facilities should be targeted based on the planned expansion areas identified through bolstered land use and energy analyses, with specific care taken to ensure they are well-suited to providing service that maximizes financial feasibility and environmental benefit.

Alongside this implementation planning, we recommend that ESAP create a clear marketing strategy and sales model. This step is a natural continuation of earlier efforts to define feasible price levels and identify potential clients. ESAP should leverage the information gleaned from stakeholders and the financial information gained from internal accounting efforts to create a strong marketing message promoting the ability for DES adopters to save money while protecting the environment. It is important to view the DES service at this step as a business; in order to attract clients, an easily accessible sales model is required for consumers to learn about the product, seek additional information, and request connection. At this step, the DES will be in direct competition with alternative heating and cooling providers, so effective business practice will be integral to successful expansion.

7.4 Implementation

The final stage of DES expansion is ongoing implementation and operations. By this point, ESAP should have a financially feasible business model, a comprehensive base of information targeting key areas and clients for expansion, and a clear implementation strategy to roll out service to the market. The theme of operations at this stage is therefore continual improvement. We recommend that ESAP take two key steps at this stage to enable continual expansion and sustainable operation: the ongoing targeting of potential clients based on building lifecycles, and a constant aim to improve system operations through innovative policy measures.

As mentioned routinely throughout this report, the most effective points at which to target clients for DES adoption are at either new construction or when heating and cooling machinery and equipment is due for replacement at the lifecycle stage of the building. In order to maintain continual and sustainable expansion, ESAP should create a database system to track potential future clients based on lifecycle dates. Given that much of this information is not publicly available, leveraging stakeholder engagement processes to present DES adoption as a win-win scenario for building owners and operators is a key priority. In a best-case scenario, ESAP will have access to building information from both the City of Ottawa and Ville de Gatineau, along with major property holders within or near to the DES service area. With that information, targeting clients based on upcoming building improvements will be a simple process.

Alongside continual marketing based on stakeholder information, we recommend that ESAP work with other levels of government to promote ongoing innovation in policy that can improve DES operations. These can range from the aforementioned land use policies at the municipal level, to environmental incentives at the provincial level, to grants and incentives provided by the Government of Canada. Regardless of the step, ongoing policy coordination is required to ensure efficacy of initiatives. For this reason, we recommend that stakeholder engagement is an ongoing process through a standing committee to maintain lines of communication and share future plans.

Altogether, the desired outcome at this stage of expansion is the ability for the PSPC DES to continually expand and operate with financial feasibility and increasing environmental benefit. By leveraging internal capacity, stakeholder information, and information from detailed analysis, DES in the NCR can take the form of a collaborative initiative that meets the needs and goals of governments, private sector interests, and non-governmental organizations, alike.

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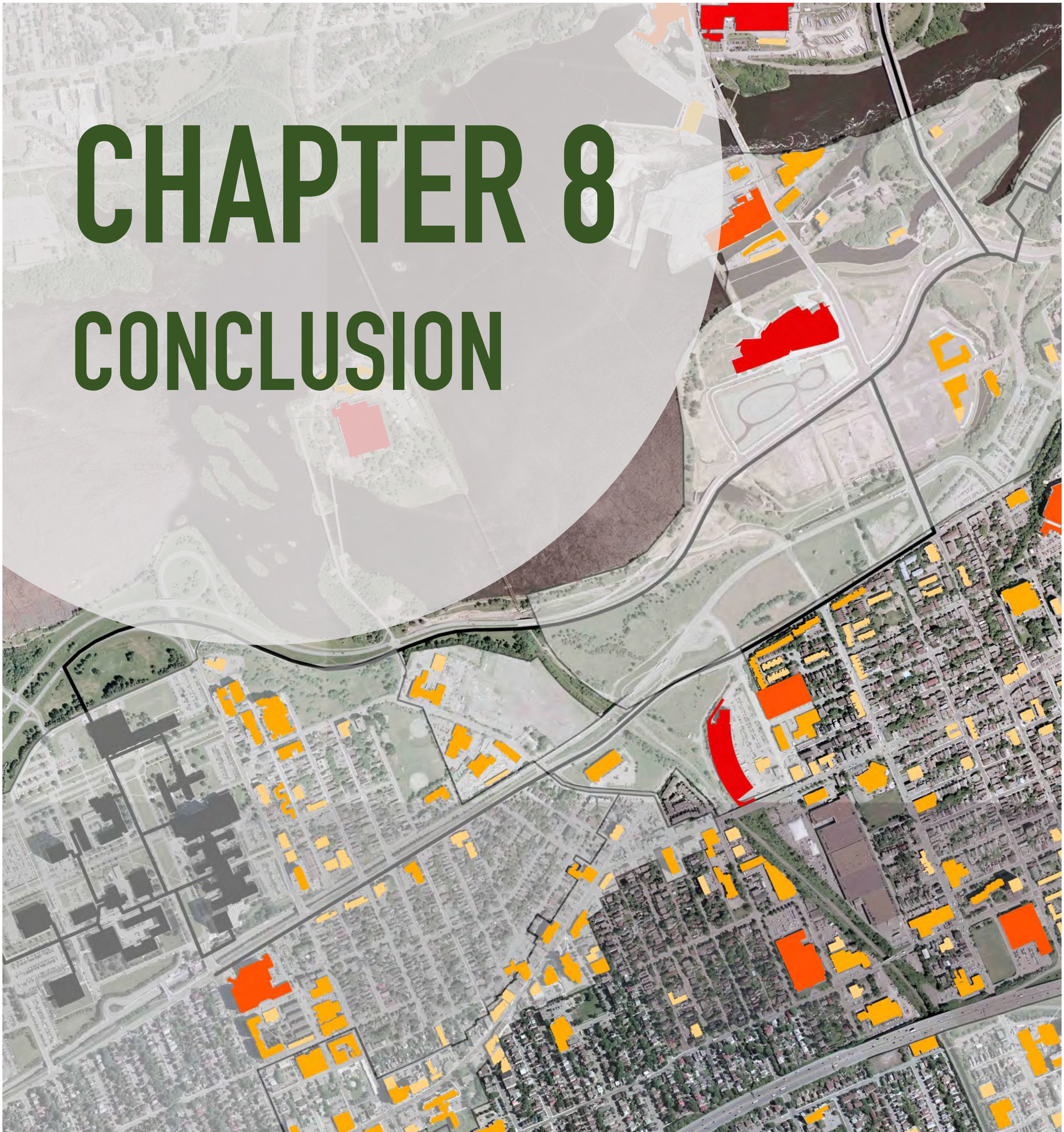
[1] Treasury Board of Canada Secretariat (n.d.). "Directory of Federal Real Property". Retrieved from https://www.tbs-sct.gc.ca/dfrp-rbif/home-accueil-eng.aspx

[2] Office of the Prime Minister. (2017). "Minister of Public Services and Procurement Canada Mandate Letter (October 4, 2017). Retrieved from https://pm.gc.ca/eng/minister-public-services-and-procurement-mandate-letter

CHAPTER 8

CONCLUSION



SURP 824 PROJECT COURSE

8.0 Conclusion

Over the course of this project, the team built upon the work of the Energy Services Acquisitions Program (ESAP) by examining the governance and stakeholder context of the region, exploring best practices from around the world, and examining growth and land use planning policies impacting the future expansion of district energy in the National Capital Region (NCR). From these analyses our team developed: (1) A framework for future land use analyses; (2) A series of 35 lessons learned for district energy system (DES) infrastructure expansion and planning, client growth, and future governance; (3) A series of six specific priority areas for DES expansion in the NCR; and (4) A roadmap for how to transition from an inward facing DES model to an outward facing and expanding business.

There is much work to be done to ensure the successful expansion of the DES in the NCR, but we believe that it is possible to both expand the physical infrastructure as well as the client base if the recommendations of this report are followed. Key to successful expansion is the need to build confidence in the system and its management, longevity, and benefit to all stakeholders. This will require collaboration between all levels of government as well as private and non-governmental sectors to identify common needs and aspirations for the system prior to expansion. With the support of all stakeholders, Public Services and Procurement Canada (PSPC), through their ESAP, will have access to more information and be able to incorporate the DES as a component of city building in the region.

As noted throughout this report, there are several timely decisions that must be made if ESAP wishes to utilize several existing opportunities, such as the redevelopment of LeBreton Flats. As such, we believe that much of the groundwork and policy development for connecting to such opportunities must begin during ESAP phase 1. It is during this time that ESAP should also be seeking to collect as much information as possible to round out the analyses contained in this report and to begin to develop a system for communicating this information to future clients.

DES expansion in the NCR will not happen overnight, but with careful planning and governance, we believe that a system expansion is feasible. ESAP is well placed to take the initiative and bring all stakeholders together to build a governance model and a DES that will be a source of national pride.

Figure 1: Parliament Hill in the National Capital Region.[1]

[1] Parliament Hill in the National Capital Region. Retrieved from https://www.tripcentral.ca/cheap-flights_00_04_XX_ottawa.html

APPENDICES

SURP 824 PROJECT COURSE

Appendix A: Acronyms

This appendix acts as a summary of the common acronyms used throughout this report.

Acronym	Full Meaning
CHCP	Central Heating and Cooling Plant
DES	District Energy System
ESAP	Energy Services Acquisition Program
GHG	Greenhouse Gas
HTHW	High Temperature Hot Water
LTHW	Low Temperature Hot Water
NCC	National Capital Commission
NCR	National Capital Region
NPB	National Print Bureau
OP	Official Plan
PSPC	Public Services and Procurement Canada
TOD	Transit-Oriented Development
P3	Public-Private Partnership
CEPS	Constellation Energy Projects and Services Group
PEI	Prince Edward Island, Canada
BMDEU	Burnaby Mountain District Energy Utility
CEP	Community Energy Plan
SWOC	Strengths, Weaknesses, Opportunities, and Challenges

Acronym	Full Meaning
LEED	Leadership in Energy and Environmental Design
SURP	School of Urban and Regional Planning
CMHC	Canadian Mortgage and Housing Corporation
LRT	Light Rail Transit
CPCU	Compagnie Parisienne du Chauffage Urban
RFP	Request For Proposals
ETS	Energy Transfer Station
SFU	Simon Fraser University
AH&P	Aberdeen Heating & Power company
GIS	Geographic Information System
HVAC	Heating, Ventilation, and Air Conditioning
LTVP	Long-Term Vision Plan (for the Parliamentary and Judicial Precinct)
FLUTA	Federal Land Use Transaction Approvals
FLUDA	Federal Land Use Design Approvals
CO_2	Carbon Dioxide
PPS	Provincial Policy Statement (of Ontario)
IESO	Independent Electricity System Operator
OEB	Ontario Energy Board
LGA	Local Government Area
NEU	Neighbourhood Energy Utility

Appendix B: Energy Demand Calculations

This appendix acts to summarize the calculations carried out to approximate the number of additional buildings that the PSPC DES will be able to support once the 25% capacity increase is completed from the second phase of ESAP. All of the values used in the calculations were taken from the ESAP PowerPoint presentations shared on September 22, 2017. Because no load changes are planned for the Confederation Heights CHCP, it was not included in these calculations. Please refer to Section 3.0 - Current Conditions: District Energy in the National Capital Region for more detail about the CHCPs.

Current System and Planned Expansion

These calculations begin with the current conditions of the PSPC DES. The table below summarizes the number of buildings served by each of the CHCP networks that are considered for these calculations. With a total of 69 buildings being heated and 58 buildings being cooled.

Once the PSPC DES has undergone modernization to provide heating with LTHW; the Cliff/NRC, NPB, and Tunney's Pasture heating network have been connected with a 25% increase in capacity; and the Tunney's Pasture cooling network capacity has been increased by 25%, the network loads will have increased. These estimated values are included in the table below.

CHCP Network	Number of Buildings Heated	Number of Buildings Cooled
Cliff/NRC	50	41
NPB	1	1
Tunney's Pasture	18	16
TOTAL	69	58

Expanded CHCP Network (all increased capacity by 25%)	Heating Load (MWt) (diversified)	Cooling Load (MWt) (diversified)
Cliff/NRC-NPB-Tunney's Pasture	126.7	N/A
Cliff/NRC-NPB	N/A	73
Tunney's Pasture	N/A	33.1
TOTAL	126.7	106.1

To then work backwards to determine the diversified energy loads on each of these systems before the 25% capacity increase, 80% of the expanded diversified energy loads was calculated. These values are shown in the table below.

Sample calculation for heating load for the Cliff/NRC-NPB-Tunney's Pasture network:

$$\text{Current Heating Load}$$
$$= \text{Expanded Heating Load} \times 0.8$$
$$= 126.7 \text{ MWt} \times 0.8$$
$$= 101.4 \text{ MWt}$$

CHCP Network	Heating Load (MWt) (diversified)	Cooling Load (MWt) (diversified)
Cliff/NRC-NPB-Tunney's Pasture	101.4	N/A
Cliff/NRC-NPB	N/A	58.4
Tunney's Pasture	N/A	26.5
TOTAL	101.4	84.9

These values were then used to approximate the average energy load of a building on the current system, which lead to the conclusion that for both heating and cooling the average load per building is approximately 1.5 MWt for the current system.

Sample calculation for heating load for the Cliff/NRC-NPB-Tunney's Pasture network:

$$\text{Average Heating Load Per Building}$$
$$= \frac{\text{Total Heating Load}}{\text{Number of Buildings Heated}}$$
$$= \frac{101.4 \text{ MWt}}{69}$$
$$= 1.5 \text{ MWt}$$

The number of additional buildings, with the average load of the buildings currently on the system, the expanded system with an increase of 25% capacity would be able to support was then calculated. The values calculated are included in the table below.

Sample calculation for heating load for the Cliff/NRC-NPB-Tunney's Pasture network:

$$\text{Number of Additional Buildings}$$
$$= \text{Number of Current Buildings} \times 0.25$$
$$= 69 \times 0.25$$
$$\cong 17$$

Expanded CHCP Network (all increased capacity by 25%)	Additional Average Buildings Heating Network Can Support (1.5 MWt per building)	Additional Average Buildings Cooling Network Can Support (1.5 MWt per building)
Cliff/NRC-NPB-Tunney's Pasture	17	N/A
Cliff/NRC-NPB	N/A	10
Tunney's Pasture	N/A	4
TOTAL	17	14

Long-Term Expansion

The above calculations only account for the planned expansion of the system to date. Beyond the two phases of the ESAP modernization of the DES, there is much more expansion expected. The table below summarizes the amount of additional diversified load expected beyond what has been discussed above.

Expanded CHCP Network (beyond the 25% capacity increase)	Additional Heating Load (MWt) (diversified)	Additional Cooling Load (MWt) (diversified)
Cliff/NRC-NPB-Tunney's Pasture	123.3	N/A
Cliff/NRC-NPB	N/A	87
Tunney's Pasture	N/A	3.9
TOTAL	123.3	90.9

Given these values, the number of additional buildings with the average load of 1.5 MWt of the buildings currently connected to the system that each network would be supporting was calculated. The results of this are included in the table below.

Sample calculation for heating load for the Cliff/NRC-NPB-Tunney's Pasture network:

Number of Additional Average Buildings Long Term

$$= \frac{\text{Additional Heating Load}}{\text{Average Heating Load per Building}}$$

$$= \frac{123.3 \text{ MWt}}{1.5 \text{ MWt}}$$

$$\cong 82$$

Expanded CHCP Network (beyond the 25% capacity increase)	Additional Average Buildings Heating Network Can Support Long Term (1.5 MWt per building)	Additional Average Buildings Cooling Network Can Support Long Term (1.5 MWt per building)
Cliff/NRC-NPB-Tunney's Pasture	82	N/A
Cliff/NRC-NPB	N/A	58
Tunney's Pasture	N/A	2.6
TOTAL	82	61

Therefore, these calculations show that, in total, beyond what the buildings currently connected to the PSPC DES, the system is projected to support 99 more average buildings for heating and 75 more average buildings for cooling.

Appendix C: Case Studies

This appendix section is a collection of the detailed descriptions of the case studies mentioned in 4.0 - Case Study Review: Lessons for Successful DES Expansion. A summary of some of the main characteristics and processes of each system is included in Table 1.

Location	Governance Structure	Financing/ Financial Incentives	Energy Source	Land Use Policies/Tools	Number of Buildings Connected
Aberdeen, UK Combined Heat and Power System	• City council formed not-for-profit Aberdeen Heat & Power company	• Government and fuel utility grants • Wholly-owned subsidiary company to turn profit from private sector clients	• Gas • Heat capture from power generation	• Heat mapping • Mixed-use connections	• 2,350 flats in 33 multi-storey blocks • 15 public & 3 private buildings
Bunhill, Islington, UK District Energy System	• Owned and managed by Islington's Council • Operations and maintenance contracted out to Vital Energy for 10-year period	• Local council, • Grants from the City of London • The Homes and Community Agency • The European Union Project Celsius	• Natural gas • Planned heat capture from London's underground tube network	• Guidelines for Connecting to Heat Network for property owners and developers	• 850 homes, 2 leisure centres, and local office buildings • Phase 2 will add 454 homes
Burlington, ON Community Energy Plan	• Stakeholder engagement in committees	• Core focus on financial feasibility planning. Incentives may be added at future date	• To be determined, DES in planning stages	• Consultation process involved targeting key Official Plan amendments • Mixed use and compact development to be prioritized	• DES in planning stages, to be integrated fully in community energy plan

Location	Governance Structure	Financing/ Financial Incentives	Energy Source	Land Use Policies/Tools	Number of Buildings Connected
Burnaby Mountain, BC District Energy Utility	• SFU Community Trust takes leadership role • Private entity contracted to run DES	• Phasing of DES introduction determined in collaboration with private sector to ensure feasibility	• Wood waste biomass • Natural gas	• Extensive development guidelines promoting energy efficiency	• 22 buildings at start, continual expansion expected • SFU Campus buildings to be connected
Denmark's District Energy System	• Federal policy gives municipalities authority over local heating systems • Heating companies publicly owned or consumer-owned cooperatives	• Investment subsidies from Federal Government • Taxes and tax exemptions	• Biomass • Natural gas • Wind power	• Heat mapping • Zoning • Obligatory connection policy • Ban on electric heating	• 63% of all private households • 98% of Copenhagen
Duluth, MN District Energy System	• Owned by the City of Duluth • Managed, operated, and expanded by Ever-Green Energy • Diverse advisory committee	• Local and state-level grants	• Natural Gas • Coal • Planned use of wood biomass and heat recovery	• Five-year master plan for improvements and expansion • Building Code optimization to align with DES • Construction coinciding with other projects • Expansion into new development areas	• 180 currently • Planned significant expansion

Location	Governance Structure	Financing/ Financial Incentives	Energy Source	Land Use Policies/Tools	Number of Buildings Connected
Gibson, BC District Energy Utility	• Town owns and operates • Home owners own the heat pump	• Multiple grants • Town tax dollars	• Geo-exchange	• Expansion into potential development areas • System preceded community to ensure connections • Phasing with new buildings prioritized	• 58 homes • Future phases will add residential, commercial, offices, and an arena
Guelph, ON District Energy System	• Planned, implemented, and operated by Envida Community Energy Inc., a company owned by the City of Guelph	• Planned sales of power to the Ontario power grid • Insufficient financing in the end	• Natural gas	• Current and projected heat mapping • Easements for piping • Master planning	• One large hockey arena, one large condominium project, and two industrial clients
Île-des-Chênes, MB District Energy System	• Owned by the Municipality of Ritchot	• Provincial and federal funds Provincial incentives program	• Geothermal	• Ensuring connection of anchor user before building constructed	• Three buildings: an area, a community centre, and a firehall
Nashville, TN District Energy System	• Public-private partnership (P3) between Metro Nashville and Constellation Energy Projects & Services Group (CEPS) • CEPS designed, built, and maintains the system on a 15-year agreement	• Tax-exempt municipal bonds	• Natural gas • Propane • 42 buildings including government buildings, offices and hotels	• Analysis of Metro Nashville buildings to select new energy centre location • Connected both metro and state government buildings • Retained many buildings from old system	• 42 buildings including government buildings, offices, and hotels

Location	Governance Structure	Financing/ Financial Incentives	Energy Source	Land Use Policies/Tools	Number of Buildings Connected
North Vancouver, BC District Heating System	• Operated by Lonsdale Energy Corporation, a separate utility company owned, governed, and regulated by the City of North Vancouver • Contract with Corix Utilities Inc. for DES expertise and services	• Competitive rates for customers	• Natural Gas • Solar • Geothermal	• Bylaw requirement for buildings over a certain size to connect • Targeting mixed-use areas	• 42 buildings total, including residential units, a hotel, and office, commercial, and municipal buildings
Paris, FR District Energy Evolution	• Two major private DES companies: Paris Urban Heating Company and Climespace	• Targeting clients based on seasonal weather changes evens out energy requirements	• Waste to energy incinerators • Combined heating and power plants using natural gas and coal (coal being phased out) • Geothermal in limited areas	• Density bonus structure • Development zones planned with mandatory connections	• Total energy equivalent to 500,000 households
Princeton University, NJ District Energy System	• Built, maintained, and operated by Engineering and Campus Energy	• Funded by the university	• Cogeneration system • Electricity from the grid • Natural gas • Diesel fuel • Biodiesel fuel • Solar energy • Operators switch the fuel depending on usage and costs		• Over 9 million square feet of university space

Location	Governance Structure	Financing/ Financial Incentives	Energy Source	Land Use Policies/Tools	Number of Buildings Connected
Southeast False Creek, BC District Energy System	• Built, operated, and managed by the City of Vancouver	• Provincial grants • A 20-year loan from the Federation of Canadian Municipalities • Interim financing through the City of Vancouver's Capital Financing Fund	• Capturing waste heat from sewers • Solar panels	• City-wide mapping to identify prime locations • Bylaw requirements • Land use objectives outlined in the SEFC Development Plan	• 28 residential, retail, commercial and community buildings • Total of 2.2 million square feet
St. Paul, MN District Energy System	• Not-for-profit municipally owned utility corporation	• Floating rate revenue bonds • Federal grants • Equity loans	• Woodchips • Solar panels • Natural Gas	• St. Paul uses an integrated planning approach to expand their system	• Heats 190 buildings, 300 single-family homes • Cools more than 100 buildings in the downtown and adjacent areas
Sydney, AUS Decentralized Energy Master Plan	• N/A (see case study)	N/A (see case study)	• Natural Gas	• Identification of four "low carbon infrastructure zones" • 13 enabling actions	• Currently 5 trigeneration plants; plans to install an additional 10-15
Vingåker, SWE District Energy System	• Public RFP process to select private operator • Several ownership changes due to financial infeasibility • Publicized conflict due to governance issues	• Inflexible regulated rates led to financial insolvency • Lack of process to deal with bankruptcy proceedings	• Wood chips used as fuel source • Difficulty in sourcing high enough quality wood chips, need for expensive additives to fuel	• N/A	• 151 customers on 13km distribution network

Table 1: Summary information for all of the case studies completed.

Aberdeen, UK Combined Heat and Power System

Overview

The combined heat and power (CHP) system in Aberdeen, UK was initiated based on the inadequate heating in the social housing owned by the city council, an issue that was highlighted in a study completed in 1999. Since the initiation of the project, hundreds of people have been removed from fuel poverty and the carbon emissions of the city have been cut significantly, causing overall high customer satisfaction.[1,2] In order to achieve this, the city council established an independent company called Aberdeen Heat & Power (AH&P), of which council still remains the largest customer with all of their social housing on the heating system.[3] The system itself is made up of a mixture of generators, for both power and heat, and boilers. The electricity produced first serves the local buildings and powers the district heating, with the remaining power sold to the national grid. The buildings connected have experienced carbon emission reductions of 45% and tenant fuel cost reductions of up to 50%.[4] Due to all the success linked to this project in Aberdeen, AH&P has been awarded four high profile awards since inception.

Land Use and Expansion

The Aberdeen CHP system as it exists today consists of four separate networks that are continually being expanded, the first of which was developed in 2003. This initial system was developed to serve the flats owned by the city council in which the tenants were living in under-heated conditions.[5] However, since this project served exclusively residential uses, major energy inefficiencies were experienced because of the homogeneity of the load.[6] The later projects had more diversified loads with a variety of uses, which improved the system efficiency overall in part by allowing the generators to run all year without interruption and allowed AH&P to secure more funding since they better contributed to carbon targets.[7] Beyond the social objectives, much of the strategic expansion has been based on a combination of interest and the extensive heat mapping that has been completed for the UK in general. Currently the system serves 2350 flats in 33 multi-storey blocks as well as 15 public and 3 private buildings.[8] The quoted goal is to expand the system to serve 40,000 more homes by 2020 and eventually connect the four separate systems to serve the buildings in between.[9] Figure 1 illustrates the current networks as well as the planned expansion.

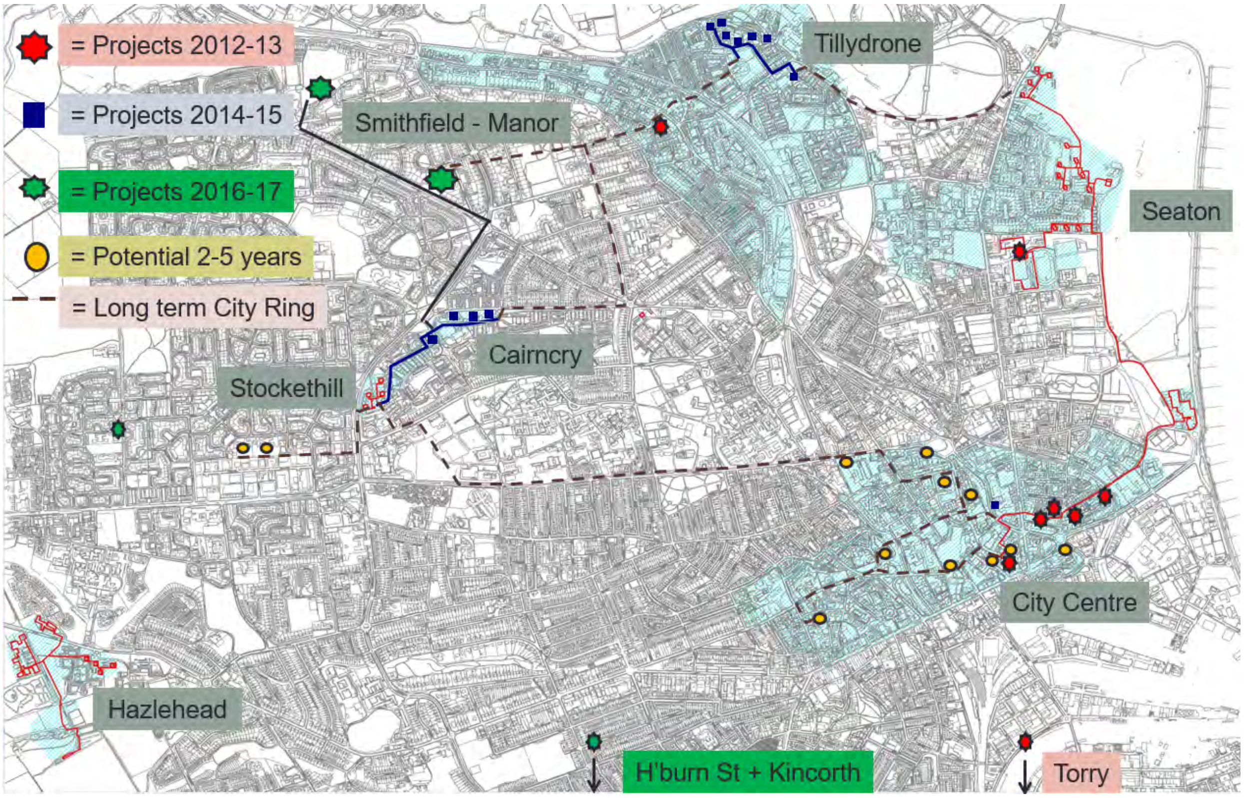


Figure 1: Map of the current CHP system as well as the planned expansions in Aberdeen, U.K.[10]

Growing Client Base

Though the initial CHP project in Aberdeen served primarily social objectives and ended up not being as environmentally friendly as it could be, it also served as a pilot project that both proved the governance model and built social capital, which lead to much more interest in connecting to the system.[11] Combining this with the fact that tenants and local residents were consulted and involved throughout the development and expansion of the system, trust was instilled in the system that seems to have led to an absence of issues in gaining connections.[12] The consultation process peaked in 2016 when the city council hosted a workshop for the interested developers, local government officials, Scottish government officials, and local businesses to discuss both the challenges and opportunities of the system.[13] There were two main outcomes from the meeting. First, the developers expressed a desire for more technical, financial, and business support, generally, in connecting to the CHP system. More specific emphasis was placed on clarity about the funding options available to them and on the expansion of these options to include incentives based, perhaps, on the amount of carbon dioxide savings experienced by connecting. Second, they discussed developing an awareness campaign that would partner local authorities with developers to prepare engagement plans to raise a consistent and accurate public awareness of the system and the associated benefits.[14] Some of the overall points of focus in attracting new connections have, and continue to be, the creation of jobs, tackling fuel poverty, and promoting renewable energies.

System Governance

In 1999 the Affordable Warmth Strategy came into effect in order to combat the fuel poverty highlighted by a study that identified the least thermally-efficient homes in the city. City council thereafter established AH&P as a not-for-profit company in 2002 to both develop and manage district heating and CHP schemes for the benefit of the people of Aberdeen.[15] The company was established separately from council so that the management, operations, and risk was transferred but remained such that council retains its power to influence the direction in which the company goes. In order to include diverse perspectives in the operations of the system, AH&P has a volunteer-based board of directors that includes people from diverse backgrounds, including both elected members and a provision for tenant members.[16] To add stability to the not-for-profit model chosen, AH&P has a 50-year framework agreement with council that entails council selecting the buildings to be connected, largely based on need for affordable heating, and AH&P building and maintaining all of the infrastructure necessary. Within this agreement exists the specification that all of the infrastructure added to the council-owned buildings is owned by council once it is installed.[17]

Since the objective was to increase access to affordable heat, the full capital costs for AH&P needed to be covered so that the burden was never transferred to the occupants, which was achieved through a combination of government and fuel utility grants.[18] Then in 2013, District Energy Aberdeen Ltd. (DEAL) was established as a wholly owned subsidiary of AH&P as a mechanism to keep the prices affordable. DEAL has the mandate of targeting the commercial sector to connect so that it can actually turn a profit, all of which would go back to AH&P to keep rates for public housing down. This model ensures that AH&P remains sustainably not-for-profit.[19] Currently, DEAL has three customers, with more expected to connect in the future.[20] It has been difficult to balance paying back the capital investments with alleviating fuel poverty, but AH&P has successfully found avenues to do so.

Lessons Learned

The case of Aberdeen, UK offers learning opportunities about how a socially-driven district energy model can experience success. Some of the key lessons learned include:

- A combined heat and power system allows for increased efficiency in function as well as increased income with the option of selling any extra power to the grid.
- A pilot project at the beginning of the expansion of a DES can build social capital by demonstrating the effectiveness of both the system and the business model chosen. If marketed well, this can lead to increased trust in the community and more connections in the future.
- A socially-driven not-for-profit DES is possible and can thrive in providing affordable heating to customers. The balance is not simple, but can be achieved through innovative business models and funding sources.
- Mixed use connections are vital for the overall efficiency and environmental benefits of a DES. Only connecting residential users could require that the system shut down during warmer months, which hugely affects efficiency.
- Including the stakeholders and the public throughout the process will again lead to developing social capital and to more informed decision making. Workshops and awareness campaigns can serve an important purpose, but a committee or

board of directors to lead the way will root decisions in what is actually needed in the community.

Bunhill, Islington, UK District Energy System

Overview

Bunhill Heat and Power, located in Islington, UK, is an award-winning DES. Part of Islington Council's Decentralized Energy Program is to cut carbon emissions by 40% by 2020 and reduce fuel bills across the town.[21] Since the original DES was constructed in the late 1890s, the outdated infrastructure needed to be updated and retrofitted in order to properly serve the inner-city. The decision of City Council to develop a new DES came from the strong pull to reduce the cost of heating in order to reduce fuel poverty, which was the Council's principle objective.[22] The system currently heats over 850 homes and two leisure centres.[23]

Phase 1 of this project, which was to build Bunhill's Heat and Power plant and connect residential homes and two large leisure centres, was completed in 2012. Phase 2 of the Bunhill Heat and Power network is currently under construction and involves building an additional energy centre and expanding the piping to capture heat from London's tube network.[24] This expansion uses a heating supply that would otherwise be wasted and will allow expansion and connection to an additional 454 homes, with the potential to supply an additional 1000 homes.[25] The current and planned system is shown in Figure 2. The use of the heat generated from London's tube network is an environmentally sustainable source and in turn will help further reduce energy prices and CO_2 emissions.

Figure 2: A map showing Islington's existing and planned network expansion.[26]

Land Use and Expansion

As mentioned above, the second phase of the Islington DES upgrade is now underway. In partnership with the European Union-funded Celsius Project, which aims to help cities develop projects to evolve into smart cities, Islington's DES network is currently under construction to be expanded.[27] Islington Council is also working with the Greater London Authority and the London Underground and UK Power Networks to expand the system and to source heat from London's underground tube. The expansion has been funded by the local council, a grant from the City of London, and a grant from the EU Project Celsius.[28] The DES was designed in a flexible way to allow future growth, which has made the expansion possible and simple.[29] Furthermore, the demand for expansion has been heavily tied to the lower heating rates the system offers, attracting more customers.

Growing Client Base

Islington City Council has released a series of guidelines meant to assist property owners and developers in connecting to the DES. Within the Guidelines for Connecting to Heat Networks, the benefits of connecting and the most likely connection scenarios are highlighted.[30] These are guiding documents that encourage property owners and developers to connect to the system. Through the use of low-carbon planning requirements and reduced energy prices, Islington has managed to secure a substantial customer base.[31]

System Governance

The Bunhill Heat and Power network is owned and managed by Islington's Council. Because Islington Council owns and manages the DES, Islington has more control over the cost of fuel used to heat the connected homes. In turn, the income that is generated from selling electricity helps to lower heating prices and allows for Council to create new schemes, such as further reducing energy costs, to benefit the residents more greatly.[32] The operation and maintenance of the system was contracted out to Vital Energy, a separate entity, which is in a 10-year contract with Islington's Council.[33]

Lessons Learned

The case of Islington, UK offers learning opportunities in successfully planning and updating an existing DES. Some of the key lessons learned include:

- A strong focus on social sustainability (i.e. reducing the fuel poverty gap) and making heat affordable to all citizens greatly encourages residential connection to a DES.
- Innovative approaches to re-using waste heat, such as the heat generated from London's underground tube, promotes environmental sustainability and helps to increase connections to the system because the waste heat can be obtained at a lower cost.

Burlington, ON Community Energy Plan

Overview

The City of Burlington, Ontario began a comprehensive community energy planning effort in 2011, which sought to establish a new 20-year Community Energy Plan (CEP) to guide the municipality in energy initiatives through policy.[34] The Burlington example is at the initial stages of planning district energy as of 2017. The value of it as a case study lies in the iterative planning process utilized to reach this point, which has been framed from the outset as a ground-up decision-making framework primarily driven by public and stakeholder input. As a result of this process, the municipality has been able to generate significant buy-in from stakeholders, develop a clear and transparent roadmap for future energy system development, identify opportunities to integrate energy strategies with land use planning efforts, and complete comprehensive feasibility analyses to test the realistic business potential of future systems. As a whole, the case study represents the benefits energy systems planners can gain from collaborative planning efforts in developing a clear roadmap for future work.

Community and Stakeholder Engagement

The Burlington CEP was initiated based on goals set out in the municipality's overarching strategic plan.[35] To guide the development of the plan, a steering committee was created with membership from the local utility corporation, Burlington Hydro, and municipal staff. One of the first actions taken by the Steering Committee was to establish a more comprehensive Stakeholder Advisory Committee (SAC) to gain expertise and diverse knowledge from members representing a range of organizations including the local economic development corporation, institutional landowners including hospitals and schools, the provincial government, the private sector, and non-profit environmental groups.[36]

As an initial step, the Steering Committee and SAC developed a list of core principles for the energy planning process. Included in these principles is a core requirement for the CEP development process to allow for "meaningful public engagement and input".[37] A number of community engagement practices were carried out including a "Let's Talk Burlington" program that enabled on-line conversations about community energy issues; targeted discussions with stakeholders including the Building Owners and Managers Association, the Burlington Housing and Development Liaison Committee, and the Chamber of Commerce; and facilitated youth outreach including a contest for local high school students to develop innovative solutions to community energy sustainability.[38]

A key result from the CEP planning process was the creation of a formal structure to guide the implementation of the plan. Through the community and stakeholder engagement process, the municipality identified a comprehensive list of potential representatives to sit on boards and committees devoted to plan implementation. A governance organizational structure was developed including an overarching Oversight Board with membership similar to the original SAC, an implementation committee with staff representation, and a number of task groups tailored to specific subject areas, as represented in the Figure 3.[39] This governance structure represents a core desire to maintain the CEP as a "living document", which involves ongoing community and stakeholder involvement.[40]

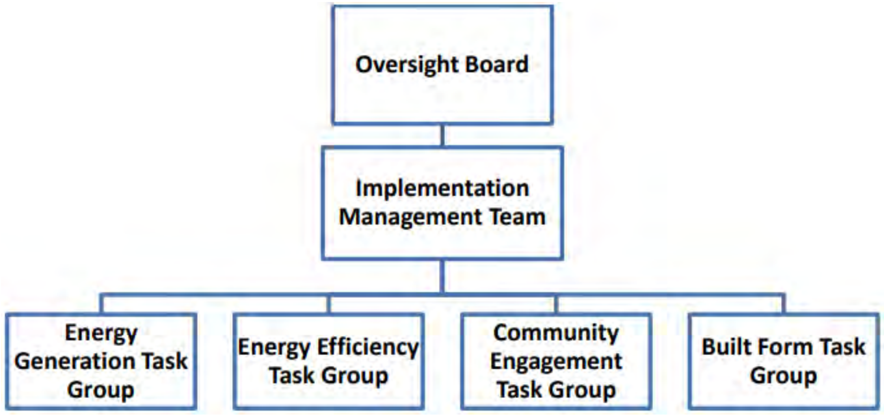


Figure 3: The governance organizational structure for the Burlington Community Energy Plan.[41]

Feasibility Analysis

One of the major outputs of the CEP was to complete a feasibility study for district energy potential. This output was decided upon based on an additional comprehensive analysis of future energy sources in the local context, which is included directly in the CEP. An analysis of current and future potential energy prices from a multitude of sources was completed, along with demand predictions.[42] Basic energy mapping was also completed for key demand areas. Included within the analysis is an overview of future district energy potential, which identified at a high-level the potential benefits and challenges of district energy in the Burlington context. The findings indicated that district energy has the potential to "significantly improve energy performance by capitalizing on opportunities and synergies at the local level".[43]

Based on this finding, the CEP formally included the creation of a more in-depth feasibility study into district energy in a future action plan.[44] Based on this recommendation, the City Council directed staff to complete a high-level feasibility analysis in two stages. The feasibility study process took place over a multi-year period, funded with a grant from the Federation of Canadian Municipalities Green Municipal Fund.[45] To carry out the study, the municipality contracted an engineering firm through a public request for proposals process to review both the technical and financial feasibility of a DES in Burlington. In developing the analysis, the contracted engineering firm, FVB Energy Inc., engaged key property owners and developers to gain expert advice. This was an effort to keep with the public engagement requirements of the municipality and the public engagement goals in the CEP.[46]

From the information gained from stakeholders and expert technical analysis, FVB identified a series of challenges, including a lack of space for new development with a considerable mix of uses and the prevalence of roads, pipelines, and rail tracks that make expansion of physical infrastructure development difficult.[47] However, three key areas were identified that are technically feasible for development, with primary focus being on the Burlington downtown core as a "showcase installation".[48]

These findings were expanded on in the second stage of feasibility analysis, which included the development of a number of recommendations for system growth. These recommendations were supported by an in-depth financial analysis, which formed a business case for a future DES. Given capital constraints at the municipal level, the need for economic sustainability in the system is a core consideration. This analysis ultimately suggested the feasibility of the system business-wise, but noted remaining challenges in the up-front costs of development.[49]

Land Use and Energy Planning Integration

A core component of the overall CEP was to complete a comprehensive land use planning analysis including future growth potential, planned developments, intensification potential, and current building stock.[50] Overall, this analysis found that land use planning is a core tool in optimizing results in community energy efficiency and sustainability. The actions identified in the CEP include a number of steps regarding land use planning that can help to achieve plan goals, including an increased emphasis on mixed-use and compact development. A key recommendation in the report is to carry out changes to the local Official Plan policies to support future connectivity to a district energy system.[51]

Lessons Learned

The Burlington Community Energy Plan process represents a good case study in generating stakeholder buy-in. The entire process to date has revolved at a base level around engaging both key stakeholders and the public in the planning process. While the actual development of a DES remains in early planning stages, the engagement and careful feasibility analyses to date have resulted in a clear roadmap for future action, as well as a comprehensive understanding of opportunities and challenges in DES development. Some key points for consideration include:

- The creation of formal stakeholder committees with clear mandates creates a venue for information sharing, collaboration, and planning between diverse perspectives. This process is highly useful in identifying future opportunities and challenges, and obtaining the information necessary to determine overall system feasibility.
- To sustain stakeholder buy-in, engagement practices should extend beyond the planning stage and into the implementation stage. This action can assist in promoting ongoing stakeholder buy-in and public confidence.
- Land use planning tools are a key opportunity to promote the success of energy planning. An early step in energy planning of any regard should be to ensure that statutory plan policies align with future system development needs.

Burnaby Mountain, BC District Energy Utility

Overview

At the outset of the Burnaby Mountain District Energy Utility (BMDEU) project, a leadership role was taken by the Simon Fraser University (SFU) Community Trust, a university affiliated organization established to oversee the planning and development of the "UniverCity" master-planned community adjacent to the main SFU campus on Burnaby Mountain[52]. The SFU Community Trust was tasked with creating a "complete community" project with a range of residential and commercial options, designed and implemented with specific focus on environmental sustainability and sustainable building practices[53]. Slated to begin construction in 2018 and be completed by mid-2019, the BMDEU is projected to achieve upwards of 80 per cent reduction in greenhouse gas (GHG) emissions when compared to typical fossil-fuel and electric systems[54] through the expansion of a limited existing DES .[55] The water, wastewater, and energy firm Corix was chosen as a private vendor to execute the project. The project will entail the expansion of a 8.3 MWt natural gas system connecting seven buildings to a 13.5 MWt wood waste biomass and 8 MWt natural gas combined system connecting 22 buildings and the main SFU campus.[56]

Stakeholder Context

The BMDEU project falls under the direct purview of the SFU Community Trust within the City of Burnaby in the Metro Vancouver region of British Columbia, Canada. Alongside the provincial, municipal, and SFU Community trust, private entities are major stakeholders in the project for real estate and utility provisions. This presents a complex stakeholder context, given four key layers of mandates, policy directions, and relevant legislation and regulations.

At the provincial level, considerable policy direction exists to reduce GHG emissions, including targeted reduction goals and regulatory instruments such as a carbon tax introduced in 2008.[57] This creates a major incentive to support less GHG-intensive systems, including localized energy sources such as a DES, particularly if the DES adopts generation mechanisms such as biomass. At the municipal level, the City of Burnaby has sought to be an environmental leader through the adoption of numerous GHG reduction targets, but is struggling to reach this goal given strong effects by other municipalities in the Metro Vancouver area.[58] The SFU Community Trust also has a stated agenda of achieving sustainability goals including energy conservation.[59]

Despite this alignment in policy direction, the three main stakeholders have disparate requirements and exist within a complex regulatory environment entailing different acts, regulations, and bylaws. Furthermore, economic feasibility is necessary for buy-in from the private sector, and for actual system operation. Altogether, though all stakeholders could potentially gain from the BMDEU, buy-in was required from all parties to move forward, and no single institutional framework existed to obtain this.[60] In the end, an innovative and effective governance mechanism was necessary to bring partners together, plan the project, and implement it.

The Governance Solution

From the outset of the BMDEU project in the early 2000s, the SFU Community Trust took a key leadership role in developing a governance system to push the project forward. The Trust began laying the groundwork for the DES by establishing a clear mandate of sustainability for itself, and working with the City of Burnaby to establish development guidelines for the UniverCity area that incentivize energy efficiency.[61] At the same time, it undertook extensive engagement with the development community to gauge their needs, and as a result worked to ensure that future requirements and goals were highly transparent as methods to build market certainty.[62] These discussions with the private sector also led the Trust to hold off on implementing a DES during the initial phases of development due to an understanding that it could damage economic feasibility and ultimately fail to reach sustainability targets.[63] Nevertheless, the work carried out by the Trust administration during the early stages resulted in the creation of a collaborative institutional framework, with the multiple stakeholders sharing information and working together to meet goals.

As the UniverCity project progressed into the late 2000s, changing global markets and provincial policy began to make DES look more attractive both economically and environmentally, with a key element being the introduction of the provincial carbon tax and associated carbon offsets.[64] New projects utilizing DES in the region such as Southeast False Creek proved that they could be a feasible sustainability option in development[65]. However, concerns about high up-front costs, such as feasibility studies and considerable financial risk in operating a business selling heat, were raised. The Trust also faced a major barrier in the lack of human resources with the skill and knowledge to carry out such a project.[66] To avoid these barriers, the Trust decided to partner with the private sector to mitigate risk and bring on the human resources necessary to execute the project. Ultimately, the Trust decided on Corix as the firm to assume responsibility of creating, owning, and operating the BMDEU.

This partnership allowed the Trust to avoid the financial risks of owning a commercial DES, bring on skilled business expertise, and avoid high up-front costs. The BMDEU, acting as a regulated utility, can operate with an effective business model aimed at financial feasibility in expansion. At the same time, the Trust was able to maintain a key leadership role in establishing an institutional framework for collaboration between disparate stakeholders and meet internal sustainability goals.

Lessons Learned

Because of the complex stakeholder landscape in the case of the BMDEU, no clear system currently exists to bridge gaps between the diverse stakeholders and to establish a governance model that works for all of them. Given this, the BMDEU project offers numerous lessons learned, including:

- It is vital for one organization to take a leadership role in establishing an institutional framework for collaboration between levels of government and private stakeholders. Consistent and continual engagement needs to occur to share information and develop a common understanding of barriers between all parties.
- Early actions are necessary to lay a foundation to ensure the future success of DES expansion. The establishment of complementary bylaws and development standards are required to enable the success of DES expansion. This requires collaborative work from an early stage with relevant municipal stakeholders, and attention to ensure future plans are transparent for private sector parties.
- DES expansion needs to be carefully timed to meet market conditions and stakeholder needs. All relevant stakeholders should be comfortable with the economic feasibility and ability for the DES to meet sustainability goals before expansion occurs.
- The implementation and operation of the DES needs to be governed by a body with the capacity to manage a financially feasible system effectively, without detracting from stakeholder goals. If expansion necessitates the sale of services, care needs to be taken to ensuring that this governing body has the ability to operate as a utility business.

Charlottetown, PEI District Energy System

Overview

The DES in Charlottetown, PEI currently serves a mixture of over 125 residential, commercial, and institutional buildings in the downtown. The system provides predominantly space heating with high temperature hot water, except for the hospital that is served by steam.[67] This established system has operated successfully since 1986, with no significant operational issues. The leaders lend this to their experienced team as well as their committed and trusting customer base.[68] Wood waste and municipal solid waste currently fulfill 85% of the fuel demand of the system, with fuel oil acting as the backup supply. The wood is supplied by the wood waste produced by two local contractors from their land clearing.[69] This structure allows for 70% of the money spent on the biomass fuel to remain in the local economy, where oil alone would only allow for 10% to remain. The heat capacity of the system is 72 MW with an additional 1.2 MW of electricity generation, which is used internally to power the plants and any excess is sold to the grid.[70]

Land Use and Expansion

The Charlottetown DES began in 1981 with the construction of three small district heating plants, which were all completed by 1989. There was a waste-to-energy steam plant for the hospital, a woodchip plant for the provincial office buildings, and a wood-fired plant at the University of PEI (UPEI).[71] In 1995 the planned consolidation of the three plants came to be, with the majority of the capacity being moved to the original waste-to-energy site. At this time, the three plants were connected via 18 kilometres of underground piping, infrastructure for electricity generation was added, and additional wood boilers were installed.[72] Today, the majority of the downtown is served by the system, the base load of which is still served from that main plant. The UPEI plant comes online for backup purposes and the third plant is not often used. Since the system serves most users downtown in a quite stable manner, future expansion is limited and largely dependent on the development of more large buildings.[73]

Growing Client Base

During the expansion phase of the Charlottetown DES, the focus was on targeting large buildings with high demand. They did so successfully, since they currently serve most large buildings in the downtown, including provincial government offices, UPEI, the Atlantic Veterinary College, the Hospital, two shopping malls, as well as various commercial and apartment buildings.[74] The successful expansion of the system and attraction of new clients has largely been considered a product of the stability of the system and rates from the beginning as well as initial and continued local stakeholder engagement. On top of the trust that has been built, many have been attracted to the DES because of the contributions it makes to the local economy.[75] No specific expansion has been planned, but because of the upgrades in 1995, the capacity is available if more demand does arise.[76]

Originally, the three plants were owned separately by the province of PEI under the PEI Energy Corporation.[77] During this time, there was a great deal of stakeholder engagement, especially with the municipality, which made final decisions and actions much more time efficient.[78] Once the private company Trigen

Energy Canada Inc. purchased all three plants, they consolidated them into one system largely to one location and added the cogeneration equipment. Thereafter, the system was purchased by US Energy Systems, then Countryside Income Trust, then Fort Chicago Energy Partners, and is now owned by Enwave Energy Corporation.[79,80] The electricity not used internally to power the heating system is sold by Enwave to the Maritime Electric Company Limited in New Brunswick, providing another source of income. Revenue is also generated from the waste fuel fees associated with the acceptance of municipal solid waste from the Island Waste Management Corp., a Canadian crown corporation.[81] Though the system has been passed around quite a bit, it has remained stable and has continued to engage stakeholders to build social capital.

Lessons Learned

The case of Charlottetown, PEI offers an example of a DES that has been successful from the beginning and that has reached all of the customers that had been targeted, with little to no expansion to come. Some of the key lessons learned include:

- Using local fuel sources can contribute to the local economy while also playing other roles, such as assisting in municipal waste management. These alternative fuels can also act as additional sources of income while stabilizing customer rates because of the reduction of risks around access.
- Large users, such as universities, can become long-term partners for a successful DES. Certain users of this type are best served by a DES and can act as the anchor user for a given area.
- Building social capital by engaging with the public and stakeholders from the beginning helps to ensure long-term support and stability in the system. With this in place consistently, the ownership of the system seems not to influence the willingness to connect to the system. Working closely with municipal staff in planning a DES can also make the installation and expansion much easier by putting certain allowances in place for the infrastructure.
- Generating power to support the internal needs of the system lends to sustainable function and can add to the income base if any excess is sold to the grid.

Denmark District Energy System

Overview

The country of Denmark is highly advanced in the implementation of regional DESs. The strength of the related Danish federal policy from the outset has fostered cooperation amongst key stakeholders in this endeavor. This has allowed for the Danish DES to evolve to become one of the most successful energy systems in the world. Following the energy crisis of the 1970s, the Danish government prioritized providing reliable and cost-effective energy sources to reduce the dependency on imported oil.[82] The goals of the federal energy policies were to significantly reduce GHG emissions and to provide citizens with an affordable, reliable, and clean energy supply. Today, 63% of all private Danish houses are connected to district heating.[83] The Copenhagen district heating system, as an example, successfully provides 98% of the city with clean, reliable, and affordable heating.[84] At its core, the success in the Danish DES lies within the federal energy regulation and legislation as well as coherent urban planning at the municipal level. Ambitious GHG reduction targets set out by the Federal Government continue to create innovation solutions for greening Denmark's energy supply. Denmark is currently striving to establish an energy system that is completely independent from fossil fuels by 2050 and Copenhagen aims to become the first carbon neutral capital in the world by 2025, with district energy being a key player in achieving this ambitious goal.[85]

Land Use and Expansion

The *Heat Supply Act (1979)* is the most important legally binding document that oversees district energy planning in Denmark. The Danish government, while recognizing that the implementation of heating plans would take time, set strong goals and developed a legislative framework that has proven to remain stable over time.[86] Under the Danish model of heat regulation, local decision makers have full authority over the heating system design, but they rely on centralized policy and a technical framework given at the federal level.[87] Strong and directive goals and objectives are the key success factors in the Danish model. Likewise, transparency between energy companies and the public reduces economic risk and encourages a strong and transparent relationship.

Heat planning in Denmark was broken into stages over time. During the first stage, local municipalities were required to map the existing heat demand, the existing heat supply, and the amounts of energy used. Thereafter, municipalities and larger regions prepared reports that outlined alternative energy options for future heat supply. Smaller municipalities and larger regions then prepared heat plans, which identified priority heat supply options for given areas, locations of future heat supply units, and networks and used zoning as a tool to map out areas that were to use district heating or natural gas.[88] The zoning tool also helped to reduce overinvestments in energy infrastructure and gave municipalities the ability to enforce mandatory connection. The obligatory connection policy and banning electric heating made it possible to ensure a secure income for energy companies as well as ensuring competitiveness of the public energy supply.[89]

Growing Client Base

The Danish government has used a variety of tools and incentives to grow the client base. Over time, the Federal Government has used the following:

- The *Heat Supply Act* – caused municipalities to begin heat planning, allowed for the general ban on electric heat and oil boilers, and granted municipalities the power to establish the 'obligation to connect' policy;
- Investment subsidies (1990s) – used to support the transition to district energy;
- Taxes and tax exemptions (throughout the 1980s) – used to discourage the use of fossil fuels and exempt biogas and biomass from taxes;
- Amendment to the *Heat Supply Act* in 1990 – introduced a "project system", helping to establish a new heat planning system, which was a political agreement that promoted expansion of district energy through converting heating plants to co-generated heat and electricity supply and focused on converting all coal fired district heating plants to natural gas, decentralized co-generated heat, and electricity; and
- Project Proposals – requires any party interested in initiating a heat-planning project to submit a proposal that outlines

economic, environmental, and energy indicators, which is sent to the municipality that then sends it to other stakeholders.[90]

System Governance

Prior to the global energy crisis of the 1970s, the Danish Federal Government set out strategic direction for energy planning through their legislation. In 1979, the *Denmark Heat Supply Act* was enacted, which marked a new era of public heat planning in the country.[91] This act created a new public planning protocol whereby the municipal heat planning process was kick-started. This legislation regulates the heating sector and provides municipalities with the power to engage in the local heat planning process, decision-making on energy infrastructure, and the prioritization of resources.[92] The *Heat Supply Act* gives municipalities full authority over the local heating systems and protects consumers from being over-charged in energy costs by utility companies.[93] Because of this model, the heating sector in Denmark is highly publicized and ensures that the public has access to fairly assessed energy prices, which greatly increases the desirability of district energy.

The strength of the federal sustainable energy planning policy in Denmark has set the framework for the implementation of district energy, pushing he country towards carbon neutrality. The five municipalities of the Copenhagen Region (Copenhagen, Frederiks-Berg, Gentofte, Gladsaxe and Taarnby) joined forces to set up a partnership with the Metropolitan Copenhagen Heating Transmission (CTR) and VEKS, another heating company.[94] This partnership remains publicly owned and is a model that is used in other municipalities across Denmark. In some areas, heat transmission companies are owned by consumer-owned cooperatives. In the consumer-owned cooperative model, a board of directors oversees the company's activities and represents its stakeholders.[95] Members are appointed by the municipality or elected by members of the cooperative. For municipally owned companies, regular meetings are held with large consumers such as housing associations or the energy manager of the municipality. These models are set out to ensure that the consumers are empowered and helps to recognize the customers as being essential stakeholders in the energy sector.[96]

The publicized nature of the Danish energy system has fostered trust and cooperation amongst stakeholders. It works on a not-for-profit basis and protects consumers from being over-charged for their energy. The energy sector Board of Appeal and the Danish Energy Regulatory Authority oversee the sector. These authoritative bodies ensure equitable prices for energy and deal with complaints regarding pricing and conditions.[97] Due to the heating sector being a public entity, the desirability for installing a DES and the transparency between the public and their governing system are both higher. To summarize, Danish heat planning evolved from the recognition that importing and using oil as their main energy source was extremely unsustainable. The Federal Government has been the driver in the heat planning process and it should be highlighted that it has been almost 40 years since the *Heat Supply Act* was initiated.

Lessons Learned

The Danish model for energy planning illustrates that coherent and strategic policy is fundamental in encouraging the expansion of district energy. As well, the Danish model exemplifies that strong support and guidance from the Federal Government is key for successful implementation of DESs. Because district energy in Denmark is a public resource and promotes socioeconomic benefits, it helps to reinforce a strong public willingness to connect to the system. Given these key findings in the Denmark model for district energy, a variety of lessons can be learned, which are as follows:

- Legislation from the top level of government is essential in establishing a framework for implementing a DES. Federal policy has been the key driver for the Danish DESs.
- Strong policy direction from the federal government that grants municipalities the freedom to use planning tools, such as zoning and obligation-to-connect policies, has proven to work extremely well in the context of Denmark's DES.
- Treating the energy sector as a public good and ensuring a fair and equitable price helps to gain public support. In addition, having regulatory authorities (i.e. the Danish Energy Regulatory Authority and the Board of Appeal) to oversee the energy sector is important to maintain fair pricing for energy.
- Having the public as a key stakeholder allows for cooperation with the government. Public ownership of a district heating systems also allows for the transfer of knowledge, which aids in gaining public support and willingness to connect to the system.
- Project proposals, as Denmark has, makes it so the process for creating or upgrading an energy network is transparent between all stakeholders involved. Assessing the economic, social and environmental factors and engaging key stakeholders also allows for strategic energy planning.
- Establishing a strong and successful model for installing a DES takes time. Policy first needs to be put in place and relationships between the public and private sectors need to be established.
- Having effective land use planning is essential for a successful DES. Dense urban areas, such as the case in Copenhagen, have been extremely effective for recognizing economies of scale.
- Energy policies across all levels of government need to be cohesive and align in order for DES to be successful.

Duluth, MN District Energy System

Overview

The Duluth, Minnesota district heating system was established in 1932.[98] The system has always been reliable in providing steam and some hot water for space and water heating as well as a small amount of chilled water for cooling, mostly in government buildings.[99] Currently, the two separate systems consist of 10 miles of piping and serve over 180 buildings, which includes approximately 40% of the buildings in the central business district.[100,101] However, the aging infrastructure of this coal-powered system is functioning at a very low efficiency by standards today. Additionally, the system does not act to achieve environmental targets in its current state because of both the reliance on coal and the open-loop configuration that results in the condensate from the steam to simply be treated as waste water, instead of being used again.[102] That being said, a system upgrade and expansion has been planned with a series of opportunities identified to improve the efficiency of the system and to move to renewable fuel sources. For example, the resources of the local forestry industry can be leveraged for wood biomass fuel. The plan also includes provisions for waste heat recovery, combined heat and power, summer-sized boilers, and a switch from steam to hot water.[103]

Land Use and Expansion

The current plans include upgrading this dated system by converting it all to supply hot water instead of steam and expanding the system to serve more customers. The upgrade is being planned to coincide with the reconstruction of one of the main downtown streets, which will reduce upfront costs by up to 40%. This initial phase will also allow for interim improvements to the efficiency of the existing system, which will continue to function throughout the upgrades, by adding a condensate return for the steam, making it a closed-loop system to reduce water waste.[104] In this way, the process will be split into two phases. First, the upgrades and conversions will be carried out opportunistically to coincide with other projects to both reduce installation costs and disruptions. Second, the system will be expanded, which will target areas where new developments are planned.[105] In order to ensure the financial sustainability of the system into the future, longer-term contracts with customers are being explored.[106]

Growing Client Base

The reliability of the existing system for such a long time has resulted in a positive reputation and the development of significant social capital and trust. However, the system has always been lacking in customer incentives, a challenge that is now being discussed.[107] The upgrade and expansion of the system is being marketed based on the benefits of the long-term stability of rates; water, energy, and emissions savings; and the production of new jobs.[108] Meetings with existing and potential customers have also been part of the feasibility and marketing strategy to better understand the willingness and challenges associated with either connecting to the system or converting from steam to hot water.[109] The expectation has been that even the minor initial infrastructure changes and expansion could lead to an over 50% increase in the potential customer base because customers adjacent to the infrastructure will be targeted. Though no explicit recruitment strategy is in place, the capacity to support the load will be available. These connections will be inexpensive because of their proximity, which will allow for the rates for all customers to be reduced, ultimately attracting more customers. This expansion is projected to lead to 50% of the downtown buildings that are currently not connected to connect. [110] For now, a pilot project with one of the steam plants being run on natural gas instead of coal for 7 months is underway in the hopes of leveraging further funding and social capital.[111]

System Governance

In 1932, the Duluth DES was developed by a private company called Duluth Steam. This company became an affiliate of the City of Duluth in 1979 when the city purchased the system to ensure that it would keep running.[112] Then, in 2012, the city hired Ever-Green Energy to manage and operate the system as well as to prepare a five-year master plan for both improvements and expansion.[113] The master plan includes the objective of partnering with both local authorities and state-level authorities in order to leverage the grant opportunities that already exist. An additional goal is to work with the city to change and improve the building code to optimize the requirements for the heating and cooling systems of buildings, hopefully so that they can connect to the DES easily.[114] Ever-Green

Energy has implemented a system advisory committee, including local citizens, businesses, academics, not-for-profit organizations, advocacy groups, and government stakeholders, to oversee the project and ensure everyone is involved. The first phase of expansion has already received $15 million in state funding and is currently moving forward.[115]

Lessons Learned

The case of Duluth, Minnesota offers learning opportunities about the process involved with developing a master plan for the upgrading and expansion of an existing DES by using innovative and opportunistic approaches. Some of the key lessons learned include:

- Social capital is an invaluable resource for both successful operations and expansion of a DES. A pilot project and a stakeholder advisory committee are two methods of developing a solid customer base.
- Planning updates and expansion opportunistically to align with other construction can lead to significant cost savings.
- Partnering with the municipality is invaluable in setting up certain planning-related mechanisms to make future expansion easy. For example, working with city staff to alter the building code to ensure heating and cooling systems are compatible with the DES could be a possibility.
- Targeting buildings directly adjacent to existing or expanded infrastructure is best to attract more customers in an inexpensive way. This can lead to a rapid increase in customer base and allow for the rates to be decreased, which will attract more customers.

Gibsons, BC District Energy Utility

Overview

The Town of Gibsons is located in the Sunshine Coast region of British Columbia, north of the City of Vancouver. Gibsons has created a Geo-exchange District Energy Utility, the first of its kind in North America, in the community to provide a renewable and sustainable source of heating and cooling to the growing population. The system has many benefits, including reducing greenhouse gas emissions and better energy price stability. It will also become a source of non-tax revenue for the town in the long-term future.[116] The system stands at the intersection of energy innovation, sustainability, and the utilization of green technology, acting to achieve three main goals of the municipality, as shown in Figure 4. To this date, only phase one of the implementation of the system has been completed; however, in 2018 future phases will be assessed.

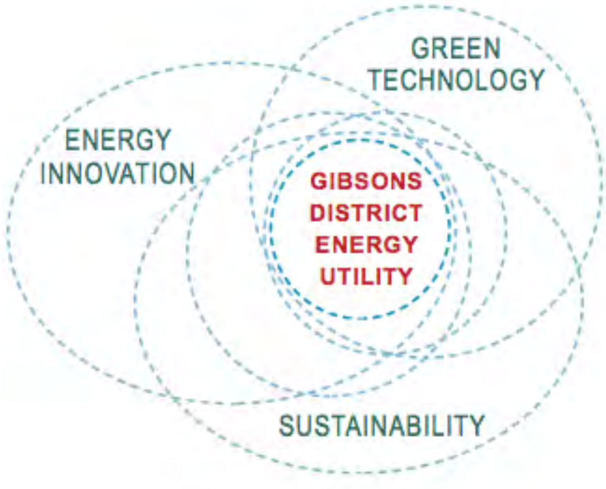


Figure 4: Energy innovation, green technology, and sustainability were the driving goals behind the development of the Gibsons district energy system. These important forces represent the values of the town and what they want to see in their planning.[117]

The Town of Gibsons is using a geothermal district energy system to heat and cool buildings in the parkland community in Upper Gibsons.[118] This type of system extracts thermal energy from deep beneath the ground to provide heating services to buildings. The fluid heated or cooled in this way is circulated via underground piping and the energy is then transferred to the heating or cooling systems of the individual buildings.[119] The three components of this type of system are: the heat exchanger to transfer thermal energy from the earth to the fluid, the distribution system to circulate the heated or cooled fluid, and the heat pumps to transfer the thermal energy to the heating or cooling system of the buildings.[120]

This type of system has the capability to extract the vast and constant energy stored in a nearby water body. Gibsons has plans to take advantage of their location along the Pacific Ocean in the near future to harness that energy. Since there is an upcoming reconstruction planned for the storm sewer line, they intend to install the necessary district energy infrastructure at the same time to save resources.[121] Figure 5 demonstrates how the town intends to tap into the energy stored in the ocean.

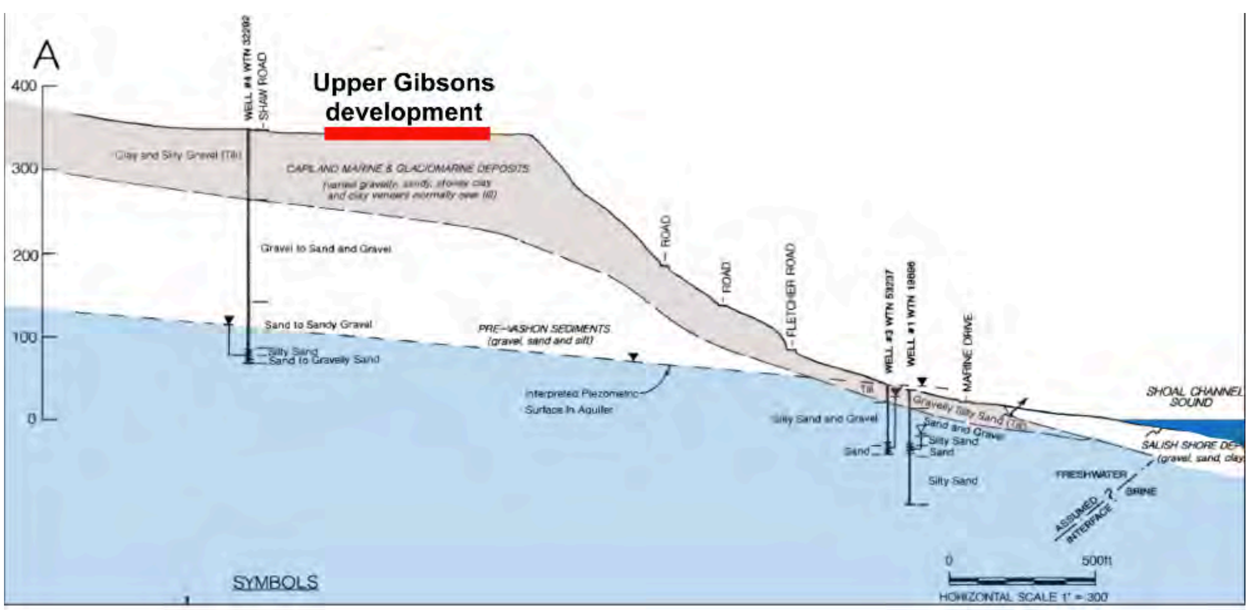


Figure 5: This diagram shows how the town wants to connect the district energy system in Upper Gibsons to the ocean to harvest energy from the water source.[122]

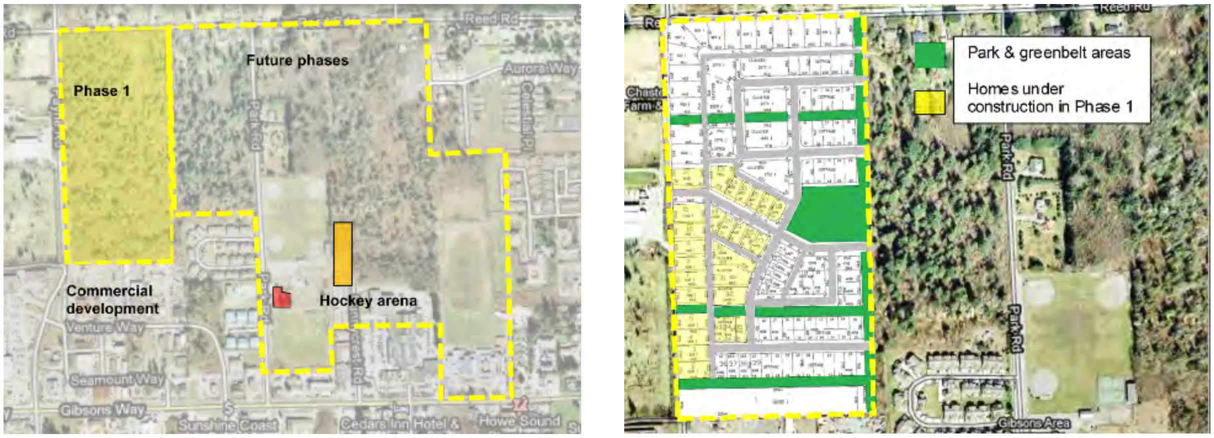


Figure 6: The first map (left) shows the location and phasing of the district energy system infrastructure. The second map (right) shows the housing being connected to the district energy system in phase one in more detail. [123]

The town has been labeled one of the world's greenest cities as well as has received a few awards for this project. The UN endorsed International Awards for livable communities has given Gibsons and gold award for being the world's most livable community with a population under 20,000. The town was also given the first-place award for outstanding achievements for "planning for the future".[124] Livability and sustainability is an important value to this community and the town is implementing these values into the planning and engineering projects.

Land Use and Expansion

This project is being implemented in phases, with only phase one being completed to date, which included connecting the parkland community to the system. Phase one construction began in the summer of 2010, connecting solely residential buildings to the district energy system.[125] The project is set to continue to be developed over a 10 to 15-year period by connecting more nearby residential buildings and the neighbouring shopping centre and hockey arena.[126] The system currently serves 58 homes at the end of phase one, which will expand in future phases.[127] Figure 6 shows two maps of the current and future phasing of the system.

Several developers own land in the parkland area in Upper Gibsons, with whom the town is working to connect all of the residential buildings to the system. The town intends to explore project expansion in more detail beginning in 2018, but the planned full build out includes the system will supplying approximately 25% of the population of Gibsons with heating and cooling services.[128,129] Phasing is necessary to make sure the system works and can sustain a substantial part of the population. The system has been developed to be flexible in order to allow for growth of the system infrastructure as well as the addition of new buildings.

The addition of the hockey arena to the system will help provide heating for approximately 150 to 200 houses annually by creating 1,500,000 to 2,000,000 kWh of heat annually.[130] The hockey arena relies mostly on cooling services but will also emit heat once the cooled fluid warms up, which will be used to heat other houses on the system.

System governance

Gibsons has used their own money in addition to multiple external sources of funding, such as the federal Gas Tax Fund and the BC Innovative Clean Energy Fund, to finance the development of the district energy system.[131] The Town of Gibsons owns most of the infrastructure related to the system, including the energy centre, the underground heat exchanger coils, and other related infrastructure. The property owners, on the other hand, are responsible for purchasing the heat pumps and thereafter owning this part of the system. The cost of the pump is roughly the same cost as installing a gas furnace and air conditioning unit to a house.[132]

The service rates are determined by heat loss from a given building, which factors in size of home, insulation rating, and number of windows.[133] The billed costs cover capital investment in the energy infrastructure, rather than the costs of the energy, since it doesn't cost the town anything to create the energy.[134] Because of this, there are substantial savings in energy prices for those connected to the district energy system compared to those connected to the regular utilities. For a typical home, the price would be approximately $600 annually, with billing occurring every six months rather than monthly.[135] This would be an approximate yearly savings of 10-15% or $200 compared to natural gas.[136] This project will give the town a source of long-term non-tax revenue since the money from the clients will go directly to the town.

Lessons learned

The case of Gibsons, BC offers learning opportunities with respect to innovative use of local resources, phasing, and governance, among others. Some of the key lessons include:

- Implementing a system in phases is very important. If an issue with the system arises, it is easier to solve the problem. It is important to phase a large project such as this one in small sections to ensure the system can handle it.
- New developments are a good place to start with DESs.
- District energy systems are a great way of significantly reducing greenhouse gas emissions and environmental impact.
- It is important for the DES operators to listen to the community through this and to acknowledge the importance of the community's desires and needs. Pressure from the community on reducing the town's environmental impact was one of the driving forces behind the DES in Gibsons.
- Provincial mandates are important for starting the conversation on DESs. The province of British Columbia has created a mandate for all municipalities, towns, and cities to develop plans to reduce their environmental impact.

Guelph, ON District Energy System

Overview

The plan for the DES in Guelph, Ontario, written by Envida Community Energy Inc., the company in charge of the system, was published in 2013, which included provisions for 10 separate district heating networks in different areas of the city powered by natural gas, shown in Figure 7. Beyond this, plans were also included for the installation of cooling with on-site chillers driven by the district heating network as needed.[137] The plan for the system built directly on the objectives of the existing Community Energy Initiative, which gave it plenty of footing. In the end, two of the 10 candidate areas, all of which are shown in Figure 7, were chosen for the initial development of the system – the downtown core and a business park. In 2014, small, temporary district heating plants were installed in each location with the goal of expanding their capacity each to 10-MW.[138] In the end, however, it was clear that these large plants would not be sustainable either economically or environmentally, since too few large, anchor users were planning to connect.[139] The expansion of the plants and the system was cancelled, after which point the leaders recognized that they should have gone with a smaller system to start with a plan to more systematically expand it with demand.[140] In 2016, after a financial analysis, city council decided to continue operating the small district heating systems that had already been installed as they are and to explore other opportunities for growth in the future.

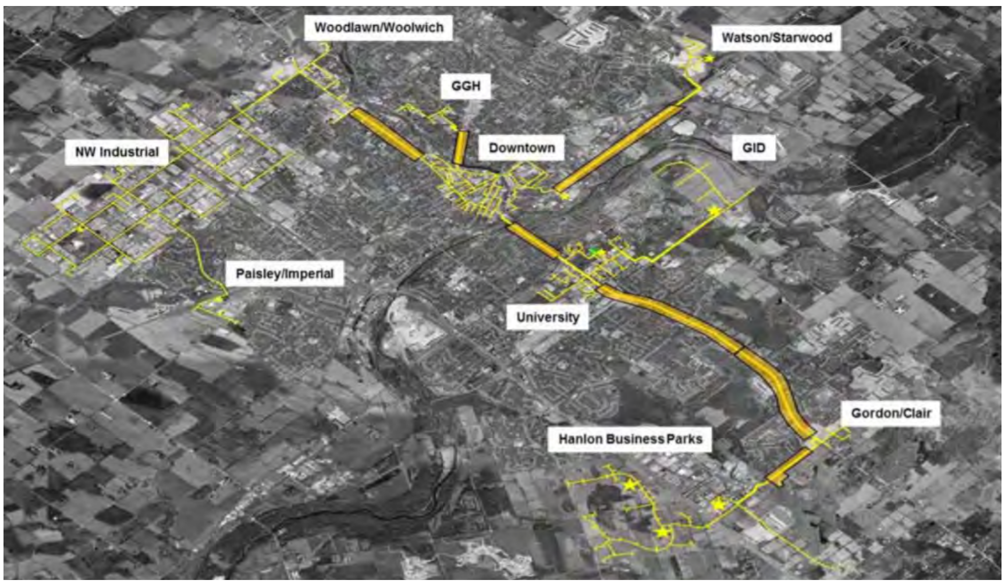


Figure 7: The plan for district energy in Guelph for the year 2041 that has been abandoned. The candidate priority areas are identified on this map.[141]

Land Use and Expansion

Initial plans for the system included the identification of areas that would be best served by a district heating system, called "high-priority areas." These target areas were identified based on current heat mapping as well as projected, modelled heat mapping by year from 2012 to 2041, an example of which is included in Figure 8.[142] The models took into account projected growth, secondary plans, redevelopment projects, local knowledge, and learnings from case studies. In this way, the target areas were largely identified by their potential to have high heating demand, but seemed to lack any knowledge about the users who might actually want to connect. Based on the models, two areas were selected for the initial installation of district heating networks. First, the downtown core was chosen because of the heat demand of the high-density infill areas, with the temporary heating plant being installed in the large hockey arena, which was connected immediately. Second, the temporary Hanlon Creek Business Park plant was installed because of the heat demand associated with the current and expected development.

Since the planning for this network was initiated while the business park was still developing, Envida worked closely with the city planners to include easement of the district heating piping.[143] The temporary heating plants came online in 2014, but based on the projected demand of the heat mapping, a 10-MW combined heat and power plant was planned for each site to serve a larger future client base.[144] Shortly after, Envida signed contracts to supply energy to the Ontario power grid once these larger plants were constructed. However, they were forced to get out of these contracts when they cancelled the construction because Envida discovered that they did not actually have the thermal load required for environmental and economic benefits to be achieved.[145] Because of the limited demand in reality, neither plant would be able to generate enough cash flow over the useful lives to recover the costs of installation. This overall failure to expand the new system was due to the gross underestimation (by 100%) of the thermal load required to be sustainable and the initial dependence solely on heat mapping.

Figure 8: The heat map for Guelph based on modelled projections for the year 2040.[146]

Growing Client Base

From the beginning, Envida was targeting potential customers that had high total heating needs. These included: apartment buildings with three or more storeys; residential developments with more than 100 homes per hectare; single buildings of more than 1,000 square metres; multi-building developments of total area more than 10,000 square metres; federal, provincial, and city buildings; the University of Guelph; Guelph General Hospital; Schools; and any industrial sites.[147] Eventually, once all of the plants were installed, the intention was to connect all of the networks to allow service to reach any customers within 200 metres of the infrastructure along the way. The marketing strategy included appealing to customers with highly competitive pricing, price stability, system reliability, and reduced maintenance and construction. Plans also included partnering with the University of Guelph to update their current steam DES to a more efficient hot water system to serve both the university campus and the surrounding area.[148] Since the larger project was cancelled, the two temporary plants became more permanent in serving the hockey arena and a condominium project downtown as well as two industrial clients in the business park.

System Governance

The company in charge of the planning, implementation, and operations of the district energy system in Guelph is Envida Community Energy Inc., which is owned by Guelph Municipal Holdings Inc., which is owned by the City of Guelph. Envida is the local hydro subsidiary company in charge of all of the projects aimed at furthering the Community Energy Initiative, generally.[149] Early on in the development of the strategy for this DES, the team aligned their expectations with respect to offered services, high-potential customers, and best areas for expansion with all of the key players.[150] Envida also planned to strategically take over the operations of existing under-utilized boilers in the downtown core of Guelph in order to optimize their function and share their capacity within the growing DES network, a goal that has yet to be achieved.[151] After the failure of the expansion of the DES, the management and oversight of Envida transferred directly to the city.[152]

Lessons Learned

The case of the Guelph, Ontario DES provides learning opportunities about the planning process behind the installation of a system. Though the failure of their overall plans lends to certain negative conclusions, some of the tangential objectives of the plan that have not yet been pursued offer interesting ideas and avenues to consider. Some key lessons learned include:

- Reliance on current and projected heat demand alone in determining the feasibility of a DES is dangerous and can lead to insufficient serious interest in connecting to the system, especially from large anchor users.
- Going too big with plans from the start can lead to significant financial burdens and an overall inefficient system. More systematic and flexible expansion from an initially small system could lend to a successful system from the beginning.
- Working closely with municipal planners can pay off in making the expansion of the system through developing areas much simpler by putting easements in place for DES piping.
- Partnering with large users that already have their own DES to both update their system and expand it to serve the surrounding area may be an easy way to expand by limiting the requirements for new infrastructure. Even taking over operations of the boilers in smaller facilities that are under-utilized to serve surrounding customers could serve a similar purpose.
- Instead of a district cooling system, cooling could be offered on an as needed basis with local or in-building chillers that are driven by the heating system.

île-des-Chênes, MB District Energy System

Overview

île-des-Chênes is a small rural community located approximately 20 kilometres south east of Winnipeg, Manitoba in the municipality of Ritchot, which has a population of approximately 5000 people. The main objective behind the development of the district energy system in île-des-Chênes is to create an energy efficient and environmentally friendly community centre that fits the needs of the community.[153]

The first project proposal was simply to convert the hockey rink to a geothermal system, shown in Figure 9. However, the costs were higher than anticipated and it made sense to expand this project to connect to others to secure more external funding.[154] The new proposal included the incorporation of the new community centre and the fire hall into the project. These changes allowed the community to attain funding from the Government of Canada, which helped pay for the system, and provincial funding, which helped pay for any extra costs of installation as well as the connection to the fire hall.[155]

The district energy system uses geothermal energy to heat and cool the connected buildings. The system was installed under the of the hockey rink parking lot where 504 holes were drilled into the earth to access the earth's thermal energy.[156] The system uses glycol to extract the heat from below the ground and pipes to transfer the heat into the buildings.[157] The system extracts the earth's heat in the winter and returns the heat into the earth in the summer.

Figure 9: A photo of the hockey rink being connected to the île-des-Chênes geothermal district energy system.[158]

The system has been able to reduce operational costs for all the buildings.[159] The community centre has seen a 60% decrease in energy consumption and a 40% reduction in costs.[160] This project received the Federation of Canadian Municipalities energy award in 2012 for the innovative ideas behind the project. This project will see one expansion over the next few years in adding an ambulance garage to the network.[161] The system is able to provide enough energy to heat and cool the garage once it is built.

Growing Client Base

By organizing surveys, a public open house, and a visioning document, the municipality was able to effectively use their resources to simultaneously educate and consult the community. The initial uncertainty of community members was overcome in this way by sharing all of the benefits of a geothermal district energy system. [162]

Currently, there are only three buildings connected to the system. The original proposal was for the arena to solely be attached to the geothermal system. The project was not feasible with only this one building, forcing the project team to come with ideas on how to make it feasible. It ended up being feasible when they added the firehall to the system as well as developing and connecting a new community centre.

System governance

The design and construction phases of this project were predominantly led by private sector companies. Laufer Enterprises were used for both the design and the project coordination phases.[163] Manitoba Geothermal Energy Alliance installers were used to install the geothermal heat pump. Consulting private sector companies with specific knowledge in geothermal energy was important and helpful for the municipality.

Geothermal systems get their heating and cooling from underneath the earth's surface; however, a small amount of electricity is needed to run the system[164]. This gives geothermal system owners huge savings potential when transferring over from traditional heating and cooling systems. The upfront costs are the main costs for geothermal systems. The île-des-Chênes project purchases the small amount of electricity from Manitoba Hydro[165]. The municipality owns and operates the system.

Lessons learned

The case of île-des-Chênes, Manitoba offers learning opportunities with respect to financing and scale. Some key lessons learned include:

- The initial costs of district energy can be very high and can stop projects from happening. Changing the project plans, grants, and incentives can help make a project feasible.
- District energy can happen at any scale. District energy can be sustainable in large cities and small, rural communities, alike.
- Rural towns need assistance from upper levels of government for DES installation. Often, these small communities do not have sufficient resources.
- DESs can be beneficial to many building uses.
- Geothermal DESs and other kinds of renewable energy projects can happen at any scale and can experience success

Nashville, TN District Heating System

Overview

In the early 2000s the City of Nashville, Tennessee was experiencing the challenges of an aging waste to heat district energy system in the downtown core that was in need of a replacement. The infrastructure was inefficient, unreliable, and costly and did not have a large enough capacity for Metro Nashville.[166] The city decided it was time to invest in a new district energy system to heat and cool buildings in the downtown core.

The City of Nashville hired the private consulting firm Gershman, Brickman & Bratton, Inc. (GBB) to help the city determine their options and select the best partner for the project.[167] GBB was responsible for selecting a contractor to design, build, and operate the new district energy system.[168] GBB was also in charge of the feasibility analysis, which helped secure the financing for the project.[169] Metro Nashville and GBB ran a large-scale public information program, which included releasing information to the public on district energy systems, designing a logo for the system to publish on websites and brochures, and creating a newsletter for the city to read and understand the benefits of district energy.[170]

GBB and the City of Nashville hired Constellation Energy Projects & Services Group (CEPS) following the request for proposals to design, build and maintain the new district energy system.[171] This system is using a public-private partnership (P3) governance structure.

The original system used waste to heat conversion to create energy for the city. The new system uses electrical power to create steam and chilled water to heat and cool the connected buildings. Underground piping is used to circulate steam and chilled water throughout the downtown core. Additional condensate pipes were also installed to make a closed-loop system to return the steam condensate to be reheated and cycle through the heating system again.[172] The steam pipes run at a temperature of 366°F, whereas the condensate pipes run at a temperature of approximately 190°F.[173] The chilled water pipes carry water between 39°F and 43°F to the buildings and cycle the water back to the energy centre at temperatures between 48°F and 54°F.[174]

In order to achieve a seamless transition period for buildings connected to the system, CEPS made updates and improvement to the original system while developing the new system.[175] The contractors were able to finish the construction and begin operations seven months early in December 2003.[176]

While most of this project is new, including the energy centre, parts of the old system have been incorporated into the project. Nashville has reused a lot of the piping from the old system as steam piping.[177] Other infrastructure has also been reutilized in this project. Revitalizing parts of an old project is useful when changing systems.

Land Use and Expansion

The system currently serves 42 buildings with heating and cooling, but was created with expansion in mind.[178] This has grown substantially over the past 15 years since operations began and will continue to do so. The system is currently connected to a variety of municipal buildings, state buildings, and private buildings, which include office buildings, a museum, hotels, an arena, and a stadium. The new Hyatt Plash Nashville and the Music City Center buildings are the most recent connections to the system.[179] Figure 10 shows all of the buildings currently connected to the system.

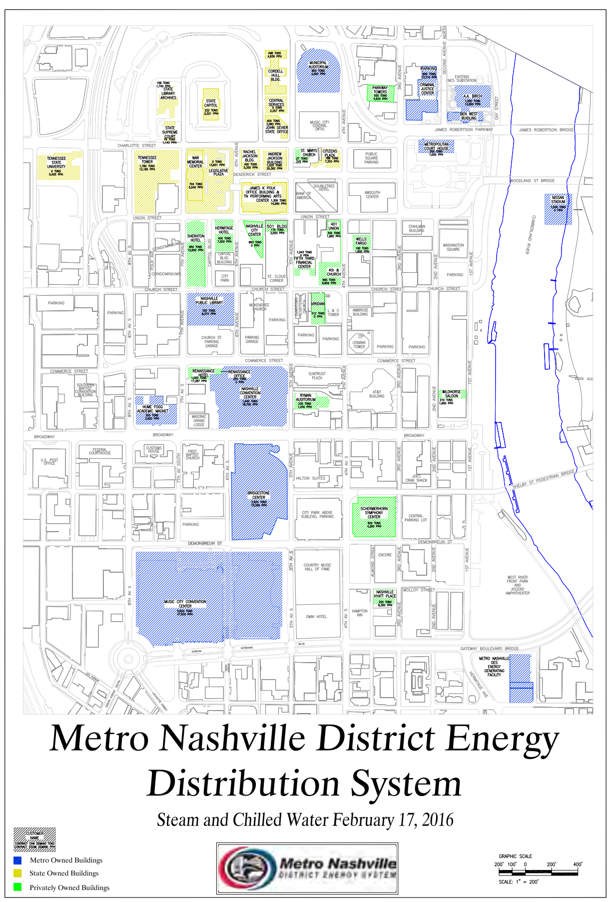


Figure 10: A map of Nashville showing the type of buildings connected to the district energy system and their location.[180]

Growing Client Base

CEPS and Metro Nashville have been working together to attract new customers to connect to the energy system.[181] Together, they aim to create the most sustainable and best system for Nashville in light of the original system not being economically or environmentally viable.[182] This project is better substantially better for the environment by emitting lower levels of greenhouse gases. The system is widely economically sustainable by providing heating and cooling to customers at a significantly reduced price compared to the old system. The upfront capital costs of construction amounted to $46 million, which is manageable since the projected savings in the first 10 years of operations are $66.9 million.[183] The combination of reduced costs and environmental impact in addition to system reliability have been marketed to attract new customers to the system. The previous system had 40 forced operating shut downs a year, but this system has only had one forced outage.[184]

Figure 11: A photo of the energy centre in Nashville, Tennessee.[185]

System governance

The Metro Nashville district energy system uses a public-private partnership wherein the city retains ownership of the facility.[186] The private company, CEPS, on the other hand, was hired by the city and GBB to design, build, operate, and maintain the system.[187] Metro Nashville and CEPS have a 15-year agreement where the CEPS runs the system including metering and invoicing clients as well as any required maintenance related to the energy system infrastructure.[188] The agreement includes a section on performance, which states that CEPS must maintain specific performance and efficiency levels throughout the 15 years.[189] The agreement has the ability to extend the operation contract three times by five years each.[190]

During the construction phase, the old plant caught on fire and it was unknown if it could be recovered.[191] Metro Nashville asked CEPS to take over the operations of the old plant for the duration of the project. CEPS kept working on the old system throughout the construction of the new system to make a seamless transition. Nashville and CEPS had to work through major problems and were still able to have a successful development.

CEPS created two methods to finance the project in their request for proposals submission. The first was to use its own equity to finance the project.[192] The second option was to sell tax-exempt municipal bonds, which is the option Metro Nashville ended up choosing to finance the new district energy system.[193]

Lessons learned

The case of Nashville, Tennessee offers learning opportunities with respect to governance and partnering as well as phasing. Some key lessons learned include:

- Choosing the right partner is very important in creating a successful DES. Aligning objectives and communicating properly can lead to significant financial benefits.

- Flexibility in the project and P3 contracts are necessary for a DES. Problems happen, and the partners need to be flexible and work through the issue.
- Not all successful DESs need to be started as completely new projects. Utilizing safe building material from an old system is an effective way to lower costs.

North Vancouver, BC District Heating System

Overview

During the planning stage of redeveloping the waterfront and urban core, the City of North Vancouver funded a feasibility study for a DES.[194] Since operation began in 2004, three separate systems of mini-plants were developed to provide high-temperature hot water (HTHW) space and water heating in three areas of the city.[195] The three systems have expanded and currently support 42 buildings, including 2700 residential units, a 106-room hotel, as well as office, commercial, and some municipal buildings.[196] Each one of the mini-plants, which consists of four to six high-efficiency boilers, is located underneath a building connected to the system in the designated underground parking area.[197] This system was chosen for a myriad of reasons, the biggest of which is the flexibility to connect future buildings. Though these boilers can use different fuel sources, including those that are renewable, the system is somewhat constrained in this way due to the reliance on HTHW, which cannot be efficiently achieved by all fuels.[198] Currently, the system is predominantly fueled by natural gas but has also begun to use solar and geothermal sources.[199] On a large scale, the benefits of this system have been significant reductions in emissions of both nitrous oxide and carbon dioxide, improving air quality.[200]

Land Use and Expansion

The biggest breakthrough of this project grew out of the work that City of North Vancouver staff committed to identifying areas that have the highest demand for heating. This work revealed, unsurprisingly, that larger buildings are best suited for connection to the system, but also that optimal areas are those that are mixed use, as they have a variety of energy demand cycles.[201] Based on these conclusions, the City of North Vancouver was able to pass a precedent-setting bylaw requiring new or retrofitted developments over 1000 square metres to connect into and use the system. The “City of North Vancouver Hydronic Energy Service Bylaw, 2004, NO. 7575” is rooted in provincial legislation and obligates the Lonsdale Energy Corporation (LEC) to expand the system and provide the necessary infrastructure to connect a given building that qualifies so long as it does not cost LEC an excessive amount.[202] Some buildings are also required to install one of the mini-plants, depending on their size and location, to allow for further expansion. In order to make the entire process as simple as possible, LEC has a set of guidelines that developers are required to adhere to in order to connect effectively to the district heating system.

Growing Client Base

Though the bylaw has certainly acted to grow the client base through requiring certain connections, it was clear from the outset that in order for the North Vancouver district heating system to be successful, the rates set for customers would have to be both competitive and stable. LEC has sold the system as both cost saving and reliable, using the 2015 average rate of $0.08060 per kWh as an example.[203] In this way, the sales strategy is that the given rate includes fuel, maintenance, operations, and heat, with no remaining concerns for the user. A given customer invoice includes three separate charges: Meter Charge, Capacity Charge, and Commodity Charge. The former two charges are constant from month-to-month and are designed to recover capital and operating costs. The latter charge differs each month depending on the kWh consumed by a customer. Additional upfront one-time fees to developers connecting to the system also include an application fee of 0.15% of the total construction value and $75 per kWh of capacity as determined by an engineer.[204] Over the lifespan of the system, the rates have remained fairly stable, aside from when Provincial Sales Tax (PST) was reintroduced in the province, which LEC was required to charge, leaving them at a competitive disadvantage for a time since other sources of heat energy were not required to charge.[205] The broad usage of natural gas in the system has also kept rates low, since this is currently the most economical fuel source.

Beyond the financial incentives, the City of North Vancouver also successfully reached out to their current and future clients in a friendly way by launching a website for the DES. This website acts as an educational platform where people can go to learn about the details of the rates, the requirements to connect, the benefits of connecting, and many more aspects.

System Governance

In 2003, the City of North Vancouver established the LEC as a separate utility company to operate the district heating system. However, LEC, which is owned, governed, and regulated by the City of North Vancouver, only assumed full responsibility for the further development and operation of the system as of January 2014.[206] Since the beginning of operation in 2004 to this date, LEC was under a contract with Corix Utilities Inc., an experienced district energy operator. To get the system functioning well, the agreement was such that Corix supplied design, procurement, construction, financing, and operation expertise and services.[207] Despite all of this, the main role of the City of North Vancouver has always been to simply regulate the rates charged to customers by LEC.

Since the City of North Vancouver is not subsidizing LEC functions, the funds stemming from the charges to customers do contribute to the city budget, but the stated goal is that this will remain minimized.[208]

Lessons Learned

The case of the City of North Vancouver district heating system operated by LEC offers a number of learning opportunities. These lessons learned include:

- Establishing a company separate from the city worked effectively along with a private company with expertise in district energy to assist in getting things running smoothly.
- Expanding to serve mixed land use areas is most efficient and effective due to varied energy demand cycles, which leads to a distribution of load on the system.
- Enacting a bylaw to require the connection of buildings over a certain size is effective in growing the system. In this case, the

requirement of the city to be responsible for ensuring the proper infrastructure is in place is important.

- Considering competing environmental regulations is vital in switching fuel sources. Sometimes a low greenhouse gas emission fuel will be higher in contributions to particulate matter, two air quality concerns that may be regulated by different policies.
- Preparing a user-friendly and thorough website for users and developers to learn about the system and understand their requirements is hugely beneficial.

Paris, FR District Energy Evolution

Overview

As a densely populated and energy intensive city with an ancient and highly developed existing built form, Paris, France has a number of unique challenges to address in district energy provision and expansion. Developed in the 1920s as a reaction to pollution from coal consumption, the current system in Paris utilizes a mix of geothermal energy, excess heat from sewers, and waste-to-energy plants to provide heating to the equivalent of 500,000 households, including major hospitals, museums, and social housing properties.[209] While DES was originally conceived in Paris as a solution to environmental issues, contemporary goals for greenhouse gas (GHG) emission reductions require large-scale changes. In order to achieve these goals, Paris has developed a strategy utilizing innovative land use policies, building regulations, and new DES generation technologies to lower total region carbon dioxide emissions by 75% by 2050.

The Evolution of Environmental Solutions

The first DES implementation in Paris occurred in 1927 with the establishment of the Paris Urban Heating Company (CPCU). This was in a large part a reaction to serious air pollution concerns due to a decentralized heating of properties with wood and coal.[210] The initial system expanded gradually over the next 80 years, transferring into a public-private partnership model with joint ownership by the municipality, a private investor, and publicly traded stock.[211]

In 2013, the CPCU system generated roughly 5.5TWh of heat, which was distributed over 475 kilometres of pipes, with a large portion of the energy from waste to energy incinerators.[212] The CPCU also operates combined heat and power plants that produce around 1TWh of electricity, with baseline production driven by gas and coal boilers and peak demand handled by fuel oil boilers.[213]

A second company called Climespace operates a large district cooling system in Paris, with 330MW of cooling capacity along 71 kilometres of pipe in the Paris central core.[214] Given a short demand season for cooling in residential markets, Climespace solely targets large consumers, including museums, such as the Louvre, along with restaurants and shops.[215] In the winter months, users with constant cooling demands, such as data servers, are targeted for service.

Just as DES was viewed as a solution to environmental issues in the 1920s, it is once again being targeted as a core mechanism for meeting climate change goals. Given the heavy reliance on gas and coal boilers for combined heat and power plants, over 412GWh of coal production are expended every year on DES in the city, representing a large contribution to the environmental footprint of the city.[216] As a global leader in environmental targets, Paris committed in 2004 to reducing emissions from 25 million tCO_2 equivalent by 75%, aiming to reach 6.25 million tCO2 eq in 2050. District energy evolution is strategized as a fundamental tool to help reach this goal.

Technology Upgrades

One of the core methods of evolving district energy in Paris to meet environmental goals is upgrading technology used for generation. As referenced above, a significant portion of the total energy supply for the current systems is provided by fossil-fuel intensive generation such as coal and gas. This is the first major area for change identified in DES evolution strategies to meet environmental goals. By 2020, the CPCU aims to transition 60% of its total generation to renewable technology. This is planned to occur through the expansion of waste-to-energy generation, along with the introduction of increased geothermal inputs targeted in areas with considerable new development. Additionally, a biomass generation facility is being introduced which will aim to fill 10% of the total fuel mix. The CPCU system is also converting from the original steam system to a hot-water loop system for all new additions to the system. Altogether, currently planned changes in generation technology aim to achieve 350,000 tCO_2 equivalent emissions reductions by 2020.[217]

In order to implement these changes, an innovative tax incentive structure is being utilized, which will allow the CPCU to reduce the value added tax charged on its services from 20% to 5.5% under the *National Housing Commitment Act*, representing roughly €35 million per year in savings[218]. Given the considerable challenges involved in upgrading to renewable technology including the cost of sourcing biomass for energy generation, financial incentives like this can go a long way to aiding feasibility.

Land Use Planning Tools

Along with upgrades to the physical infrastructure of the system, Paris is undertaking a number of innovative land use planning measures that will aid in reaching environmental targets both internally and by making the adoption of DES more attractive. A density bonus system has been created under which developers can enjoy significantly higher saleable square footage if they meet high efficiency standards or include renewable energy generation technologies.[219] Given that DES connections can allow developers to meet these requirements, the density bonus structure has resulted in considerable uptake on the system including a 10 kilometre increase in delivery pipe.[220]

In addition to the density bonus system, Paris has set specific areas as “Urban Development Zones”, within which the municipality pays for the expansion of pipes and developers are required to connect to the DES.[221]

Lessons Learned

The history of DES in Paris serves as an example that district energy can be a long-term solution to environmental issues. Given the flexibility of the system in integrating a mix of generation technologies, long-term evolution is possible to meet increasing environmental targets. To assist along the way, authorities can utilize a range of tools including land use provisions and financial incentives. Specific considerations include:

- As needs change and environmental targets evolve, district energy systems need to evolve along with them. A DES is a powerful opportunity to meet environmental goals, but if generation technology stagnates it can end up contributing to issues more than it helps them.
- A key benefit of district energy is the ability to integrate a mix of generation technologies, which allows for the slow evolution of the system. Taking advantage of the flexibility allows for the gradual replacement of facilities with more environmentally sustainable ones, and the location of different generation technologies in areas that are conducive to their success.
- Local land use tools and policies can be instrumental in promoting the success of a DES. These can take the form of either incentives or requirements, both of which make the adoption and expansion of systems more attractive for property owners, investors, and system operators alike.

Princeton University, NJ District Energy System

Overview

Princeton University has developed an efficient and low-cost district energy system to provide heating, cooling, and power across the university campus. Because of this system, Princeton University has been able to reduce its carbon emission levels, which is one of the goals of their sustainability plan.[222] The university has been able to reduce the required installations from 150 boilers and 150 chillers to three boilers and eight chillers.[223]

The Princeton district energy system provides energy and heating and cooling services to a wide range of buildings, including research laboratories, athletic centres, libraries, academic buildings, and residences, which all have unique needs. The energy system includes four main parts: steam boilers and water chillers, from which chilled water and steam are circulated to heat and cool the campus; an electric generator, and a thermal energy storage system.[224,225] The

district energy system has four sources for producing electricity to supply the university buildings, three of which are located on campus, including solar, gas, and steam turbines at the energy centre shown in Figure 12.[226,227] Princeton also purchases power from the grid power, which is the fourth power source.[228] The amount used of each type changes over the day according to campus conditions. Most of the grid power is purchased over night while prices are at their lowest and is then stored in the thermal energy storage system.[229]

Figure 12: A photo of the energy centre on the Princeton University campus.[230]

The Princeton University system uses cogeneration to increase the efficiency of their system by capturing the waste energy released by the natural gas to heat water and create the steam.[231,232] Cogeneration has increased the system energy efficiency from roughly 25-45% to 70-80%, making it so that much less natural gas and diesel are required to heat the campus.[233] Figure 13 demonstrates how this increased efficiency is achieved through cogeneration.

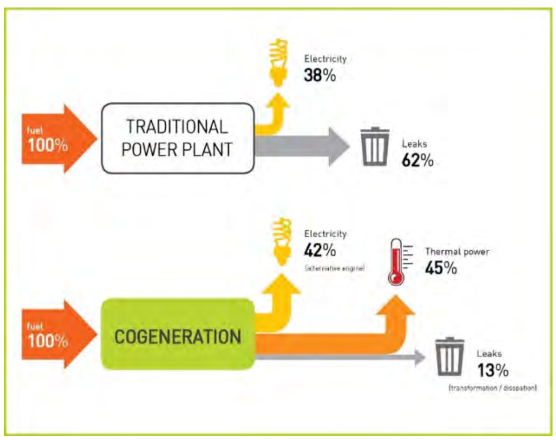


Figure 13: This diagram shows how cogeneration captures energy loss form system leaks and uses it to power buildings resulting in a more efficient system.[234]

An economic dispatch model was introduced to the system in 2001 to further reduce the amount of imported energy needed and lower the cost of the system.[235] Within this system, operators monitor the system and decide how much energy the system should make and how much energy should be purchased. These operators are also able to switch the system between natural gas and diesel, a change that depends on how much energy is being used at a given time and the cost of imported energy. Figure 14 shows how all four energy sources are used within the system.

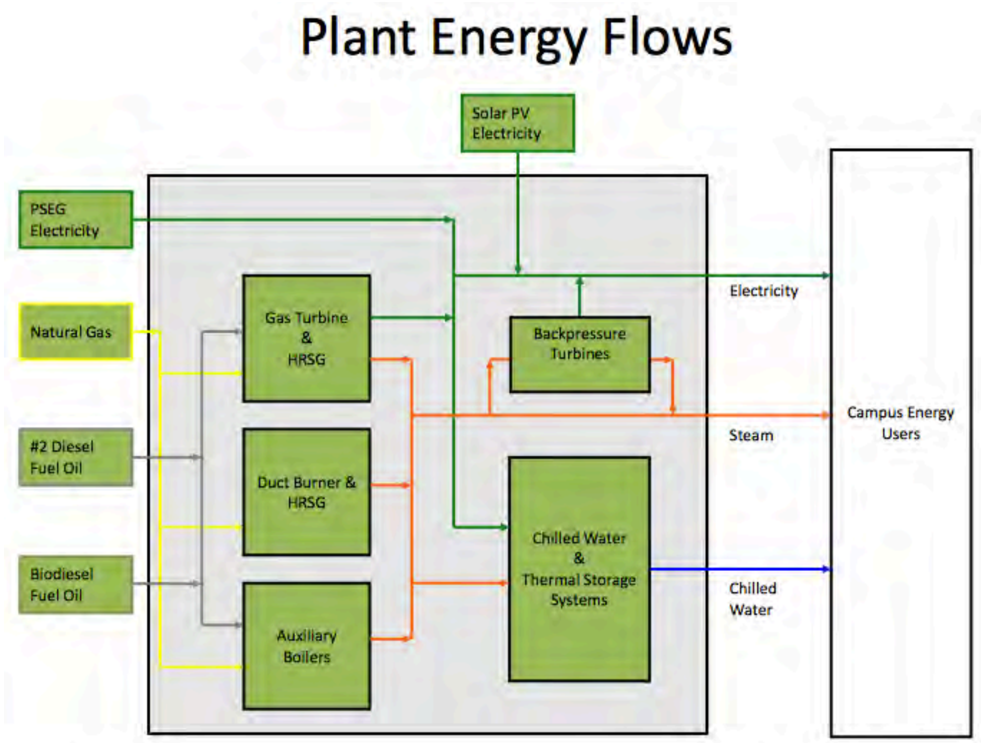


Figure 14: This image shows how the four sources of energy go through the district energy system to end up providing heating and cooling to the university campus.[236]

Land Use and Expansion

The Princeton University district energy system is solely connected to campus buildings. As the university grows and more buildings are added to the campus, the system is being expanded to provide services to those new areas. The energy system currently serves over nine million square feet of space and will be expanded to supply over one million square feet more space in the next decade.[237]

The first boilers and district steam system were installed on the campus in 1876.[238] In 1880, the first cogeneration system was created after the relocation of the boilers. Over the next century and a half, the system was continually updated and expanded throughout the campus, which was aided by technological advances.

Growing Client Base

Reliability and cost savings are the main benefits of this system for Princeton University. The client imports energy at lower costs at nonpeak hours, acting as a cost-saving mechanism. There are also cost reductions from the more centralized system, which removes the need for boilers and chillers in every building on campus. The Princeton University system is also very reliable because they are able to store energy and use it when needed, which means if something happens there is back up energy to keep providing services to the campus.

The Princeton University system was created to fufill the University's energy and heating and cooling needs. The University is the only client on the operating system. The University is currently not looking to expand to new clients.

System Governance

The Princeton Engineering and Campus Energy staff build, maintain, and operate the district energy system.[239] The staff includes electrical engineers, mechanical engineers, system operators, building control system operators, and designers to help manage the cogeneration plant.[240] The operators determine fuel source as well as when to use imported energy versus energy created by the system.

Lessons Learned

The case of Princeton University offers learning opportunities with respect to the long-term expansion and the innovative energy sources. Some of the key lessons learned include:

- Creating a versatile system that meets the objectives of a project while meeting the needs of the users is vital.
- Understanding the clients' needs is an important way to create a successful district energy system. Creating a system that can change to support those evolving needs throughout is an important addition to a project.
- Flexibility in how a system is powered should be considered in the implementation of DESs. A system that can be powered by multiple fuel sources helps get the cheapest energy possible for a project. Changing a system's operating fuel depending on market conditions can help achieve financial feasibility in a project.
- A system storage component can provide energy if the system is unable to produce enough to meet the demand.
- Cogeneration is an important addition to any district energy system. It increases the reliability of the system, lowers costs, and reduces the system's environmental impact.

South East False Creek, BC District Energy System

Overview

The South East False Creek (SEFC) is a 32-hectare brownfield development that has historically been used as a ship-yard, rail-yard, and works-yard, located in located in Vancouver, British Columbia.[241] Today SEFC is a mixed use development that includes a mix of 28 residential, retail, commercial, and community buildings, totaling 2.2 million square feet.[242] In 2003, there was a strong push to install a district energy system as a means to achieve the energy efficiency and energy goals of the City of Vancouver.[243] FVB Energy and Compass Resource Management were retained by the City of Vancouver to conduct a feasibility analysis for installing a DES in SEFC. Based on the research presented, the City approved the development of a Neighbourhood Energy Utility (NEU) in 2006.[244] While the City's decision to move forward with installing a DES was supported in preliminary studies, the clear objectives and goals to minimize the carbon footprint of the development set out in the SEFC Development Plan affirmed the City's final decision.

Figure 15: Map of underground distribution in SEFC.[245]

After deciding that installing a DES would be the best option in supporting carbon neutrality, the City decided to use sewer heat recovery over biomass. This decision was made primarily because of the public resistance to biomass, related to the perceived negative impacts and risks associated with obtaining the necessary air emissions permits from Metro Vancouver.[246] Completed in 2010, the False Creek Energy Centre (FCEC), designed to house four heat pumps and three large boilers, uses a heat exchange process that is integrated into the City of Vancouver sewage pump station. In total, 70% of the NEU energy is produced by waste water recovery and the remaining 30% of its heat is supplied by high-efficiency natural gas boilers.[247] A series of underground distribution pipes connect the SEFC to the surrounding buildings, shown in Figure 15. In addition, each building has an Energy Transfer Station that distributes the heat and hot water to buildings. While sewer heat recovery is the main source of energy, the system has been designed to use other energy sources, including renewable sources, which helps to keep the system up to date with technological advancements.[248] To date, the SEFC development has installed three solar thermal panels that contribute to the energy supply for the community.

A key attribute of the FCEC is that it serves as a public art piece. The public expressed concern over where the energy plant would be located and the overall aesthetics of the plant. Through several rounds of public engagement, the City of Vancouver decided to install the energy centre underground and turn the system's emissions stacks, which are located above ground, into a community landmark.[249] Through art competitions, the winning design is meant to instill human quality to the system by representing a human hand. The 'fingernails' of the hand use LED fixtures that change colours to represent the amount of energy produced by the system.[250] Today, the energy centre provides tours to the public helping to spread knowledge on the benefits of the system. Overall, including the public in the development of the energy centre allowed for the City of Vancouver to transform the plant into an educational platform. This also helped with the marketing of the project.

Land Use and Expansion

The City of Vancouver has strong goals to become the Greenest City in the world by 2020. One of the City's objectives under this plan is to emit zero carbon. The City began moving towards this goal by recognizing the opportunity to install a district energy system in SEFC. The successful implementation of the SEFC DES has set a strong precedent for seeking out other areas in the City where a DES could be installed. Currently, the City is mapping out potential future sites and has recognized that areas that are being developed to support high density and a mix of uses are prime candidates for installing a DES, similar to the SEFC development.[251] In particular, in June 2012, Council approved the expansion of the NEU to the Great Northern Way Campus Lands and adjacent lands in the False Creek Flats South Area.[252] In addition, the Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines-9772 has identified three additional target areas: the Downtown, Central Broadway, and the Cambie Corridor, indicated in Figure 16. It was noted in this report that high density areas or areas seeking rezoning approval for redevelopment for mixed use are prime candidates for connection to the network.

The City recognizes that there are high up-front capital costs for installing a DES. In the case of SEFC, the City was able to mitigate this financial burden by staging the construction of the project with installed floor area.[253] This included delaying installing the most capital-intensive portion of the project towards the end of the district's build-out when a certain demand threshold was achieved.[254]

In SEFC, the City of Vancouver has used policy to enforce connection to the NEU. The Energy Utility System Bylaw 9552 makes it compulsory for new buildings proposed for construction or existing buildings with renovations larger than $95,000 within the boundary of SFEC to connect to the NEU.[255] In addition, there is a provision within this bylaw that allows permissive use, meaning developers need to apply to the city in order to connect, of the energy system for buildings in the vicinity of SEFC.[256] The City Engineer is the approval authority for such cases and judges by a set of criteria found within the bylaw. Rezoning policy is also used to help secure connections of new developments.[257] These policy tools are used to ensure that the DES establishes economies of scale, which in turn, make the cost for heating and hot water lower for the consumers connected the system.

The land use objectives are set out in the SEFC Development Plan, which speak to ensuring that the development remains a high-density, mixed use community.[258] This reiterates one of the common themes of the case studies in this report, which is that a DES is most economically viable in dense urban areas (as seen in North Vancouver, UniverCity, and Copenhagen).

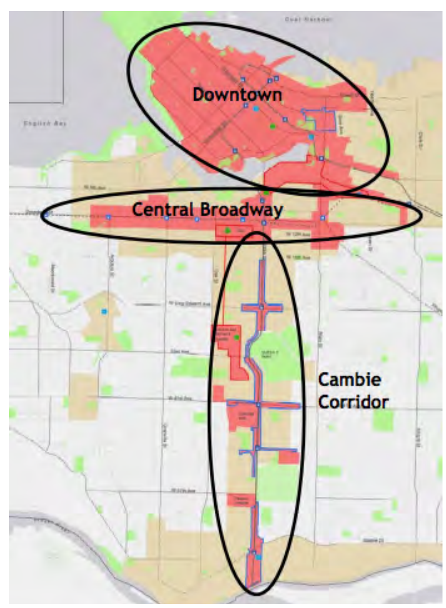


Figure 16: Areas identified by the City of Vancouver that would best be suited for DE.[259]

Growing Client Base

As mentioned in the section above, legal documents are used to enforce connection to the NEU. These policies ensure that the growth of the DES will occur in areas that are supportive of district energy. Because the City of Vancouver retains ownership of the NEU, they have also arranged the financing of the project. The City has placed a Return on Investment to the utilities owners, which is the City of Vancouver, so that the NEU can attract future private buyers if the City decides to sell the utility to the private sector in the event that the public would be best served by an investor-owned, rate regulated utility.[260]

System Governance

The City of Vancouver is a charter city, meaning that its governing system is defined by the Vancouver Charter*,* rather than by provincial legislation. As such, it is not regulated by the *Local Government Act*. This is important to note because the Province of British Columbia amended the *Charter* to give the City the authority to be able to own and operate an energy utility.[261] In British Columbia, municipalities are allowed to set up their own utility governance structure and are thus not governed by the British Columbia Utilities Commission (BCUC).[262] This allowed the City of Vancouver to establish an energy utility, the NEU, and to create principals that govern the utility. The governance of the NEU is done through regulations set out in the Energy Utility System By-law No.9552, as discussed above.

To date, the City of Vancouver remains the owner and operator of the NEU. The City has maintained ownership and continued operations largely due to the tight schedule of the construction because of the link to the Olympics in 2010, which prevented them to secure enough time for procurement. Since the NEU is only available to a small subset of Vancouver's taxpayers and is in competition with other private-sector energy providers, it operates as its own commercial business and takes no money from Vancouver's tax payers.[263]

The rates are set by the NEU Expert Rate Review Panel (ERRP), who are a group of individuals with expertise in the fields of finance, utility rate setting, and who are appointed by City Council. Because the NEU is municipally owned, the rates are not subject to regulations of the BCUC; however, the municipal governance structure is similar to the regulations under BCUC.

Funding for the development of the SEFC DES came from three separate sources, which are:

- A provincial grant provided by the Government of Canada's federal Gas Tax Transfer fund.
- A 20-year loan from the Federation of Canadian Municipalities (FCM) Green Municipal Fund (GMF).
- Interim financing through the City of Vancouver's Capital Financing Fund (CFF).[264]

Lessons Learned

The case of South East False Creek offers learning opportunities largely with respect to governance. Some of the key lessons learned include:

- Public engagement and consultation is a necessary step in the implementation of a DES. The SEFC illustrates that engaging the public can evolve into an educational platform and bring the community together by transforming an otherwise aesthetically unappealing energy centre into a community art piece.
- City bylaws are effective in ensuring the successful expansion of a DES. It is important to work closely with municipal governments to ensure that land use planning tools are effectively employed. This will help to secure clients and expand the system.
- Seeking out areas of the city that are either being redeveloped, densified, or newly constructed pose as best locations for installing a DES.

St. Paul, MN District Energy System

Overview

St. Paul, Minnesota is home to one of North America's most successful district energy systems, which began with the need to upgrade the existing aging infrastructure. In the wake of the 1970s energy crisis, St. Paul recognized the need to find more sustainable energy options. As such, St. Paul capitalized on this opportunity and pushed to incorporate district energy into their city grid.

District Energy St. Paul, which is operated and managed by Ever-Green Energy, was established by the City in 1983.[265] The DES has now been in operation for three decades and currently heats over 190 buildings and 300 single-family homes and cools more than 100 buildings in the downtown and adjacent areas.[266] The current system uses a variety of fuel sources, including biomass and solar. In 2003, St. Paul built the nation's largest wood-fired combined heat and power (CHP) plant.[267] In 2011 St. Paul's DES installed solar panels, which were the first in the United States to be integrated into a DES.[268]

Land Use and Expansion

St. Paul has taken advantage of dense urban forms to support the DES and is a prime example of taking an integrated planning to DES expansion. The City of St. Paul has worked closely with the transportation, urban planning, and energy sectors, which has allowed them to seek out opportunities to expand the DES cost-effectively.[269] The City capitalized on the construction of the Light Rail Transit (LRT) line that was being installed in 2010 by simultaneously installing district energy infrastructure, allowing the system to be expanded by 11-kilometres to reach large industrial users.[270] As a result, this expansion offered an opportunity to incrementally expand the customer base.[271] Developing or expanding the system alongside transit lines greatly encourages connections because economies of scale are more easily met in dense urban areas. Considering that roughly 60% of the costs for installing district energy comes from pipe installation, correlating expansion with new developments and/or transit oriented development initiatives reduces these initial up-front capital costs.[272]

Growing Client Base

St. Paul was faced from the beginning with the challenge of retrofitting old buildings and making district energy appealing to property owners. The energy crisis of 1970 made the City of St. Paul eager to find alternative solutions to the city's energy needs. Through a public-private partnership between the City of St. Paul, the State of Minnesota, the U.S. Department of Energy, and downtown businesses, a feasibility study to replace the City's aging district steam heating system was initiated.[273] A challenge, however, was finding incentives for property owners to connect to the system because of the high up-front capital cost for installation. To overcome this barrier, St. Paul established an Energy Reinvestment Revolving Loan Fund to offset the cost of converting buildings.[274] This fund was established by the St. Paul Foundation at the request of the mayor of St. Paul to assist non-profit customers in paying for building retrofits.[275] It was funded by $2.6 million in grants and long-term loans from a variety of foundations and corporate donors.[276] This helped to secure clients in the early phases, which in turn encouraged the growth of the DES.

While financial incentives have helped establish a strong client base and expand the system, other marketing tools have been used to encourage connections. For example, the City recognized that there were great discrepancies in building conditions, which affected the initial capital costs of retrofitting and installing the infrastructure needed to support a DES. As such, District Energy St. Paul responded to this issue by creating a comprehensive marketing program to educate owners about the wide range of design, financial, and logistical challenges associated with connecting each building to the DES and the associated solutions.[277]

System Governance

The DES system in St. Paul was launched in 1983. Originally the project was a public-private partnership between the City of St. Paul, State of Minnesota, U.S. Department of Energy, and the downtown business community, with New corporate entities being formed to help implement the project.[278] Ever-Green Energy was formed to help develop the project and Cinergy joined the project and put up the financial capital. State biomass legislation, on the other hand, facilitated the development of the project.[279] As mentioned, the required capital led the city to come into an agreement with an external financial partner. There was also supportive federal legislation that made the biomass portion of the project doable. The final "compromise" legislation established by the federal government created new mandates for renewable energy.[280] In addition, there was strong local leadership, which set out clear goals and established pathways to achieve these goals.[281]

Today, District Energy St. Paul is a private, non-profit utility corporation that is governed by a seven-member board. Three members are appointed by the local government, thee members are selected by customers, and the seventh is selected by the 6 other members.[282] Under District Energy St. Paul, a series of non-profit affiliated companies have been developed, which are as follows:

- Market Street Energy oversees the management of the DES.
- District Cooling St. Paul provides district cooling to downtown St. Paul.

- Ever-Green Energy was created to develop biomass-fueled CHP and to manage operations of District Energy St. Paul.
- St. Paul Cogeneration owns and operates the St. Paul CHP plant.
- Environmental Wood Supply locates, collects, processes, and hauls wood waste to the CHP facility.
- Energy Innovations develops deep-water cooling renewable energy projects.[283]

The financial capital that allowed the DES in St. Paul to flourish was derived from a variety of sources. Financing mechanisms included floating rate revenue bonds, federal grants, and equity loans.[284] To be able to secure these financing mechanisms, District Energy St. Paul had to establish long-term contracts with customers.[285] Working as a non-profit system, the DES is able to put an estimated $12 million annually back into St. Paul's local economy.[286]

Lessons Learned

The case of St. Paul, Minnesota offers learning opportunities with respect to both governance and planning. Some of the key lessons learned include:

- Strong leadership from the beginning of implementation from local and federal governments aid in the success of installing and expanding a DES.
- Integrative energy planning is crucial so as to not miss any opportunities to mitigate high up-front capital costs and to expand the system.
- Marketing the DES project in a way that educates the public and business clients pose as significant solutions to gain a client base.

Sydney, AUS Trigeneration Master Plan

Overview

The City of Sydney has caught on to the global trend of sourcing out alternative energy supplies that reduce the negative externalities that are attributed to the use of coal-dominated energy plants. Under the Sustainable Sydney 2030 strategic plan, the City of Sydney is striving to become a green and global city. The plan details that Sydney is aiming to reduce its greenhouse gas (GHG) emissions by 70% below 2006 levels and will meet 100% of electricity demand by local generation by 2030.[287] Because 80% of Sydney's GHG emissions are derived from coal fired power plants, it is mandatory that all coal fired power plants are replaced by centralized energy generation so that their reduction targets can be met.[288] Hence, the city hired Kinesis to develop the City of Sydney's Decentralized Energy Master Plan (DEMP), which will be used to guide Sydney in achieving their emission reduction targets.

While the City of Sydney does not have a large-scale DES in place, this case study is useful because it exemplifies the need for cohesive city-wide energy planning. It recognizes that installing a DES will not occur over night and that it will take time to implement efficiently. The DEMP is a document that guides the City of Sydney in investing and installing district energy infrastructure and highlights key areas of the city that would be best suited for a DES. As such, the DEMP is not a business case, but a guiding document that will help the City of Sydney realize its potential in installing DESs across the city.

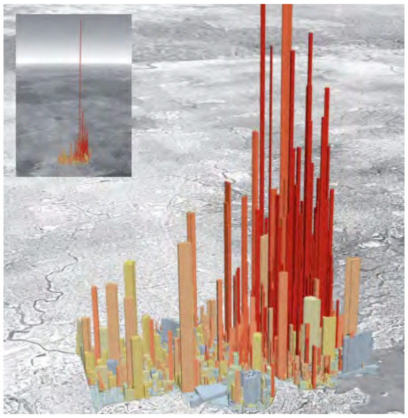


Figure 17: A display of the amount of GHG emissions through vertical height and intensity through color i.e. the greater the stake the higher emissions and the darker the colour the greater the intensity.[289]

Land Use and Expansion

A very important aspect of the DEMP is that it moves away from the conventional view of city building. Alternatively, it moves towards recognizing the built form of the city and its interrelatedness to the city's energy consumption. To recognize this, Kinesis used the City's land use and floor space data along with metered electricity and gas consumption data to map out the city's energy and thermal demands.[290] This technology created a spatial representation of the buildings and land uses in the city that have the most significant energy demand and emit the greatest GHG emissions, shown in Figure 17, allowing for the easy identification of areas that would be best served by a DES. These maps led to Kinesis identifying priority areas within the City of Sydney, which they have termed Low Carbon Infrastructure Zones, shown in Figure 18.

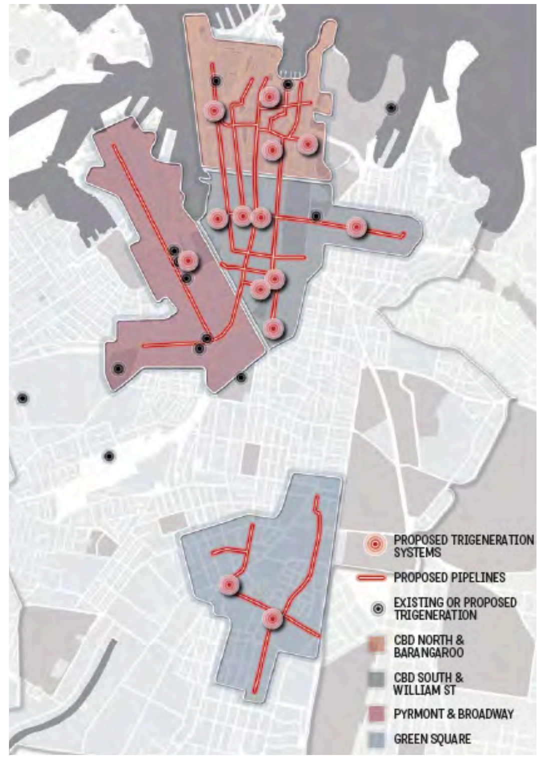


Figure 18: Low Carbon Infrastructure Zones.[291]

These zones would best support low carbon electricity and zero carbon energy for hot water, heating, and cooling.[292] In the DEMP, it was highlighted that to achieve emission reductions, implementing centralized energy within these Low Carbon Infrastructure Zones must not be done on a building by building basis. Rather, the DEMP recognizes that the most successful way to achieve GHG emission reduction targets is to connect buildings to a DES within these specified areas. Outside of these areas, alternative emission reduction initiatives will be used.[293] Currently there are five trigeneration plants operating in the city with an additional 10-15 new plants being installed in the Low Carbon Infrastructure Zones. The DEMP also recognizes that as the city grows, urban areas that increase in density will warrant the development of smaller scale trigeneration networks that connect multiple buildings.[294]

Trigeneration is the simultaneous production of electricity and the exploitation of waste heat from the generation process to serve heating and hot water needs while also using this heat to fuel electric chillers to provide cooling services.[295] Because Sydney has a warm climate year-round, the ability to generate cooling simultaneously with the production of hot water will greatly reduce the city's GHG emissions. In fact, because the engine will be powered by gas rather than coal, it will produce 40% less GHG emissions.[296]

Growing Client Base

The DEMP outlines 13 enabling actions that would assist in the implementation and delivery of the proposed energy network.[297] The plan fully recognizes that the city alone cannot implement the plan. Rather, there is the recognition that the business community along with the State and Federal governments need to work collaboratively with the City of Sydney to transform this plan into a reality.[298] Moreover, the DEMP highlights the fact that there is no single entity in the public or private sectors that can implement the project of this scale on its own.

Governance Structure

Currently, it remains unclear as to what the governing structure will look like for the City of Sydney's city-wide DES. This case study was useful to illustrate that a clear planning framework is necessary for successful DES expansion.

Lessons Learned

The case of Sydney, Australia offers vast learned opportunities with respect to the planning of district energy systems. Some of the key lessons learned include:

- Having a cohesive and well researched energy plan, such as the Decentralized Energy Master Plan, allows for clear guidance on the steps towards how to go about implementing a DES within a city.
- Installing a DES involves a variety of stake holders, not just one. As such, this will require immense participation and collaboration between the public and private sectors for the installment of a DES to be successful.
- Looking at the built form within a city in relation to its energy consumption is an important tool in identifying areas within a city that are the best contenders to install a DES. Heat mapping is very useful for mapping out high-energy consumption areas across a city.
- Some of the key enabling actions found within this document are interchangeable for other DES projects. Examples of interchangeable actions include:
  - Incentivizing energy efficiency and low carbon energy;
  - standardizing connection fees for gas and electricity networks;
  - modification of development control plans to reflect areas that are best suited for DE;
  - making provincial and federal funds available;
  - introducing environmental upgrade agreements to new developments; and,
  - streamlining provincial environmental planning policy for DE.

Vingåker, SWE District Energy System

Overview

The municipality of Vingåker is a small regional centre of roughly 9,000 people in central Sweden.[299] As a minor system in a small town, the Vingåker DES (VDES) is an excellent example of the importance of effective governance systems and business models to the success of a DES. Run primarily using biofuel, the VDES serves a collection of individual homes, multi-family residences, and industrial properties throughout the municipality and is operated by a private corporation that provides district energy services across the country.[300] However, this was not always the case. Up until very recently, the VDES customer base was almost completely dominated by the municipality itself.[301] This consolidation of customer base along with a poorly regulated and designed governance and business structure ultimately led to the total bankruptcy of the VDES in 2004 and subsequent purchase by the above mentioned national corporation.[302] As a result, this example offers unique insight into the governance and business model roadblocks that need to be avoided to ensure financial sustainability in the long-term evolution of a DES.

Historical Context

The VDES was originally created as the result of a public procurement process in 1998 to select a company that would develop the system and then sell power to the municipality.[303] This procurement process is very common in Sweden, where DES has been widespread since the 1980s and private systems with public contracts have been increasingly common since the late 1990s.[304] As a result, the stakeholders involved in establishing the system and public contract were confident that the system would be effective in the long term – a conclusion bolstered by numerous bids from interested companies.[305] In sum, a typical public procurement process was followed with a resultant regulatory and governance process. A total of 115 district heating customers were connected on a distribution system roughly 13 kilometres long, run with wood chip fuel inputs.[306]

Unfortunately, the typical structure of contract did not pan out as expected. In Swedish systems, contracts for DES services normally involve some form of a regulated rate. This regulation is derived from concerns about the "natural monopoly" that a DES forms, given the high cost of entrance to market and the comparative advantage that existing providers have over new entrants.[307] This natural monopoly therefore makes it easy for existing providers to overcharge customers, as there are no short-term alternatives. As such, a regulated rate was introduced that sets maximum rates, which in the Vingåker example is a 15-year fixed-price system.

In the Vingåker example, this regulated rate failed to respond to market conditions from the outset. The initial contract holder invested heavily in technologies that did not pan out as intended and fuel input costs jumped unpredictably due to difficulty in sourcing high quality wood chips and the need for expensive additives to fuel, leading to multiple transfers of ownership from 2002 through 2004.[308] Despite numerous bids from private companies approximating the fixed-price contract value, unexpected changes in input costs made the investment increasingly unfavourable. Ultimately, the company that held the contract in 2004 was faced with the reality of long-term financial infeasibility and declared bankruptcy.

Dealing with Bankruptcy

As the 2004 declaration of bankruptcy was entirely unexpected at the outset, little preparation had been done in terms of regulation to address the possibility of it happening. This left creditors with a strong 15-year fixed-price contract to deal with, and no possibility of carrying it out with financial success. On the other hand, a range of customers, including the municipality, were faced with sudden unpredictability in receiving heating, an essential service in the cold climate of central Sweden.

The essential nature of the DES services left the customer base at a disadvantage. The bankruptcy estate representing creditors took advantage of the situation and presented an ultimatum in early 2005: the municipality would have to accept a new contract at more favourable rates or face a discontinuation of their heating supply during the freezing month of January.[309] As the company was in total bankruptcy, the municipality had no recourse against this action, as there were no assets remaining to go after if services were to be discontinued.

This situation spiraled into a highly politicized and public fight, with local politicians and officials putting off the deadline by offering press releases stating that the contract remained in place. The bankruptcy estate threatened more specific service discontinuation that would result in irreparable infrastructure damage, including burst pipes and building damage.[310] The dispute escalated into a court case in March 2005, during which the creditors to the bankruptcy estate were seeking a new long-term owner of the DES and the municipality was beginning to transfer some properties to individual pellet-fueled boiler heating systems.[311]

In December 2005, the creditors found a new buyer for the system, Rindi Energy AB. With the municipality facing an ongoing lawsuit from the bankruptcy estate and creditors, and the new owners facing a potential transfer of the largest portion of their customer base to different heating systems. Both parties at this point had an incentive to end the dispute and enter into a rewritten contract. Starting with a clean slate, Rindi Energy AB, the municipality, and other contractors negotiated a more realistic rate system that would ensure no overpayment for the municipality but offer long-term feasibility for the provider. Additionally, Rindi Energy AB began a process of considerable expansion in order to diversify their customer base and insulate against the threat of infeasibility from one contract falling through.[312]

Lessons Learned

The Vingåker case study offers excellent evidence of the importance of effective governance and business models for DES implementation. Despite following typical conventions in procurement and operation, the VDES faced catastrophic financial failure from the outset due to improper rate contracts. An ineffectual governance system then exacerbated bankruptcy proceedings due to the complete lack of established processes for renegotiation and the subsequent politicization of the process.

This is not in itself evidence of the failure of a private DES offering to public clients. A public offering could have experienced the same financial feasibility, but then been forced to subsidize the service with ever increasing taxpayer investment. This would be a particular threat if the public owner of the system were to offer services to an expansive customer base including other levels of government and private property owners. This case is evidence that governance systems and business models need to be flexible, proactive in adjusting to changing conditions, and organized in a manner that promotes cooperative negotiation. Specific lessons learned include:

- Rate regulation systems need to be adequately flexible to ensure that long-term financial feasibility is possible in the face of changing economic conditions.
- Contracts for all service provision need to incorporate a mechanism to deal with financial infeasibility should it occur, including methods of service continuation, contract renegotiation, and the transfer of existing system infrastructure.
- Governance systems should involve all key stakeholders in strategic planning and decision making to ensure the transparent flow of information and to prevent adversarial and politicized conflicts.

Appendix D: Maps

Shapefiles	Last updated	Created	Source	Source Description	Modificatons/Display
City of Ottawa					
Urban buildings	October 31,2017	January 20, 2017	City of Ottawa OpenData	http://data.ottawa.ca/	No modifications to data. Urban buildings were categorized by building footprint in square metres. Buildings with footprint of less than 547 were not displayed.
Secondary Plans	November 1, 2017	May 29, 2016	City of Ottawa OpenData	http://data.ottawa.ca/	No modifications to data. One map categorizeds secondary plans for display by plan name.
Roads	October 31,2017	August 24, 2015	City of Ottawa OpenData	http://data.ottawa.ca/	No modifications to data.
Industrial and Business park boundaries	July 6, 2016	July 6, 2016	City of Ottawa OpenData	http://data.ottawa.ca/	No modifications to data.
Community Design Plans	November 29, 2017	May 29, 2016	City of Ottawa OpenData	http://data.ottawa.ca/	No modifications to data.
Mixed Use Areas		November 20, 2017	City of Ottawa Official Plan Schedule B PDF	http://documents.ottawa.ca/sites/documents.ottawa.ca/files/schedule_b_en_4.pdf	Digitized mixed use policy area polygons based upon pdf document, showing drawing of area.
600m Transit Area		November 20, 2017	City of Ottawa Transit Stops PDF	http://maps.ottawa.ca/geoottawa/ - Planning layer - 600 metre zoning bylaw area around transit	Georeferenced PDF using roads shapefile. Then, digitized points for approximate centre of transit stop buffer. After points shapefile was created, a 600 metre buffer was geoprocessed around each point.

Shapefiles	Last updated	Created	Source	Source Description	Modificatons/Display
Ville de Gatineau					
700m Transit Area		November 20, 2017		http://www.sto.ca/fileadmin/user_upload/communications/PDF/Carte_reseau/Carte_reseau.pdf	Digitized points for approximate centre of transit stop buffer by visually referencing PDF. After points shapefile was created, a 700 metre buffer was geoprocessed around each point.
Original Files					
New District Energy Pipes		November 20, 2017	ESAP Service Area Sketches (FVB Energy Inc)	PDF of ESAP PSOS	Using PDF as a visual reference compared to aerial imagery in GIS, digitized piping to create polyline shapefile. The line segments were then categorized in a new table column for type. Type was then used for display purposes for each category.
Existing Users		November 20, 2017	City of Ottawa Urban Buildings shapfile		Selected individual buildings showing piping leading to the building from New Distirct Energy Pipes shapefile and Urban Buildings shapefile to create new shapefile from selection.
Original Files					
Large buildings		November 20, 2017	Esri, HERE, DeLorme, MapmyIndia, OpenStreetMap contibutors, and the GIS user community	GIS Basemap	Created polygons based upon outline from GIS basemap of existing buildings in Gatineau near the DES piping. Visually determined size over 547 square metres based upon identification of approximate size of footprints.

Table 1: Metadata information used for GIS mapping.

Figure 1: This map shows all of the transit areas, mixed use policy areas, secondary plan areas, and community design plan areas relative to the existing and proposed PSPC. DES infrastructure.

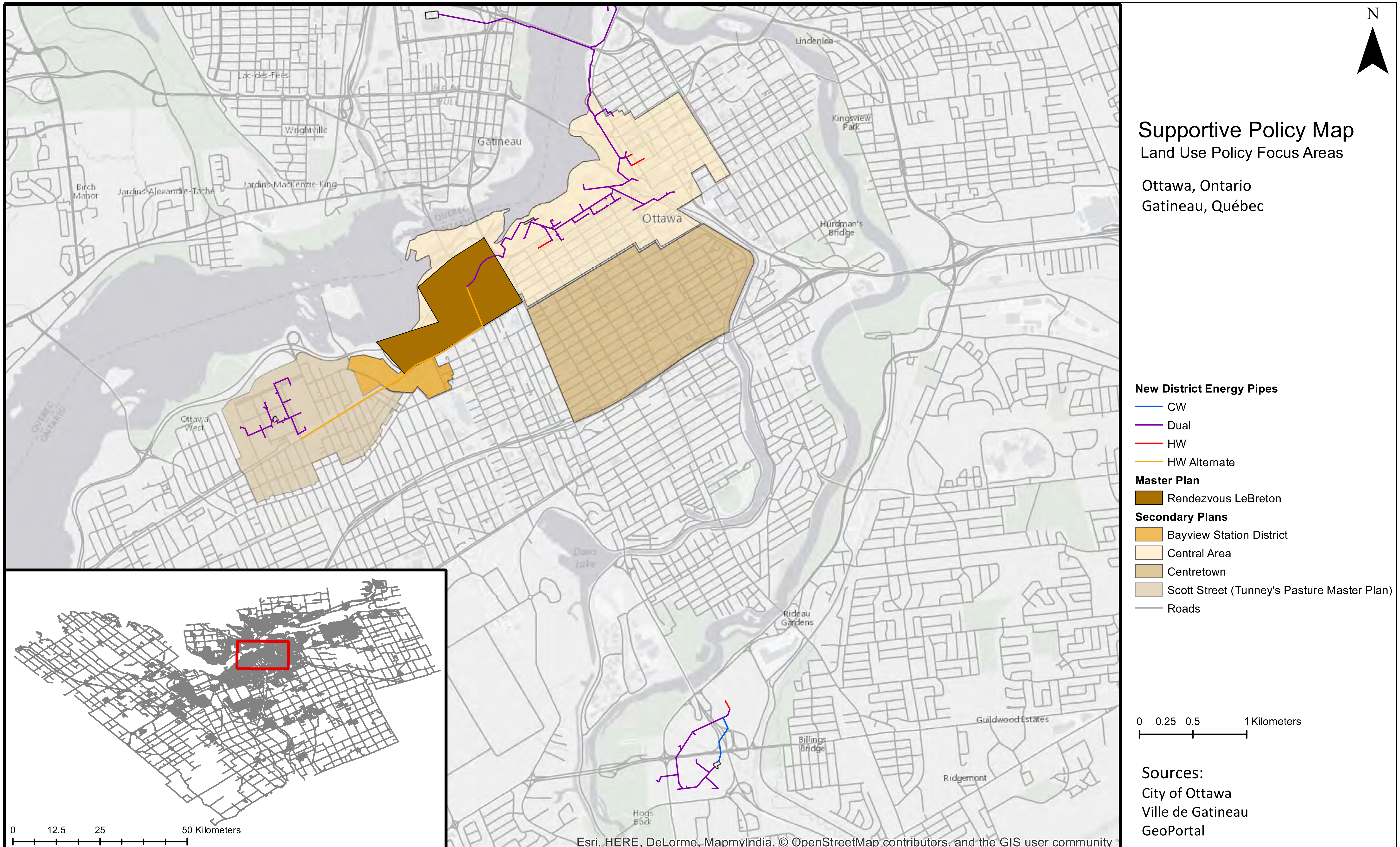


Figure 2: This map shows all of the policy areas deemed supportive of DES expansion.

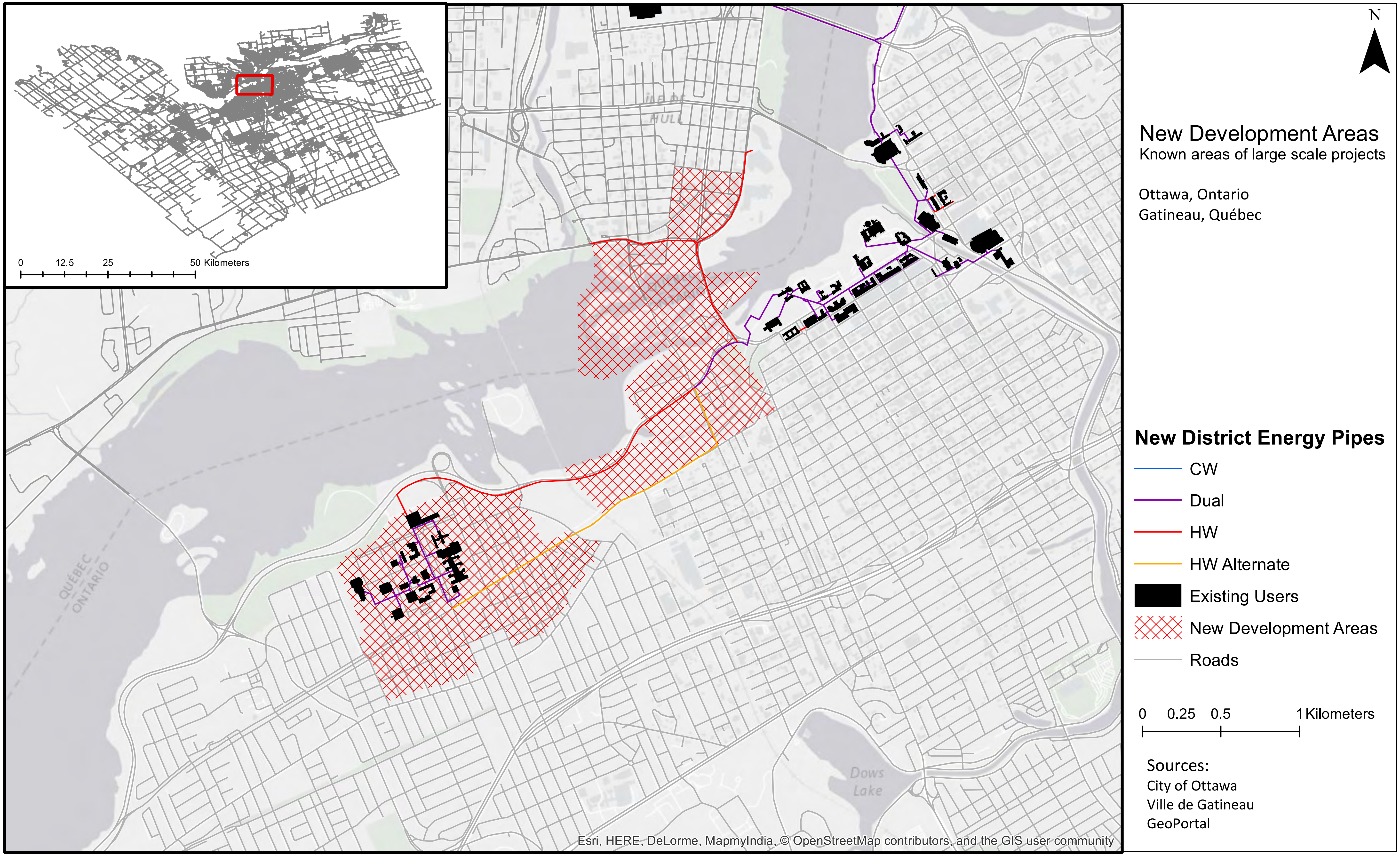


Figure 3: Mapping of the identified new development areas.

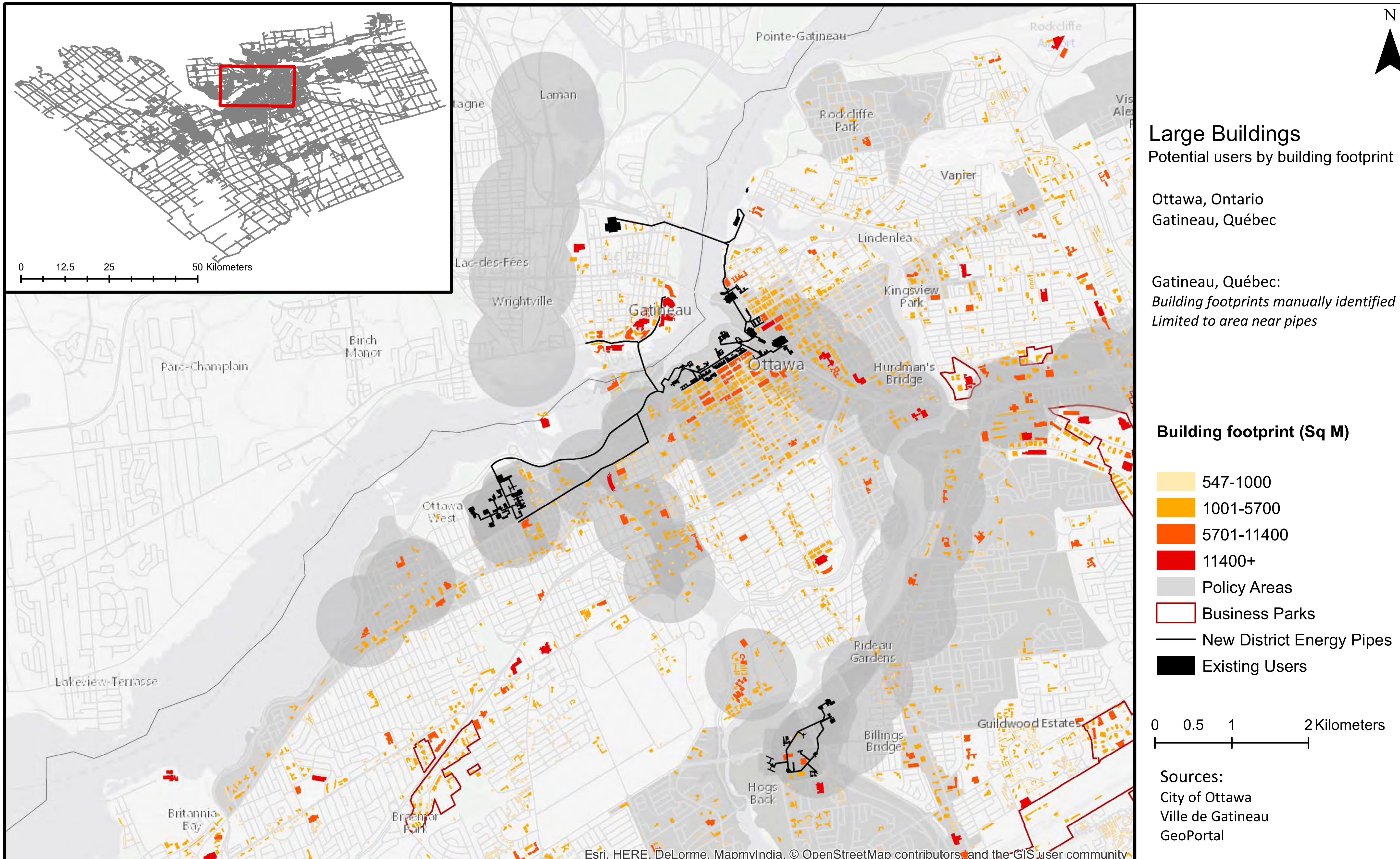


Figure 4: Mapping of the large buildings within the policy areas deemed supportive of DES expansion.

Figure 5: Key priority areas for DES expansion in the NCR as identified through the land use analysis.

[1] Aberdeen City Council. (2013, August 24). Aberdeen firm powers its way to global green award. Retrieved from http://www.aberdeencity.gov.uk/CouncilNews/ci_cns/pr_AHPGLobalAward_240913.asp

[2] Aberdeen Heat and Power Ltd. (2015). Aberdeen Heat and Power. Retrieved from http://www.aberdeenheatandpower.co.uk/

[3] Hawkey, D., Webb, J., and Winskel, M. (2013). Organisation and governance or urban energy systems: district heating and cooling in the UK. Journal of Cleaner Production: Advancing Sustainable Urban Transformation. Retrieved from http://www.citsee.ed.ac.uk/__data/assets/pdf_file/0012/88869/JCPOrgGovEnergyV9.pdf

[4] Aberdeen Heat and Power Ltd. (2015).

[5] Aberdeen Heat and Power Ltd. (2015).

[6] Hawkey, D. Webb, J., and Winskel, M. (2013).

[7] Hawkey, D. Webb, J., and Winskel, M. (2013).

[8] Aberdeen Heat and Power Ltd. (2015).

[9] Aberdeen Heat & Power. (2016). District Heat Networks in Aberdeen. Retrieved from http://www.aberdeencity.gov.uk/CouncilNews/ci_cns/pr_AHPGLobalAward_240913.asp

[10] Aberdeen Heat & Power. (2016).

[11] Hawkey, D. Webb, J., and Winskel, M. (2013).

[12] Aberdeen Heat and Power Ltd. (2015).

[13] Edwards, J. (2016). District Heating in Aberdeen. Retrieved from http://www.aberdeenheatandpower.co.uk/wp-content/uploads/2016/07/District-Heating-Newsletter-1.pdf

[14] Edwards, J. (2016).

[15] Aberdeen Heat & Power. (2016).

[16] Hawkey, D. Webb, J., and Winskel, M. (2013).

[17] Aberdeen Heat & Power. (2016).

[18] Aberdeen Heat & Power. (2016).

[19] Aberdeen Heat & Power. (2016).

[20] District Energy Aberdeen Limited. (2017). Directors' Report and Financial Statements. Retrieved from https://beta.companieshouse.gov.uk/company/SC458298/filing-history

[21] Decentralized Energy. (2014). City Heating Schemes: Leading the UK CHP Awards. Retrieved from http://www.decentralized-energy.com/articles/print/volume-15/issue-1/features/city-heating-schemes-leading-the-uk-chp-awards.html

[22] UNEP. (n.d.). District Energy in Cities: Unlocking the full potential of energy efficiency and renewable energy. Retrieved from file:///Users/StefEkeli/Downloads/District_Energy_Advanced-summary_12pager_lowres-2-.pdf

[23] Islington Council. (n.d.). Bunhill Heat and Power: Case Study. Retrieved from https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=ae95be02-aefe-0f9c-456e-e98c32d506b8&forceDialog=0

[24] Islington. (n.d.) Bunhill heat network. Retrieved from https://www.islington.gov.uk/energy-and-pollution/energy/bunhill-heat-network

[25] Islington Council. (n.d.) Bunhill heat network. Retrieved from https://www.islington.gov.uk/energy-and-pollution/energy/bunhill-heat-network

[26] Islington Council. (n.d.). Bunhill Heat and Power: Case Study. Retrieved from https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=ae95be02-aefe-0f9c-456e-e98c32d506b8&forceDialog=0

[27] Islington. (n.d.).

[28] UNEP. (n.d.).

[29] Decentralized Energy. (2014). City Heating Schemes: Leading the UK CHP Awards. Retrieved from http://www.decentralized-energy.com/articles/print/volume-15/issue-1/features/city-heating-schemes-leading-the-uk-chp-awards.html

[30] Islington Council. (n.d.). Guidelines for connecting to the heat network. Part 1: A guide for developers and building owners. Retrieved from https://www.islington.gov.uk//~/media/sharepoint-lists/public-records/energyservices/information/guidance/20152016/20160310connectionsguidepart1

[31] Tipper, H.A. (2013). Decentralized energy: powering a sustainable future. Carbon Trust. Retrieved from https://www.carbontrust.com/news/2013/01/decentralised-energy-powering-a-sustainable-future/

[32] Islington. (n.d.).

[33] Vital Energi. (n.d.). Islington Borough Council Bunhill heat and Power. Retrieved from https://www.vitalenergi.co.uk/london/case-studies/?q=Islington%20Borough%20Council%20Bunhill%20Heat%20and%20Power&slug=bunhill

[34] City of Burlington. (2014). Community Energy Plan. Retrieved from: https://www.burlington.ca/en/live-and-play/resources/Environment/Burlington_Community_Energy_Plan.pdf. Pg. 8.

[35] City of Burlington. (2014). Pg. 8.

[36] City of Burlington. (2014). Pg. 9.

[37] City of Burlington. (2014). Pg. 10.

[38] City of Burlington. (2014). Pg. 29.

[39] City of Burlington. (2014). Pg. 19-20.

[40] City of Burlington. (2014). Pg. 11.

[41] City of Burlington. (2014). Pg. 19-20.

[42] City of Burlington. (2014). Pg. 45-67.

[43] City of Burlington. (2014). Pg. 57.

[44] City of Burlington. (2014). Pg. 16.

[45] Burlington Hydro. (2015). City Awarded Grant for Feasibility Study re: District Energy Options. https://www.burlingtonhydro.com/your-bhi/news-announcements/435-city-awarded-grant-for-district-energy-feasibility-study.html

[46] City of Burlington Capital Works. (2016). Community Energy Feasibility Study – Phase 1 Results. Retrieved from: https://www.burlington.ca/en/live-and-play/resources/Environment/Energy/CW-01-16-Community-Energy-Feasibility-Report.pdf. Pg. 7.

[47] City of Burlington Capital Works. (2016). Pg. 3.

[48] City of Burlington Capital Works. (2016). Pg. 4.

[49] City of Burlington Capital Works. (2017). Community Energy Feasibility Study – Phase 2 Results. Retrieved from: https://www.burlington.ca/en/your-city/resources/CW-08-17-Integrated-Community-Energy-System-Phase-2.pdf. Pg. 8.

[50] City of Burlington. (2014). Pg. 37-43.

[51] City of Burlington. (2014). Pg. 87.

[52] Li, Cheuk Lam Charling. (2016). District Energy and Sustainable Neighbourhood Planning: A Study of the Burnaby Mountain DES. University of Waterloo Master of Urban Studies Thesis. Retrieved from: http://summit.sfu.ca/item/16122

[53] SFU Community Trust. (n.d.) About Us: History. Retrieved from: http://univercity.ca/about-us/history/

[54] Corix. (2017). Burnaby Mountain District Energy Utility Project. Retrieved from: http://www.corix.com/services/energy-systems/burnaby-mountain-district-energy-utility

[55] Corix. (2017). BCIT Low Carbon DES Workshop. Burnaby Mountain DEU. Retrieved from: https://commons.bcit.ca/factorfour/files/2017/03/Burnaby-Mountain-DEU.pdf

[56] Corix. (2017). BCIT Low Carbon DES Workshop. Burnaby Mountain DEU.

[57] British Columbia Ministry of Finance. (n.d.). Carbon Tax. Retrieved from: http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm

[58] Li, Cheuk Lam Charling. (2016).

[59] SFU Community Trust. (n.d.) Sustainability. Retrieved from: http://univercity.ca/sustainability/

[60] Li, Cheuk Lam Charling. (2016). Pg. 23-24.

[61] Li, Cheuk Lam Charling. (2016). Pg. 45-46.

[62] Li, Cheuk Lam Charling. (2016). Pg. 45-46.

[63] Li, Cheuk Lam Charling. (2016). Pg. 51-52.

[64] Li, Cheuk Lam Charling. (2016). Pg. 55.

[65] Li, Cheuk Lam Charling. (2016). Pg. 58.

[66] Li, Cheuk Lam Charling. (2016). Pg. 60-61.

[67] Natural Resources Canada. (2009). Community Energy Case Studies: PEI Energy Systems Charlottetown, PEI. Retrieved from http://canmetenergy-canmetenergie.rncan-nrcan.gc.ca/fichier/81083/DE%2013%20PEI%20Energy%20Systems%20(ENG).pdf

[68] Enwave Chicago. (2017). Enwave Expands Canadian Presence. Retrieved from http://enwavechicago.com/latest-on-enwave-chicago-and-more/at-enwave/enwave-expands-canadian-presence/

[69] Biomass Energy Resource Center. (2009). In Prince Edward Island's Capital, a Biomass Pioneer Just Keeps on Working. Retrieved from http://www.biomasscenter.org/images/stories/Charlottetown.pdf

[70] Natural Resources Canada. (2009).

[71] Veresen Inc. (2007). PEI Energy Systems Consolidation leads to economic benefits. Retrieved from https://www.iwmc.pe.ca/pdfs/PEI-Energy-Systems9-25-07.pdf

[72] Biomass Energy Resource Center. (2009).

[73] Natural Resources Canada. (2009).

[74] Biomass Energy Resource Center. (2009).

[75] Veresen Inc. (2007).

[76] Dunsky Energy Consulting. (2016). Prince Edward Island Provincial Energy Strategy 2016/17. Retrieved from https://www.princeedwardisland.ca/sites/default/files/publications/pei_energystrategymarch_2017_web.pdf

[77] Biomass Energy Resource Center. (2009).

[78] Veresen Inc. (2007).

[79] Biomass Energy Resource Center. (2009).

[80] Enwave Chicago. (2017).

[81] Natural Resources Canada. (2009).

[82] Fernandez, M.G., Roger-Lacan, C., Gahrs, U. and Aumaitre, V. (2016). "Efficient District Energy Heating and Cooling systems in the EU- Case studies analysis, replicable key success factors and potential policy implications."

EUR 28418 EN. Retrieved from https://ec.europa.eu/jrc/en/publication/efficient-district-heating-and-cooling-markets-eu-case-studies-analysis-replicable-key-success

[83] Baek, M. (June 2017). "Regulation and Planning of District Heating in Denmark." Danish Energy Agency. Retreived from https://ens.dk/en/our-responsibilities/global-cooperation/danish-energy-model

[84] NYC Global Partners' Innovation Exchange (May 25, 2011). "Best Practice: District Heating System- Copenhagen." Retrieved from www.nyc.gov/globalpartners/innovationexchange

[85] Fernandez, M.G., Roger-Lacan, C., Gahrs, U. and Aumaitre, V. (2016).

[86] Danish Board of District Heating (n.d.). "DHC in Denmark." Retrieved from http://dbdh.dk/characteristics/.

[87] Baek, M. (February 2016).

[88] Baek, M. (June 2017).

[89] Danish Energy Authority. (2005). "Heat supply in Denmark- Who, what, where and why." The Danish Energy Authority. Retrieved from http://www.seas.columbia.edu/earth/wtert/sofos/DEA_Heat_supply_in_denmark.pdf

[90] Danish Energy Authority. (2005).

[91] Dyrelund, A. (February 2016). "The Integrated District Heating System in Greater Copenhagen" in District Energy- Energy Efficiency for Urban Areas. The State of Green

[92] Baek, M. (February 2016). "Planning and Regulation- A prerequisite" in District Energy- Energy Efficiency for Urban Areas. The State of Green. Retrieved from https://stateofgreen.com/files/download/9499

[93] Baek, M. (February 2016).

[94] C40 Cities (November 3, 2011). "Case Study-98% of Copenhagen City Heating Supplied by Waste Heat". Retrieved from http://www.c40.org/case_studies/98-of-copenhagen-city-heating-supplied-by-waste-heat

[95] Fernandez, M.G., Roger-Lacan, C., Gahrs, U. and Aumaitre, V. (2016).

[96] Fernandez, M.G., Roger-Lacan, C., Gahrs, U. and Aumaitre, V. (2016).

[97] Baek, M. (June 2017).

[98] Ever-Green Energy. (2017). Duluth Energy Systems. Retrieved from http://www.ever-greenenergy.com/project/duluth-energy-systems/

[99] Ever-Green Energy. (2013). Duluth Steam Master Plan. Retrieved from http://www.duluthenergysystems.com/wp-content/uploads/2013/01/Duluth-Master-Plan-Final_December2013.pdf

[100] Ever-Green Energy. (2017).

[101] Ever-Green Energy. (2013).

[102] Burns, M. and Green, J. (n.d.). Duluth Steam Energy System Transformation. Retrieved from https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=51b8ec82-c78f-c21c-815e-11ac8f8efc7a&forceDialog=0

[103] Ever-Green Energy. (2015). Duluth's Energy Transformation. Retrieved from http://www.duluthenergysystems.com/wp-content/uploads/2015/02/Duluth-Energy-Transformation.pdf

[104] Burns, M. and Green, J. (n.d.).

[105] Ever-Green Energy. (2013).

[106] Ever-Green Energy. (2017).

[107] Burns, M. and Green, J. (n.d.).

[108] Duluth Energy Systems. (2015). What Future Do We Want For Duluth? Retrieved from http://www.duluthenergysystems.com/wp-content/uploads/2016/01/Critical-Upgrades-for-Duluth-Energy-Systems-12.04.15.pdf

[109] Ever-Green Energy. (2013).

[110] Ever-Green Energy. (2013).

[111] Kirov, A. (2017, April 12). Duluth Announces Energy Pilot Project. Fox 21 Local News. Retrieved from http://www.fox21online.com/2017/04/12/duluth-announces-energy-pilot-project/

[112] Ever-Green Energy. (2013).

[113] Haugen, D. (2013, December 10). Duluth seeks to bring steam plant 'into 21st century'. Midwest Energy News. Retrieved from http://midwestenergynews.com/2013/12/10/duluth-seeks-to-bring-steam-plant-into-the-21st-century/

[114] Ever-Green Energy. (2013).

[115] Duluth Energy Systems. (2017). Duluth Energy Systems. Retrieved from http://www.duluthenergysystems.com/

[116] Town of Gibsons. (2014). Geo-exchange Utility. Retrieved from http://www.gibsons.ca/geo-exchange-utility

[117] Town of Gibsons. (n.d.). Gibsons District Energy Utility. Retrieved from http://www.gibsons.ca/geo-exchange-utility

[118] Quest: Quality Urban Energy Systems of Tomorrow. (2017). Gibsons Geo-Exchange Energy Utility (GDEU). Retrieved from http://www.questcanada.org/maps/gibsons-geoexchange-energy-utility-gdeu

[119] Geo-Exergy Systems Inc. (2017). Town of Gibsons- District Energy System. Retrieved from http://www.geoxergy.com/gibsons-district-energy-system/

[120] Geo-Exergy Systems Inc. (2017).

[121] Ed Lohrenz. (2011). Gibsons, BC District Geothermal Energy System. Retrieved from http://www.geoptimize.ca/uploads/2/2/3/6/22361732/gibsons_district_systems.pdf

[122] Ed Lohrenz. (2011).

[123] Ed Lohrenz. (2011).

[124] Real Estate Board of Greater Vancouver. (2017). Gibsons- most livable town in the world. Retrieved from http://www.rebgv.org/gibsons-most-liveable-town-world

[125] Ed Lohrenz. (2011).

[126] Ed Lohrenz. (2011).

[127] Town of Gibsons. (2014).

[128] Town of Gibsons. (2014).

[129] Island Coastal Economic Trust. (2014). Gibsons Geo-Exchange District Energy Utility. Retrieved from http://www.islandcoastaltrust.ca/project/forestry-energy-and-mining/gibsons-geo-exchange-district-energy-utility

[130] Ed Lohrenz. (2011).

[131] Island Coastal Economic Trust. (2014).

[132] Ed Lohrenz. (2011).

[133] Town of Gibsons. (n.d.). Gibsons District Energy Utility. Retrieved from http://www.gibsons.ca/geo-exchange-utility

[134] Ed Lohrenz. (2011).

[135] Town of Gibsons. (n.d.).

[136] Town of Gibsons. (n.d.).

[137] Envida Community Energy. (2013). District Energy Strategic Plan for the City of Guelph. Retrieved from http://guelph.ca/wp-content/uploads/011514_DistrictEnergyStrategicPlan_web.pdf

[138] Hallett, D. (2016, May 18). Guelph looks into future of District Energy after determining projects so far amount to an $8.7-million writeoff. Guelph Mercury Tribune. Retrieved from https://www.guelphmercury.com/news-

story/6559833-guelph-looks-into-the-future-of-district-energy-after-determining-projects-so-far-amount-to-an-8-7-million-writeoff/

[139] City of Guelph. (2017, January 9). City and Envida recoup costs for proposed district energy system. Retrieved from http://guelph.ca/2017/01/city-envida-recoup-costs-proposed-district-energy-system/

[140] Hallett, D. (2016, May 18).

[141] Envida Community Energy. (2013).

[142] Envida Community Energy. (2013).

[143] Envida Community Energy. (2013).

[144] Hallett, D. (2016, May 18).

[145] Hallett, D. (2017, January 6). Guelph sidesteps penalties over power plant cancellations. Guelph Mercury Tribune. Retrieved from https://www.guelphmercury.com/news-story/7053650-guelph-sidesteps-penalties-over-power-plant-cancellations/

[146] Envida Community Energy. (2013).

[147] Envida Community Energy. (2013).

[148] Envida Community Energy. (2013).

[149] Hallett, D. (2017, January 6).

[150] Envida Community Energy. (2013).

[151] Envida Community Energy. (2013).

[152] City of Guelph. (2017, June 28). City Council approves redistribution of Envida's energy assets. Retrieved from http://guelph.ca/2017/06/city-council-approves-redistribution-envidas-energy-assets/

[153] Federation of Canadian Municipalities. (2016). 2012 Energy- Co- winner 1: Rural Municipality of Ritchot, Manitoba. Retrieved from https://fcm.ca/home/awards/sustainable-communities-awards/past-winners/2012-winners/2012-energy---co-winner-1.htm

[154] Federation of Canadian Municipalities. (2016).

[155] Federation of Canadian Municipalities. (n.d.). île-des-Chênes Community Centre District Geothermal Project. Retrieved from https://fcm.ca/Documents/case-studies/GMF/2012/SCAwards_2012_ENERGY_Ritchot_EN.pdf

[156] Federation of Canadian Municipalities. (n.d.).

[157] Federation of Canadian Municipalities. (n.d.).

[158] Federation of Canadian Municipalities. (n.d.).

[159] Federation of Canadian Municipalities. (n.d.).

[160] Federation of Canadian Municipalities. (2016).

[161] Municipality of Ritchot. (2014). île-des-Chênes District Geothermal Energy. Retrieved from http://www.cdem.com/Forum2014/Roger_Perron_-_District_Geothermal_Energy.pdf

[162] Municipality of Ritchot. (2014).

[163] Municipality of Ritchot. (2014).

[164] Manitoba. (2017). Geothermal Heat Pumps. Retrieved from https://www.gov.mb.ca/jec/energy/geothermal/index.html

[165] Manitoba. (2017). Energy Efficiency. Retrieved from https://www.gov.mb.ca/jec/energy/green_bldg.html

[166] The National Capital for Public-Private Partnerships. (2017). The Metropolitan Government of Nashville and Davidson County District Energy System. Retrieved from https://www.ncppp.org/resources/case-studies/energy/the-metropolitan-government-of-nashville-and-davidson-county-district-energy-system/

[167] The National Capital for Public-Private Partnerships. (2017).

[168] GBB Solid Waste Management Consultants. (2017). District Energy System Study and Implementation (Metropolitan Nashville, Tennessee). Retrieved from http://gbbinc.com/services/district-energy-systems/district-energy-system-study-and-implementation

[169] GBB Solid Waste Management Consultants. (2017).

[170] GBB Solid Waste Management Consultants. (2017).

[171] GBB Solid Waste Management Consultants. (2017).

[172] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES System Descriptions. Retrieved from http://www.nashville.gov/District-Energy-System/Technical-Information/System-Descriptions.aspx

[173] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES System Descriptions.

[174] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES System Descriptions.

[175] GBB Solid Waste Management Consultants. (2017).

[176] GBB Solid Waste Management Consultants. (2017).

[177] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES System Descriptions.

[178] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES Customers. Retrieved from http://www.nashville.gov/District-Energy-System/Customers.aspx

[179] Metro Government of Nashville & Davidson County, Tennessee. (2017). DES Customers.

[180] Metro Nashville. (2016). Metro Nashville District Energy Distribution System. Retrieved from http://www.nashville.gov/Portals/0/SiteContent/DistrictEnergySystem/images/NDES%20MAP-REV%2020%20PRESENTATION_021716.pdf

[181] The National Capital for Public-Private Partnerships. (2017).

[182] The National Capital for Public-Private Partnerships. (2017)

[183] Constellation. (2012). A Study in Physical Plant Efficiency: Metro Government of Nashville and Davidson Counties, Nashville, Tennessee. Retrieved from https://www.constellation.com/content/dam/constellation/Case%20Studies/Metro%20Nashville.pdf

[184] The National Capital for Public-Private Partnerships. (2017).

[185] WEG. (October 29, 2012). Constellation Energy's Nashville District Energy Plant Uses WEG Electric Products to Meet the New Demand for Clean Water and Steam. Retrieved from http://old.weg.net/sc/Media-Center/Actualites/Produits-et-Solutions/Constellation-Energy-s-Nashville-District-Energy-Plant-Uses-WEG-Electric-Products-to-Meet-the-New-Demand-for-Clean-Water-and-Steam

[186] Constellation. (2012).

[187] Constellation. (2012).

[188] The National Capital for Public-Private Partnerships. (2017).

[189] The National Capital for Public-Private Partnerships. (2017)

[190] Constellation. (2012).

[191] The National Capital for Public-Private Partnerships. (2017).

[192] The National Capital for Public-Private Partnerships. (2017).

[193] The National Capital for Public-Private Partnerships. (2017).

[194] Quality Urban Energy Systems of Tomorrow. (2017). City of North Vancouver District Energy System. Retrieved from: http://www.questcanada.org/maps/city-of-north-vancouver-district-energy-system

[195] City of North Vancouver. (2017). Lonsdale Energy (LEC). Retrieved from: http://www.cnv.org/city-services/lonsdale-energy

[196] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[197] Lonsdale Energy Corporation. (2009). District Heating in North Vancouver. Retrieved from: https://civicinfo.bc.ca/practices_innovations/district_heating--north_vancouver--2009.pdf

[198] Envida Community Energy. (2013). District Energy Strategic Plan for the City of Guelph. Retrieved from: http://guelph.ca/wp-content/uploads/011514_DistrictEnergyStrategicPlan_web.pdf

[199] Quality Urban Energy Systems of Tomorrow. (2017).

[200] Lonsdale Energy Corporation. (2009).

[201] Lonsdale Energy Corporation. (2009).

[202] City of North Vancouver. (2017). City of North Vancouver Hydronic Energy Service Bylaw, 2004, No. 7575. Retrieved from: http://www.cnv.org/~/media/D2293D5EE2E5440C859203E86A71D683.pdf

[203] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[204] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[205] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[206] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[207] Lonsdale Energy Corporation. (2009).

[208] City of North Vancouver. (2017). Lonsdale Energy (LEC).

[209] United Nations Environment Programme. (n.d.). District energy: a tried-and-tested answer to modern urban energy problems. Our Planet. Retrieved from http://web.unep.org/ourplanet/october-2016/unep-work/district-energy-tried-and-tested-answer-modern-urban-energy-problems//

[210] United Nations Environment Programme. (n.d.). District Energy in Cities: Paris Case Study. Retrieved from https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=b7d8029e-fb30-d023-a362-50f251a39458&forceDialog=0. Pg. 5.

[211] United Nations Environment Programme. (n.d.). Pg. 5.

[212] United Nations Environment Programme. (n.d.). Pg. 5.

[213] United Nations Environment Programme. (n.d.). Pg. 5.

[214] United Nations Environment Programme. (n.d.). Pg. 7.

[215] United Nations Environment Programme. (n.d.). Pg. 8.

[216] United Nations Environment Programme. (n.d.). Pg. 1.

[217] United Nations Environment Programme. (n.d.). Pg. 16

[218] United Nations Environment Programme. (n.d.) Pg. 6

[219] United Nations Environment Programme. (n.d.). Pg. 3.

[220] United Nations Environment Programme. (n.d.).. Pg. 3.

[221] United Nations Environment Programme. (n.d.). Pg. 4.

[222] Princeton University. (Jan 5, 2015). The Princeton Energy Plant. Retrieved from https://facilities.princeton.edu/news/the-princeton-energy-plant

[223]Princeton University. (March 22, 2012). Princeton's Cogeneration Plant. Retrieved from https://www.princeton.edu/news/2012/03/22/princetons-cogeneration-plant?section=mm-featured

[224] Tiger Energy. (2017). Tiger Energy: Tracking Princeton's Energy Impact. Princeton's University Campus Electricity Supply. Retrieved from https://tiger-energy.appspot.com/supply/chilled_water

[225] Princeton University. (Jan 5, 2015).

[226] Tiger Energy. (2017).

[227] Tiger Energy. (2017)

[228] Tiger Energy. (2017).

[229] Tiger Energy. (2017)

[230] Princeton University. (Jan 5, 2015).

[231] SaskPower. (2017). SaskPower: Powering the future. Cogeneration. Retrieved from http://www.saskpower.com/our-power-future/our-electricity/supply-options/cogeneration/

[232] Princeton University. (Jan 5, 2015).

[233] Princeton University. (Jan 5, 2015).

[234] Enpowered Solutions. (n.d.). Retrieved from http://enpoweredsolutions.com/wp-content/uploads/2015/01/Cogeneration1.jpg

[235] Princeton University. (Jan 5, 2015).

[236] Edward Borer. (April 2013). Energy Efficient Infrastructure for More Resilient Local Economies. Retrieved from http://www.eesi.org/files/050813_Borer.pdf

[237] Meckler, M., and Hyman, L. B. (2010). Sustainable on-site CHP systems: Design, construction, and operations. New York: McGraw-Hill. https://accessengineeringlibrary.com/browse/sustainable-on-site-chp-systems-design-construction-and-operations/p20019d2d9970321001

[238] Meckler, M., and Hyman, L. B. (2010).

[239] Princeton University. (2017). Engineering and Campus Energy. Retrieved from https://facilities.princeton.edu/about-us/engineering-and-campus-energy

[240] Princeton University. (2017).

[241] Comeault, C. (October 2011). Integrated Community Energy System Business Case Study: Southeast False Creek Neighbourhood Energy Utility. Quest Business Case. Retrieved from http://www.sauder.ubc.ca/Faculty/Research_Centres/Centre_for_Social_Innovation_and_Impact_Investing/Core_Themes/Low_Carbon_Economy/~/media/Files/ISIS/Reports/Carbon%20Management%20Reports/QUEST-ICES-Business-Case-Southeast-False-Creek-Neighbourhood-Energy-Utility.ashx

[2] City of Vancouver. (n.d.). Southeast False Creek Neighbourhood Utility: in depth. Retrieved October 30, 2017 from http://vancouver.ca/home-property-development/utility-facts-and-presentations-in-depth.aspx

[243] The Challenge Series. (n.d.). Millennium Water: The Southeast False Creek Olympic Village- Vancouver, Canada. Retrieved from http://www.thechallengeseries.ca/chapter-05/neighbourhood-energy-utility/

[244] The Challenge Series. (n.d.).

[245] Comeault, C. (October 2011).

[246] Comeault, C. (October 2011).

[247] City of Vancouver Neighbourhood Energy. (January 2016). Building Connection Guideline. Retrieved from http://vancouver.ca/files/cov/neighbourhood-energy-utility-connection-guidelines.pdf

[248] Comeault, C. (October 2011).

[249] The Challenge Series. (n.d.).

[250] The Challenge Series. (n.d.).

[251] The Challenge Series. (n.d.).

[252] City of Vancouver. (September 25, 2012). Policy Report Environment- Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines. Retrieved from http://vancouver.ca/files/cov/neighbourhood-energy-strategy-and-energy-centre-guidelines-committee-report.pdf

[253] Comeault, C. (October 2011).

[254] Comeault, C. (October 2011).

[255] City of Vancouver. (2016). Energy Utility System By-Law No.9552. Retrieved from http://bylaws.vancouver.ca/9552c.PDF

[256] City of Vancouver. (2016)

[257] City of Vancouver. (September 25, 2012).

[258] City of Vancouver. (2007). SEFC Official Development Plan. Retrieved from http://bylaws.vancouver.ca/odp/SEFC.pdf

[259] City of Vancouver. (September 25, 2012).

[260] Comeault, C. (October 2011).

[261] Comeault, C. (October 2011).

[262] Comeault, C. (October 2011).

[263] Comeault, C. (October 2011).

[264] Comeault, C. (October 2011).

[265] District Energy Saint Paul. (n.d.). History. Retrieved from http://www.districtenergy.com/inside-district-energy/

[266] District Energy Saint Paul. (n.d.). Inside District Energy. Retrieved from http://www.districtenergy.com/inside-district-energy/

[267] District Energy Saint Paul. (n.d.). History.

[268] District Energy Saint Paul (n.d.). History.

[269] UNEP. (2015). District Energy in Cities - Unlocking the Potential of Energy Efficiency and Renewable Energy. Retrieved from http://districtenergyinitiative.org/report/DistrictEnergyReportBook.pdf

[270] UNEP. (2015).

[271]Osdoba, T., Dunn, L., Hemert, H.V., and Love, J. (2010). The Role of District Energy in Greening Existing Neighbourhoods. Preservation Green Lab. Retrieved from http://www3.cec.org/islandora-gb/en/islandora/object/islandora%3A1024/datastream/OBJ-EN/view

[272] UNEP. (2015).

[273] Seidman, K.F. and Pierson, D. (2013). Financing Urban District Energy Systems. Massachusetts Institute of Technology. Retrieved from http://web.mit.edu/colab/gedi/pdf/Financing%20District%20Energy/MIT_CoLab_GEDI_Financing%20District%20Energy.pdf

[274] Seidman, K.F. and Pierson, D. (2013).

[275] Seidman, K.F. and Pierson, D. (2013).

[276] Seidman, K.F. and Pierson, D. (2013).

[277] Seidman, K.F. and Pierson, D. (2013).

[278] District Energy Saint Paul. (n.d.). History.

[279] Anderson, E. and Butler, M. (2016). Duluth Energy Future Report Chapter 3: Combined Heat and Power (CHP)-Barriers and Opportunities. University of Minnesota. Retrieved from http://energytransition.umn.edu/wp-content/uploads/2016/08/Duluth-Energy-Future-Chapter-3-Combined-Heat-and-Power-Barriers-and-Opportunities.pdf

[280]Anderson, E. and Butler, M. (2016).

[281]Anderson, E. and Butler, M. (2016).

[282] Compass Resource Management Ltd. (2012). Neighbourhood District Energy System for UBC Expansion Areas. Prepared for the University of British Columbia. Retrieved from https://www.corix.com/docs/default-source/regulatory-affairs/ubc-ndes/appendix-2---compass---ubc-final-ndes-business-case-report_nov2012.pdf?sfvrsn=2

[283] Compass Resource Management Ltd. (2012).

[284] Seidman, K.F. and Pierson, D. (2013). Financing Urban District Energy Systems. Massachusetts Institute of Technology. Retrieved from

http://web.mit.edu/colab/gedi/pdf/Financing%20District%20Energy/MIT_CoLab_GEDI_Financing%20District%20Energy.pdf

[285] Local Governments for Sustainability. (n.d.). District Energy Initiatives. Retrieved from http://www.iclei.org/activities/agendas/low-carbon-city/districtenergy.html

[286] Compass Resource Management Ltd. (2012).

[287] Jones, A. (2017). City of Sydney Decentralized Energy Master Plan. International Energy Advisory Council. Retrieved from https://www.ieac.info/City-Of-Sydney-Decentralized-Energy-Master-Plan-Case-Study

[288] Jones, A. (2017).

[289] City of Sydney. (2013). Decentralized Energy Master Plan. Retrieved from http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0007/193057/Trigeneration-Master-Plan-Kinesis.pdf

[290] City of Sydney. (2013).

[291] City of Sydney. (2013).

[292] City of Sydney. (2013).

[293] City of Sydney. (2013).

[294] City of Sydney. (2013).

[295] City of Sydney. (2013).

[296]City of Sydney. (2013).

[297]City of Sydney. (2013).

[298]City of Sydney. (2013).

[299] Information om Sverige. (n.d.). Vingåker. Retrieved from: https://www.informationsverige.se/Engelska/Leva-och-bo/lan-och-kommuner/Pages/Vingaker.aspx

[300] Rindi Energy AB. (n.d.). Vingåker. Retrieved from: http://www.rindi.se/orter/vingaker/

[301] Palm, J. (2007). District Heating as a Secure Heat Supply – A Question of Regulation. Pg. 747. Retrieved from: http://liu.diva-portal.org/smash/get/diva2:259114/fulltext01.pdf

[302] Palm, J. (2007). Pg. 747.

[303] Palm, J. (2007). Pg. 753.

[304] Palm, J. (2007). Pg. 747.

[305] Palm, J. (2007). Pg. 753.

[306] Palm, J. (2007). Pg. 751.

[307] Palm, J. (2007). Pg. 749.

[308] Palm, J. (2007). Pg. 752.

[309] Palm, J. (2007). Pg. 753-754.

[310] Palm, J. (2007). Pg. 755.

[311] Palm, J. (2007). Pg. 756.

[312] Palm, J. (2007). Pg. 757-759.