A Plan for a Sustainable Toronto Discovery District

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ABSTRACT

The members of the Toronto Discovery District (TDD), located in downtown, Toronto Canada, have developed a district wide Energy Management Plan that represents a coordinated and integrated approach to energy management and district energy for the buildings within the Toronto Discovery District. The Toronto Discovery District is Canada's largest concentration of scientific research facilities and consists of major teaching hospitals, the University of Toronto, and more than 20 affiliated research institutes. This Energy Management Plan represents a major opportunity for the TDD members to work together to achieve significant energy and water savings and GHG emission reductions.

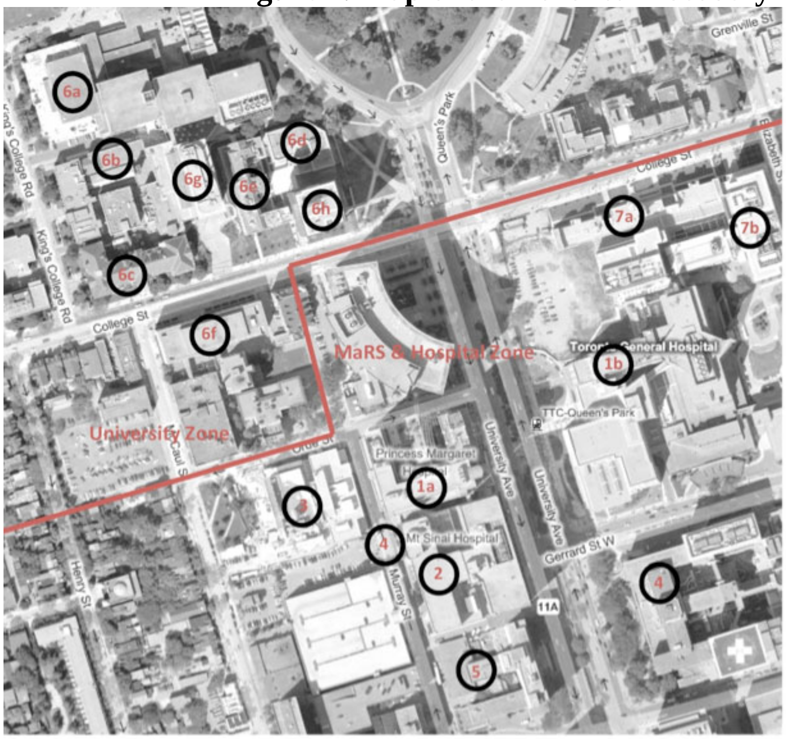
Implementation of the Energy Management Plan is expected to achieve a 34% reduction in energy consumption (electricity, natural gas and steam), a 41.4% reduction in electricity demand, and a 10% reduction in water usage per year over the life of the 5 year plan. This translates into an estimated cost savings of $16.3 million per year. The TDD uses 2,397,785 GJ of energy annually. Implementing the Energy Management Plan is also expected to achieve large environmental benefits, including reducing greenhouse gas emissions by 127,735 tonnes or 61% per year, which is the equivalent of taking 27,648 cars off the road every year. Work is underway on the implementation of this important and comprehensive plan including the development of a feasibility study for the district heating and cooling systems and funding applications for the development of a TDD wide facilities staff training program.

Introduction

In 2008-2009 the members of the Toronto Discovery District (TDD), located in downtown Toronto, Canada, agreed to develop a District Wide Energy Management Plan (EMP) that represents a coordinated and integrated approach to energy management and district energy for 29 buildings within the Toronto Discovery District. IndEco Strategic Consulting (IndEco), along with their partners, were hired by the members of the TDD (led by the City of Toronto Economic Development Corporation and MaRS) to develop the energy management plan.

The Toronto Discovery District is Canada's largest concentration of scientific research facilities and consists of major teaching hospitals, the University of Toronto, and more than 20 affiliated research institutes including Toronto General Hospital, Princess Margaret Hospital, the Hospital for Sick Children, Toronto Rehabilitation Institute, Mount Sinai Hospital, Centre for Addiction and Mental Health. The area covered by the TDD and the member organizations of the TDD are shown in the map below (Figure 1). Below the red line is the MaRS and hospital zone – the area in which the majority of the hospitals and MaRS are located. Above the red line is the university zone, which is the area in which the University buildings are located. Both of these zones contain research facilities.

Figure 1. Map of the Toronto Discovery District



1a. Princess Margaret

1b. Toronto General Hospital

2. Mt Sinai Hospital

3. Toronto Centre for Phenogenomics

4. Hospital for Sick Children

5. Toronto Rehab

6. University of Toronto

7. MaRS

Centre for Addiction and Mental Health, Toronto Western Hospital and Women's College Hospital not shown

The Energy Management Plan represents a major opportunity for the TDD members to work together to achieve significant energy and water savings and greenhouse gas (GHG) emission reductions and create a more sustainable District. These savings can be achieved through collaboration on energy efficiency, education and awareness, and district energy opportunities that were identified through the work carried out in the three phases of the development of the EMP.

The development of the plan was carried out in three phases. Each is discussed in sequence below. The project was phased in this manner at the request of the client. This phased approach was taken to meet the requirements of the client's funder (the Canadian Federation of Municipalities) and not based on any Canadian or international standard. This paper also provides a forecast of expected results due to plan implementation and a status report on the implementation of the plan.

District Energy Plans

The development of community or district energy plans is certainly not unique with cities and towns all over the world developing community energy plans to help them systematically reduce their GHG emissions. For example as part of the C40 Cities Climate Leadership Group cities from North and South America, Europe, Africa, Asia and Australia have all signed on to reduce carbon emissions and increase energy efficiency including the development of energy and climate change plans (C40 Cities Climate Leadership Group, 2010). Developing plans for designing and implementing district energy systems is also not unique. According to the International District Energy Association there are 123 district energy systems in hospitals alone in the United States (International District Energy Association, 2010). What makes this study unique is that it provides an energy management plan that not only covers district energy but also energy efficiency, and education, training and behavioural change. In addition this EMP has not been prepared for a cohesive city, community or corporation but for a group of institutional organizations located close to one another that have different owners, managers and uses but with a common goal of reducing energy use and GHG emissions.

Phase 1 – Energy and Water Data Collection and Energy Profiles

The first phase of the project involved the collection of energy (electricity, gas and steam) and water data from each of the participating TDD buildings in order to obtain a comprehensive understanding of energy and water use patterns and trends for each of the buildings and for the TDD as a whole. It also involved the collection of information related to education and awareness activities conducted by the TDD members. This information was gathered through obtaining energy and water use data from the buildings, mainly in the form of utility bills. Interviews with key facilities staff for each building and detailed on-site visits were also conducted.

This phase culminated in the preparation of energy profiles for each of the participating buildings, or group of buildings belonging to a participating TDD member. The energy profiles included a detailed description of the energy and water use of each TDD member as well as a description of the education and awareness programs that are being carried out in the buildings. These energy profiles were provided to the participating buildings but due to their confidential nature were not included in the EMP and cannot be discussed explicitly as part of this paper. However, through this work a detailed understanding of the energy use and heating and cooling demands of the TDD as a whole was gained. As can be seen in the Table 1 below, the TDD uses significant amounts of energy including 2,397,785 GJ of energy annually, has an energy intensity of 0.22 GJ/ft^2, and annual energy costs of approximately $50 million (Canadian).

Table 1. Total Energy Use in the TDD and by Sector

Sector	Total energy usage	Energy use intensity	Cost
Hospitals	1,512,507 GJ	0.19 GJ/ft^2	$30,673,264
Research Facilities	403,881 GJ	0.31 GJ/ft^2	$8,622,571
University Buildings	481,396 GJ	0.29 GJ/ft^2	$10,995,267
Total	**2,397,785 GJ**	**0.22 GJ/ft^2**	**$50,291,102**

The energy intensity calculated for the hospitals was lower than anticipated. According to a 2003 study by Natural Resources Canada (NRCan) the average energy intensity of Canadian hospitals was 0.24 GJ/ft^2 (Natural Resources Canada, 2003). Some of the reasons for this lower intensity for the TDD members may include their status as leaders in the field in Canada's largest city and the energy efficiency and district energy measures that have already been implemented in these facilities. The energy intensity for the University of Toronto buildings was higher than anticipated. The same NRCan study indicated that in 2003 Canadian universities had an average energy intensity of 0.19 GJ/ft^2 (Natural Resources Canada, 2003). This greater intensity could be due in part to the age of many of the University buildings included in this study some of which date back to the turn of the 20th centaury.

The three main types of fuel used within the TDD buildings are electricity, gas and steam. In total, the TDD used approximately 314 million kWh of electricity and 1,266,800 GJ of gas and steam. The water usage in the TDD buildings totaled 2,155,860 m³ in 2007/2008.

Phase 2 – Energy Saving Opportunities

Based on a review[1] of the heating and cooling demands for the TDD study area and the energy profiles prepared in Phase 1 of the project, the potential for savings in energy and water through the implementation of energy efficiency measures, an education, awareness and training program, and a Community Energy System (CES) approach, were identified.

Energy Efficiency Measures

Based on the detailed on-site visits that were conducted by IndEco and their team it was found that the TDD buildings in this study are generally well operated and well maintained. The interviews conducted with facilities managers for the buildings revealed that the facilities included in the study have all carried out energy efficiency projects of some type or another, from lighting retrofits to comprehensive energy retrofit projects. Regardless, there remain many opportunities for energy savings for the facilities. The major areas for energy and water savings opportunities are described in Table 2 below. This table provides a list of common types of measures that could be employed in the facilities based on the type of facility and their uses. There are of course many other potential energy savings measures specific to each building in the TDD. These building specific opportunities would be identified through the energy audits indentified below. The identification of these building specific opportunities were beyond the scope of the study. The client simply asked for a description of the types of measures that could be implemented in buildings of this nature

[1] This review included detailed on-site visits to each of the study buildings.

Table 2. Opportunities for Implementing Energy Efficiency Measures

Category	Identified Opportunities
Retro-commissioning (RCx)	• Conduct RCx in each of the TDD facilities. RCx is a systematic, documented process that identifies low-cost operational and maintenance improvements in existing buildings and brings the buildings up to the design intentions of its current usage. Retro-commissioning focuses on optimizing existing system performance, rather than relying on major equipment replacement.
Energy audits	• Conduct energy audits in each of the TDD facilities
Energy monitoring	• Integrate energy monitoring into facilities operations including comparing energy use to weather and occupancy corrected baselines
Lighting	• Upgrade all magnetic ballasts in light fixtures to electronic • Replace all incandescent lighting with florescent • Install occupancy sensors where appropriate • Install LED exit signs • Measure light levels and reduce the number of lamps and/or fixtures accordingly • Conduct night audits to ensure lighting is switched off at night by staff
Plug load	• Investigate options for automatically shutting down electronic equipment e.g. computers • Install Vending Misers on vending machines
Heating, Ventilation and Air Conditioning	• Take advantage of free cooling and heat recovery opportunities • Install variable frequency drives (VFD) on pumping stations and air handling units where possible • Use the building automation system to optimize the chiller and chilled water system • Seal and insulate all air systems and hot water piping • Implement a stream trap maintenance and replacement program • Conduct a boiler combustion analysis and implement any identified corrections
Kitchens and laundries	• Install demand ventilation systems with VFDs on all kitchen exhaust hoods • Turn down or off all kitchen equipment (e.g. fryers, broilers etc.) during slow periods • Clean refrigerator coils quarterly • Install strap curtains or plastic doors on walk-in refrigerators and freezers • Only run washers and dryers when full and washers using the lowest water temperature possible
Water	• Conduct water consumption audits in each of the TDD facilities • Install low-flow fixtures including toilets, urinals, showerheads and kitchen spray valves
Fume hoods	• Convert all constant air volume hoods to variable air volume hoods • Encourage users to lower the fume hood sash to 2.5” at all times • Reschedule hood operations to 12hour/per day for 7:00 a.m. to 7:00 p.m.

Education, Awareness and Training

There is an opportunity to adapt and implement the well-established education and awareness programs currently being implemented in some TDD buildings into those facilities that have provided limited or informal education, awareness and training to their staff to date, and those that have yet to consider energy education, awareness and training. For example, the University Health Network’s (UHN) TLC - Care to Conserve program components related to education, awareness and training can be readily transferred to other hospitals in the TDD. This can be done through the use of the template UHN has developed to assist other hospitals in integrating the entire TLC program or certain TLC program elements into their regular hospital routines and processes. With some adaptation to the particular type of building, these TLC program elements can also be integrated into the business practices of the other TDD buildings. The TLC program is also designed and managed by IndEco Strategic Consulting. A proposal is currently being considered by the Ontario Power Authority to fund the development and implementation of a TDD wide training program for all facilities staff including senior managers, specialized building operators and trades staff (e.g. electricians, painters, carpenters etc.) based recommendations of the EMP and based on the materials developed and experience gained through the TLC program.

Community Energy Systems

There is the opportunity to implement both district heating and cooling in the TDD. With regards to district heating there is the opportunity to install a community energy system to supply base hot water load using natural gas fired cogeneration of approximately 20 MW electrical. Installation of this district heating will reduce electricity consumption for the TDD, while increasing the natural gas consumption, however, the net overall energy savings is anticipated to be $4.2 million (Canadian) per year.

There is an opportunity to take advantage of Toronto's Deep Lake Water Cooling (DLWC) to provide district cooling. DLWC, distributed by Enwave, uses cold water pumped from deep within Lake Ontario to cool buildings in the city. In the TDD there is the opportunity to implement a district cooling system, which consists of energy transfer stations and 10 branch connections to the existing DLWC system. It is proposed that this system be implemented in three phases. The first stage involves each building signing a contract with Enwave for interruptible DLWC service. Each building only runs its chillers when Enwave calls for an interruption in service. In the second stage the buildings are interrupted in descending order of efficiency, thereby bringing the most efficient chillers on first. The efficient chillers export spare capacity thereby eliminating part loading of any chiller and minimizing operation of the most inefficient chillers. The third stage involves thermal storage, charged at night from DLWC, being used as an additional supply source to decrease chiller operating time and perhaps allow some chillers to be retired. Most of the energy savings would be realized in the first phase. An initial capital investment of the new branch connections to the DWLC is approximately $9.5M, which is projected to provide a societal net present value (NPV) of approximately $21M over 20 years[2]. At the time of the study Enwave stated that there was enough capacity in the DLWC system to meet the demands of this district cooling system.

A feasibility study is currently underway to determine the specific requirements and costing required to implement the district heating and cooling systems opportunities identified in the EMP.

[2] The societal NPV is the sum of the difference in annual cash flows for the proposed cases versus Business-as-Usual over 20 years (2011-2030 for cooling, 2013-2032 for heating), using a real discount rate of 5%. Cash flows were developed from projected consumption multiplied by cost of service for utilities (water, electricity, gas, steam, chilled water and hot water), together with estimated capital and operating costs, but without allocating revenues or costs to any particular party. The costs of service were taken to be recent average rates for existing utility services (water, electricity, gas and steam), but only incremental costs of production for the proposed new services (chilled water and hot water).

Phase 3 – Future Planning

The work in Phase 3 involved developing a plan for how to implement the energy savings opportunities identified in the first two phases of the project, as well as the additional opportunities identified during the planning process. Phase 3 saw the development of the EMP document. The EMP operationalizes all previous work done in the first two phases of the project. The EMP is a five-year plan covering the period from 2009 to 2013. The objectives are of the plan are to:

- Foster a collaborative approach to energy and water management on a sustainable basis among members of the TDD
- Identify and implement opportunities for joint actions on energy and water management among members of the TDD
- Build on existing and planned infrastructure within the TDD
- Encourage measurement of District wide performance on energy and water management.

The actions identified in the EMP represent ways to transform the current energy and water situation within the TDD (the present state) into a desired state of energy and water management and use within the TDD (preferred state). The actions and the description of the preferred state are grouped according to the seven components of the energy management framework:

1. Organizational commitment;
2. Energy and water efficiency opportunities and initiatives;
3. District energy opportunities and initiatives;
4. Education and awareness opportunities and initiatives;
5. Utility consumption monitoring and tracking;
6. Communications; and
7. Incentives and financing.

Based on a strategic planning session held with members of the TDD, the following actions were identified as priorities that need to begin immediately:

- Appoint a Secretariat and form a EMP Working Group of the TDD members; including development of a governance model, terms of reference and policy statement
- Secure a high level commitment by all of the TDD members to work together to deliver the EMP
- Conduct a detailed feasibility study of the EMP recommendations for the district heating and cooling system
- Develop a District wide and streamlined strategy for identifying and applying for funding and financial incentives to support implementation of actions laid out in the EMP, including the other priority actions described above
- Gather and report on best practices from member organizations related to: procuring energy efficient products and services; retro-commissioning; energy and water audits;

implementation of energy and water efficiency measures; operator training; education and awareness (social marketing and employee engagement); monitoring and tracking; sub-metering; communications.

Results

If the EMP is implemented, then the TDD is expected to achieve a 34% reduction in energy consumption (electricity, natural gas and steam), a 41.4% reduction in electricity demand, and a 10% reduction in water usage per year[3]. This translates into an estimated cost savings of $16.3 million per year. These savings are shown in Table 3 below.

Table 3. Achievable Annual Savings Through Implementation of the EMP

	Estimated savings			**Estimated cost savings**
Energy Savings	875,282	GJ or	34.1%	$15.9 million
Demand Savings	23,900	kW or	41.4%	
Water Savings	215,809	m³ or	10.0%	$0.4 million
Total				**$16.3 million**

Implementing the EMP is also expected to achieve large environmental benefits, including reducing greenhouse gas emissions by 127,735 tonnes[4] or 61% per year, which is the equivalent of taking 27,648 cars off the road every year. Table 4 below shows these GHG reductions. These estimated savings and GHG reductions are based on only the TDD members participating in this study. Extending these measures throughout the District and also including new TDD developments will increase the savings exponentially.

Table 4. Achievable Annual Greenhouse Gas Reductions through Implementation of the EMP

	Estimated savings			**Equiv. no of cars off the road**
Electricity	120,101	tonnes or	57%	25,996
Natural gas and steam	7,634	tonnes or	4%	1,652
Total	127,735	tonnes or	61%	**27,648**

Conclusion

The Energy Management Plan for the Toronto Discovery District represents a major opportunity for the TDD members to work together to achieve significant energy and water

[3] These values are derived from engineering calculations of the potential savings associated with the district heating and cooling and energy efficiency measures including education, training and behavioural changes. These estimated energy savings are also based on the experience of the study partners in implementing measures and programs of a similar nature in institutional buildings.
[4] The GHG emissions for the energy efficiency and behavioural components of the study are based on the emission factors presented in the Ontario Guideline for Greenhouse Gas Emissions Reporting. The GHG emissions from the district heating and cooling systems are assumed to be higher than the Ontario Guideline for Greenhouse Gas Emissions Reporting as the electricity saved is assumed to mainly come in the form of displacement of peak loads, which in Ontario are primarily generated by coal fired generation plants.

savings and greenhouse gas emission reductions and to create a more sustainable community. The processes and measures used to generate these large potential savings have been described in this paper. This project represents a unique, integrated, joint energy planning process for large downtown commercial and institutional buildings. This joint energy planning process can be used by other similar groups of commercial and institutional buildings in major cities across North America to create their own joint energy management plans. These joint energy plans allow buildings and institutions to capture energy saving opportunities that are bigger than just one building e.g. district energy and renewables it also allows for the easy transfer of technologies, information and best practices between the participating buildings and institutions.

Work is underway on the implementation of this important and comprehensive plan including the development of a feasibility study for the district heating and cooling systems and funding applications for the development of a TDD wide facilities staff training program.

References

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