EB 2010-0215
Conservation Demand Management Strategy for 2011-2014
Guelph Hydro Electric Systems Inc.

Submitted to Ontario Energy Board
November 1, 2010

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In the spirit of conservation, Guelph Hydro has prepared this report using the font "Century Gothic" which has been shown to reduce printer ink usage by up to 30%.[1]

[1] University of Wisconsin – Green Bay http://www.uwgb.edu/compserv/topics/CenturyGothicGreen.htm

CDM Strategy

1. Distributor's Name:

Guelph Hydro Electric Systems Inc.

2. Total Reduction in Peak Provincial Electricity Demand (MW) Target:

17 MW

3. Total Reduction in Electricity Consumption (kWh) Target:

83,000,000 kWh

4. CDM Strategy

a. Overview and Objectives

All of the OPA-contracted province-wide (Tier 1) programs will be offered to our customers and Guelph Hydro plans to meet its CDM targets through the delivery of these Tier 1 programs as described more fully below. In addition, Guelph Hydro plans to offer Tier 2 programs, delivered jointly with other LDCs, as well as Tier 3 programs to our customers to encourage additional conservation and demand response (DR) participation. A specific strategy to encourage our customers to participate in a DR program has been provided in this section under item d, below. The Tier 2 and 3 programs are currently under development, but several that are being considered for inclusion in Guelph Hydro's portfolio have been described in section 6 below. Additional information related to Tier 2 and 3 programs will be provided when the appropriate application is submitted to the Ontario Energy Board (OEB).

Guelph Hydro is focused on delivering programs that will help customers reduce their energy requirements. However, there is an added benefit to programs that meet this objective and also help customers to reduce their other natural resource requirements. Therefore, several of the Tier 2 and 3 programs described below are partnerships that would encourage decreased consumption of electricity as well as in water and/or natural gas.

Guelph Hydro has attached the study *"Ontario's Water-Energy Nexus: Will We Find Ourselves in Hot Water... or Tap into Opportunity?"* by Carol Maas of The POLIS Water Sustainability Project as Appendix A. This study evaluates the electricity savings that results from each cubic metre of water saved due to the reduction in upstream city water processing and distribution. Guelph Hydro intends to use this study to support including the electricity savings that result from water savings in the cost benefit analyses required for some Tier 2 and 3 programs under the *Conservation and Demand Management Code for Electricity Distributors*. In addition, a low-flow toilet water savings program is being evaluated for inclusion in our strategy. The program description has been provided in section 6.b.ii below.

The overall results for Tier 1 programs over the period 2011-2014 are projected to be 17.02 MW and 87,071,000 kWh.

b. Annual Plan: Tier 1 Programs

The Tier 1 programs will be offered during each year in the planning period 2011-2014. In general, Guelph Hydro has assumed that residential customer participation in the Tier 1 programs will represent 0.9% of the provincial total target for each measure. In a few cases, Guelph Hydro varied from this percentage of the provincial target. For example, in the residential demand response program, Guelph Hydro assumed that there would be zero participants in the central air conditioner configurations using switch technology during 2011. Similarly, since Guelph has a much higher proportion of residences built since 2006, Guelph Hydro increased the share of the provincial target related to new home construction.

Guelph Hydro intends to apply for a Roving Energy Manager to encourage maximum participation in the CDM programs offered. Based on the acquisition of a Roving Energy Manager, business customers have been projected to participate in Tier 1 programs at a rate equal to 1.75% of the provincial targets for each program with the exception of DR 1 and DR 3. For industrial programs as well as participation by business customers in DR 1 and DR 3, Guelph Hydro projected participation based on an assessment of which customers were likely to participate in each program.

2011 Plan

Guelph Hydro plans to initiate a campaign to promote CDM programs with larger customers while continuing to promote residential and small business programs. Guelph Hydro intends to apply for a Roving Energy Manager to assist in meeting the targets. It is possible that some results could be delayed depending on when funding is approved for this position.

During 2011, Guelph Hydro has assumed that there will be no participation in the residential and small business DR programs for central air conditioning configurations using switch technology. Guelph Hydro has assumed a return to our standard assumptions for the remaining years (2012-2014).

2012 Plan

Overall, Guelph Hydro intends to evaluate the performance of each program and adjust program promotion and support to ensure the best possible results are attained. Any pilot programs initiated during 2011 will be evaluated and re-designed as necessary. The portfolio will be evaluated to ensure that all customer segments are participating in CDM programs and, if exceptions are noted, a strategy developed to address this situation. Guelph Hydro will also evaluate new programs, including successful programs offered by other LDCs, for inclusion in the CDM portfolio.

<u>2013 Plan</u>

As described in the 2012 Plan section above, Guelph Hydro will evaluate the performance of each program and adjust program promotion and support to ensure the best possible results are attained.

In addition, Guelph Hydro will specifically re-evaluate the likelihood of reaching the targets by the end of 2014. If a shortfall is projected at this time, Guelph Hydro will develop a strategy to address this situation.

<u>2014 Plan</u>

Guelph Hydro will evaluate the success of each program in the context of designing a portfolio for the period following the end of the planning period. Guelph Hydro will give specific attention to the evaluation of the Tier 2 and 3 programs that were offered to determine whether they should be continued.

c. Annual Milestones

The focus of the plan presented below is to meet the targets set out using Tier 1 programs no later than 2014. Tier 2 and 3 programs are being evaluated for inclusion in the CDM strategy to provide assurance that Guelph Hydro's targets will be met. The Tier 2 and 3 programs may also result in exceeding the targets. Guelph Hydro has provided our targets as annual milestones in Table 1 as well as cumulative totals in Table 2 on the following page, using the OPA Resources for Conservation Portfolio Development Consumer, Business and Industrial Tools.

Table 1: Projected Tier 1 Energy Savings by Year

	2011		2012		2013		2014		TOTAL	
	MWh	kW	MWh	kW	MWh	kW	MWh	kW	MWh	kW
Consumer Tool 1 of 3	602	20	968	20	1,335	20	1,701	20	4,606	80
Consumer Tool 2 of 3	637	250	1,283	260	1,859	260	2,447	270	6,226	1,040
Consumer Tool 3 of 3	427	420	1,457	460	2,745	570	4,074	600	8,703	2,050
Business Tool 1 of 5	1,101	630	2,566	840	3,899	970	5,792	1,320	13,358	3,760
Business Tool 2 of 5	2,719	640	5,568	740	7,216	640	8,776	740	24,279	2,760
Business Tool 3 of 5	4	10	19	20	36	20	54	30	113	80
Business Tool 4 of 5	0	0	0	0	0	0	0	0	0	0
Business Tool 5 of 5	6	220	12	220	24	450	36	440	78	1,330
Industrial Tool 1 of 3	2,861	50	5,661	940	8,983	570	12,160	560	29,665	2,120
Industrial Tool 2 of 3	1	280	2	360	4	560	7	1,120	14	2,320
Industrial Tool 3 of 3	2	220	5	300	8	440	14	520	29	1,480
Total Tier 1 Programs	**8,360**	**2,740**	**17,541**	**4,160**	**26,109**	**4,500**	**35,061**	**5,620**	**87,071**	**17,020**

Totals may not add due to rounding errors

Table 2: Projected Tier 1 Cumulative Energy Savings by Year

	2011		2012		2013		2014		TOTAL	
	MWh	kW	MWh	kW	MWh	kW	MWh	kW	MWh	kW
Consumer Tool 1 of 3	602	20	1,570	40	2,905	60	4,606	80	4,606	80
Consumer Tool 2 of 3	637	250	1,920	510	3,779	770	6,226	1,040	6,226	1,040
Consumer Tool 3 of 3	427	420	1,884	880	4,629	1,450	8,703	2,050	8,703	2,050
Business Tool 1 of 5	1,101	630	3,667	1,470	7,566	2,440	13,358	3,760	13,358	3,760
Business Tool 2 of 5	2,719	640	8,287	1,380	15,503	2,020	24,279	2,760	24,279	2,760
Business Tool 3 of 5	4	10	23	30	59	50	113	80	113	80
Business Tool 4 of 5	0	0	0	0	0	0	0	0	0	0
Business Tool 5 of 5	6	220	18	440	42	890	78	1,330	78	1,330
Industrial Tool 1 of 3	2,861	50	8,522	990	17,505	1,560	29,665	2,120	29,665	2,120
Industrial Tool 2 of 3	1	280	3	640	7	1,200	14	2,320	14	2,320
Industrial Tool 3 of 3	2	220	7	520	15	960	29	1,480	29	1,480
Total Tier 1 Programs	**8,360**	**2,740**	**25,901**	**6,900**	**52,010**	**11,400**	**87,071**	**17,020**	**87,071**	**17,020**

Totals may not add due to rounding errors

d. Demand Response Strategy

Most of the C&I programs will be delivered directly by Guelph Hydro. However, the Demand Response 1 (DR 1) and Demand Response 3 (DR 3) programs are delivered through multiple parties. In order to maximize participation in the DR 1 and DR 3 programs, Guelph Hydro has developed a multi-pronged strategy. Guelph Hydro will continue to provide metering data to all DR aggregators who request assistance in this manner. In addition, Guelph Hydro has partnered with one DR aggregator and is considering partnering with two additional DR aggregators. Guelph Hydro will continue to promote DR programs during large CI&I customer visits and plans to apply for a Roving Energy Manager to assist in completing these visits as noted below. Finally, Guelph Hydro is planning to offer DR workshops to promote DR to smaller C&I and Industrial customers. Taken together, these initiatives should maximize the DR participation by Guelph Hydro customers.

e. Roving Energy Manager

Guelph Hydro has identified a number of opportunities to increase participation on CDM programs and plans to apply for a Roving Energy Manager in order to maximize the participation rates by industrial customers. Note that Guelph Hydro also has a number of larger commercial and institutional customers that could benefit from the services of the REM. The results projected throughout the Tier 1 programs are predicated on the approval of a Roving Energy Manager.

f. Smart Meters/Time of Use Rates

Demand and energy savings related to smart meters and the implementation of Time of Use (TOU) rates have been excluded from Guelph Hydro's targets. Guelph Hydro intends to evaluate opportunities to encourage savings through smart meters and TOU rates and develop programs as warranted. Therefore, Guelph Hydro expects that savings results related to TOU and smart meters will be counted towards Guelph Hydro's targets once available. These additional savings results will supplement savings shortfalls or contribute to exceeding Guelph Hydro's savings targets.

Guelph Hydro intends to make relevant tools available to our customers to encourage conservation or load shifting, such as a 'web energy portal'.

5. OPA-Contracted Province-Wide CDM Programs

Guelph Hydro plans to participate in all the OPA-contracted province-wide CDM programs for the period 2011-2014. The following tables summarize the programs this encompasses by type of customer along with the anticipated results for each OPA Program Tool. For each of the Consumer Tools provided by the OPA, Guelph Hydro has assumed that our customer's contribution will represent 0.9% of the provincial projected targets. For non-Consumer Tools, Guelph Hydro has assumed that our customer's participation will represent 1.75% of the provincial projected targets. These percentages are higher than the assumption provided by the OPA of 0.9% and 1.49%, respectively, to take into consideration the opportunities that Guelph Hydro expects to be able to deliver at this time. *Please note that budget information is not available at this time.*

Table 3: Projected Tier 1 Program Results

OPA Tool Name	Projected Budget ($ 000)	Projected Reduction in Peak Electricity Demand (kW)	Projected Reduction in Electricity Consumption (MWh)
Consumer Tool 1 of 3		80	4,606
Consumer Tool 2 of 3		1,040	6,226
Consumer Tool 3 of 3		2,050	8,703
Business Tool 1 of 5		3,760	13,358
Business Tool 2 of 5		2,760	24,279
Business Tool 3 of 5		80	113
Business Tool 4 of 5		0	0
Business Tool 5 of 5		1,330	78
Industrial Tool 1 of 3		2,120	29,665
Industrial Tool 2 of 3		2,320	14
Industrial Tool 3 of 3		1,480	29
Total Tier 1 Programs		**17,020**	**87,070**

Totals may not add due to rounding errors

a. Low Income Programs

The Consumer programs are tailored to residential customers and will be offered to all residential customers including those categorized as Low Income. As soon as the OPA-Contracted province-wide Low Income programs are available, Guelph Hydro will offer these programs to our Low Income consumers. Contributions from Low Income programs have not been included in Guelph Hydro's results at this time as the program details are not yet available. Low Income programs, once available, will be offered in order to assist those customers who face the largest burden from electricity costs. Also, offering Low Income programs ensures customers are not discouraged from participation due to their economic circumstances.

b. Consumer Programs

The following Table 4 shows the planned results for Tier 1 Consumer Programs. A description of each program included in each Consumer Tool has been provided following the projected results table.

Table 4: Projected Tier 1 Consumer Program Results

OPA Tool Name	Projected Budget ($ 000)	Projected Reduction in Peak Electricity Demand (kW)	Projected Reduction in Electricity Consumption (MWh)
Consumer Tool 1 of 3		80	4,606
Consumer Tool 2 of 3		1,040	6,226
Consumer Tool 3 of 3		2,050	8,703
Total Tier 1 Consumer Programs		**3,160**	**19,536**

Totals may not add due to rounding errors

<u>Consumer Tool 1 of 3 Program Descriptions:</u>

The OPA model titled Consumer Tool 1 of 3 includes the Instant Rebates program as well as the Midstream Pool and Electronics Incentive programs.

The Instant Rebates program offers coupons and in-store rebates for energy saving items. This program is a carry forward of Power Savings Event.

The Mid-Stream Incentives program provides incentives for satellite and cable providers to use high efficiency set-top boxes and network configurations. This program is a carry forward and improvement from Power Savings Event.

<u>Consumer Tool 2 of 3 Program Descriptions:</u>

The OPA model titled Consumer Tool 2 of 3 includes the HVAC Rebates, Appliance Retirement, Exchange Events and Residential New Construction programs.

The HVAC Rebates program provides HVAC rebates delivered through contractors. This program is a carry forward of Cool Savings Rebate.

The Appliance Retirement program replaces old appliances with energy efficient ones. This program is a carry forward of Great Refrigerator Roundup.

Exchange Events: This is a carry-forward of previous Exchange Events previously hosted by retailers. The focus is on room air conditioners and dehumidifiers. The Spring event will feature a $50 coupon toward the purchase of a high efficiency unit and the Fall event will feature a $25 gift card.

The Residential New Construction program provides incentives for builders to build new, single family homes above Codes and Standards.

Consumer Tool 3 of 3 Program Descriptions:

The OPA model titled Consumer Tool 3 of 3 includes the Residential Demand Response program. The residential Demand Response program is a carry forward of *peaksaver®*. There are pilots in progress with a plan to redesign the program effective July 1, 2011.

c. Commercial and Institutional (C&I) Programs

The Commercial and Institutional (C&I) programs were designed to cover both existing and new buildings in all business market segments as shown below.

Business Segments covered under Commercial and Institutional Programs
(New and Existing Buildings)

Commercial Buildings	Institutional Buildings	Multi-Family Buildings	Agricultural Facilities
– Offices – Retail stores – Grocery stores – Restaurants – Other services – Hotels/motels – Warehouses	– Health care facilities – Universities, colleges, and schools – Municipal buildings	– Apartments (including low income and social/assisted housing) – Condominiums	– Livestock and poultry – Fruits and vegetables – Grains and hay – Greenhouses and nurseries

Guelph Hydro will offer services to all C&I customers. However, Guelph Hydro does not have customers in the Agricultural category in their franchise. Therefore, Guelph Hydro's plan assumes no participation from this customer category.

The overall results for the Business Tools have been provided in Table 5 below. A list of programs included in each tool along with program descriptions has been provided following the projected results table.

Table 5: Projected Tier 1 Business Program Results

OPA Tool Name	Projected Budget ($ 000)	Projected Reduction in Peak Electricity Demand (kW)	Projected Reduction in Electricity Consumption (MWh)
Business Tool 1 of 5		3,760	13,358
Business Tool 2 of 5		2,760	24,279
Business Tool 3 of 5		80	113
Business Tool 4 of 5		0	0
Business Tool 5 of 5		1,330	78
Total Tier 1 Programs		**7,940**	**37,827**

Totals may not add due to rounding errors

Guelph Hydro
Electric Systems Inc.

Business Tool 1 of 5

The OPA model titled Business Tool 1 of 5 includes medium and large building programs related primarily to equipment replacement incentives (ERIP). The specific programs included are: Pre-Project Assessments and Building Archetypes for the Equipment Replacement Incentive component for multi-residential condominiums, large offices and secondary schools.

The Existing Building Retrofits (ERIP) program is available for equipment replacement and there is a prescriptive, engineered or custom approach for medium and large buildings.

Business Tool 2 of 5

The OPA model titled Business Tool 2 of 5 includes Small Building programs related primarily to energy efficiency targets. The specific programs included are: Direct Install Lighting, Direct Serviced Space Cooling (an updated version of the Power Savings Blitz A/C Tune Up program) and Building Archetypes for the Equipment Replacement Incentive (ERIP) component for small offices, small retail, large retail, agricultural, multi-residential buildings (refrigerator replacement) and elementary schools.

The Direct Install Lighting program targets General Service customers with less than 50 kW of demand. It replaces the Power Savings Blitz and makes up to $1,000 available for equipment upgrades at no charge. There are standard prescriptive incentives for eligible equipment beyond the initial $1,000 limit.

The Direct Serviced Space Cooling program targets roof-top or ground-mounted air conditioning systems sized at 25 tons or less. It is mainly aimed at the General Service account category with loads less than 50 kW but some customers with loads greater then 50 kW will also be eligible. The program provides up to $750 for the cost of parts and labour to service each air-conditioning unit.

The Existing Building Retrofits (ERIP) program is available for equipment replacement and there is a prescriptive approach used for small buildings.

Business Tool 3 of 5

The OPA model titled Business Tool 3 of 5 includes the small commercial Demand Response program. This is an updated version of the *peaksaver*® program.

Demand Response: This program targets small business customers and is a re-design of peaksaver® with two options available. Participation with a Demand Response unit is available for central air conditioning units only. Participation without Demand

Response is offered where price and real-time consumption information is available via an in-home display or on-line display.

Business Tool 4 of 5

The OPA model titled Business Tool 4 of 5 is the Demand Response 1 (DR 1) program. This program focuses on large commercial customers who have an interval meter and contract to participate in demand response on a voluntary basis each time there is an event.

The Demand Response 1 (DR 1) program targets medium and large buildings. It is a voluntary demand response program with availability payments of $4,000 per month and utilization payments at the HOEP with a cap of $170 per MWh.

Business Tool 5 of 5

The OPA model titled Business Tool 5 of 5 is the Demand Response 3 (DR 3) program. This program focuses on large commercial customers who have an interval meter and contract to participate in demand response on a mandatory basis each time there is an event.

The Demand Response 3 (DR 3) program targets medium and large buildings. It is a mandatory demand response program that offers both availability and utilization payments as contracted with an aggregator.

d. Industrial Programs

The Industrial programs feature both demand response programs, DR 1 and DR 3, along with the Industrial Accelerator program. Industrial customers can also participate in the ERIP program, but will need to complete the on-line process using the C&I application provided by the OPA. A brief description of each of the Industrial programs follows the projected results by tool shown in the table below.

Table 6: Projected Tier 1 Industrial Program Results

OPA Tool Name	Projected Budget ($ 000)	Projected Reduction in Peak Electricity Demand (kW)	Projected Reduction in Electricity Consumption (MWh)
Industrial Tool 1 of 3		2,120	29,665
Industrial Tool 2 of 3		2,320	14
Industrial Tool 3 of 3		1,480	29
Total Tier 1 Programs		**5,920**	**29,707**

Totals may not add due to rounding errors

Industrial Tool 1 of 3

The OPA model titled Industrial Tool 1 of 3 includes the Industrial Accelerator and Component Replacement programs.

The Industrial Accelerator program aims to improve the efficiency of equipment and production processes.

Industrial Tool 2 of 3

The OPA model titled Industrial Tool 2 of 3 is the DR 1 program. This program focuses on industrial customers who have an interval meter and contract to participate in demand response on a voluntary basis each time there is an event.

DR 1 is a voluntary demand response program with availability payments of $4,000 per month and utilization payments at the HOEP with a cap of $170 per MWh.

Industrial Tool 3 of 3

The OPA model titled Industrial Tool 3 of 3 is the DR 3 program. This program focuses on industrial customers who have an interval meter and contract to participate in demand response on a mandatory basis each time there is an event.

DR 3 targets medium and large buildings. It is a mandatory demand response program that offers both availability and utilization payments as contracted with an aggregator.

6. Potential Board-Approved CDM Programs

Guelph Hydro is evaluating Tier 2 and 3 programs for inclusion in their strategy to exceed the targets of 17 MW and 83 GWh during the period 2011-2014. The following program descriptions are examples of the types of programs under consideration for inclusion.

a. Tier 2 Program Descriptions

Guelph Hydro will continue to evaluate opportunities to work with other LDCs to deliver conservation and demand management programs. At this time, Guelph Hydro is considering two programs for inclusion in the CDM strategy: Home Energy and Water Audits and Generation Conservation, an educational program with LED installation included as a component of the program. The projected program results and budgets will be provided upon submission of an application to the OEB for Tier 2 program funding.

i. Home Energy and Water Audits

Program Description

The Home Energy and Water Audits pilot program is in the early stages of development. However, the overall plan is to partner with Union Gas, the City of Guelph and Guelph Environmental Leadership to have trained and certified home energy efficiency staff visit residences to install basic energy efficiency measures, provide basic energy efficiency information, as well as promotion of the OPA-contracted province-wide programs described above. Initial thoughts are to have a package including items that promote energy savings initiatives and allow for simple repairs. The home energy efficiency staff would not only provide these materials at a very reasonable cost, they would also install these items in the home.

The plan is to do a pilot program in 2011 with 1,500 homes participating in order to refine the delivery mechanism, define the measure acceptance rates and revise the program and TRC as appropriate. Assuming the program is successful, Guelph Hydro plans to rollout the program across Guelph beginning in 2012. The number of homes that will be offered the program for the years 2012-2014 has yet to be determined. Including the pilot, Guelph Hydro plans to offer the Home Energy and Water Audit program for the entire planning period of 2011-2014.

Anticipated Benefits

The overall objective is for the City of Guelph to use less energy and water per capita than any comparable Canadian city.

ii. Generation Conservation

Program Description

The Generation Conservation program will in operation for the full four years with the understanding that it will be periodically refreshed to meet changing needs and emerging information.

The program is a CDM Education program that aims to build a culture of conservation through the school/home connection. Generation Conservation closes the gap in CDM Education – educating the teachers and providing the resources they need to teach their students who in turn educate their parents about the priority of electricity conservation.

Generation Conservation firstly targets grade 5 teachers who are typical middle class consumers. However, the teachers then educate youth ages 10 to 12 who learn this now and build lifelong conservation habits. The program is also designed so that the student involves parents/guardians in assessing energy use at home and developing conservation plans. This take-home component ensures that program reaches into as many residences as there are students in grade in the service area.

We expect the new program to include Guelph Hydro, Hydro One, Orangeville, Centre Wellington, and Wellington North Hydro. As the program is promoted further, additional LDCs may choose to participate as well.

In the Guelph/Wellington County area, the program will reach 2,800 students/household each year. (There is the potential to reach up to the total of 140,000 students/households in grade 5 every year in Ontario.) The typical age of these parents (adult consumers) is between 30 and 50, which is a key target for effecting a change in consumption in the consumer base.

The program will reach all customer types as it is being implemented through the public and Catholic district school boards. The funding obtained through the OEB process will enable every child/household to access their own take-home conservation booklet, which includes a home-audit, and every teacher all necessary training and classroom materials. This program is unique in its effectiveness. It will literally reach into every home with grade 5 students no matter their social-economic status. In order to encourage conservation, one assignment will be to install a LED light bulb in a high usage area and to report back on the location selected. A second assignment will be to provide feedback on the LED light in terms of perceived lighting similarity to the previous incandescent bulb (2011) or CFL (2012 on) and other qualities that might encourage additional purchases.

Generation Conservation provides thorough hands-on learning experiences that cover all the key aspects of energy conservation in the home. The 10 lessons cover the following topics:

• how electricity is generated and how it is used
• the resources used to generate electricity
'• the environmental trade-offs and consequences of electricity generation
• measuring the electrical load of common appliances
• assessing the benefits of Energy Star appliances
• conducting a home energy audit
• assessing the value and impact of energy saving devices
• measuring phantom power and learning how to halt it
• completing a home energy diary to establish time of energy use
• understanding the connection between air quality and energy generation
• understanding the tradeoffs in the energy mix (IESO)
• examine energy peaks and exploring how to shift the load to off-peak times (smart meters/10 Smart Meter Lane)
• developing a personal energy conservation plan that suits individual circumstances.

In addition, a summer camp program will be provided that is offered through existing camp programs as a specialty program day. The children will be offered fun and educational activities focused on electricity that teaches the importance of conservation. We expect the conservation day programming to be utilized in multiple camp programs.

Finally, the Guelph Hydro website will be enhanced by adding a children's webpage that provides the Generation Conservation activities for home use.

In all aspects, this program teaches that Conservation = Generation. The more we conserve, the less we have to generate and the lower our costs – environmentally and otherwise.

Anticipated Benefits

The benefits of the program that have already been documented by the Durham Questionnaire include:

• Participants found that they understood conservation more thoroughly; particularly phantom power, the choice of new appliances and how to use electricity at home, and they knew many more strategies to conserve in ways that were easy and convenient.

• The participants understood why conservation was being promoted on the basis of environmental, societal and economic concerns, supporting the entire premise of the Green Energy Act and CDM initiatives.

• The participants took actions in their own lives to reduce the consumption of electricity and this influenced their decision making when it came to other behaviors that have an environmental impact.

• The participants understood electrical generation and learned about the complexities and costs of the generation process so that they saw electricity as a precious commodity for which they previously had little regard.

This program changes behaviours and attitudes to effectively begin to create a culture of conservation.

b. Tier 3 Program Descriptions

Similar to the Tier 2 programs, Guelph Hydro has not yet determined which Tier 3 programs will be included in the CDM strategy. However, the program descriptions for several programs under consideration have been provided below. The projected program results and budgets will be provided upon submission of an application to the OEB for Tier 3 program funding.

i. Smart Wash

Program Description

The Smart Wash program is a continuation of an existing program and would be provided under a partnership with the City of Guelph with Guelph Hydro providing the program administration as well as a portion of the incentive. In the Smart Wash program, customers are encouraged to buy high efficiency washing machines through the provision of an incentive of $100 per washer. Guelph Hydro has requested that the City of Guelph consider committing to a four-year term in order to be able to ensure program continuity for the entire planning period of 2011-2014.

Anticipated Benefits

The Smart Wash program encourages the use of higher efficiency washing machines that leads to the consumption of less electricity as well as less water and natural gas.

ii. Royal Flush

Program Description

Assuming the OEB approves the methodology being proposed for calculating the electricity savings that result from each cubic metre of water saved in Guelph based on the study attached as Appendix A, Guelph Hydro is considering extending the partnership with the City of Guelph to reduce water consumption and the related electricity consumption using a low flow toilet incentive program. In past, the program has been offered to residential customers, but Guelph Hydro is considering expanding this program to target school boards, University of Guelph hotels, the hospitality industry and other larger accounts.

The concept is for the City of Guelph and Guelph Hydro to jointly fund an incentive payment to encourage customers to replace normal toilets with low flow toilets. Guelph Hydro would provide funding toward the incentive as well as provide the administration of the program by ensuring the processing payments to customers.

Anticipated Benefits

The Royal Flush program encourages the use of low flow toilets. This leads to the consumption of less water resulting in a lower requirement of electricity as well.

7. Program Mix

Guelph Hydro plans to meet its CDM targets using Tier 1 programs, with Tier 2 and 3 programs being considered to enable customers to use less energy and may also allow Guelph Hydro to exceed the targets. All of the province-wide OPA programs (Tier 1 programs) will be offered to our customers. In addition, a specific strategy to encourage our customers to participate in a demand response program has been developed and provided in section 4.d above.

The Consumer programs are tailored to residential customers and will be offered to all customers including those categorized as Low Income. As noted in section 5.a, Guelph Hydro plans to offer OPA-contracted province-wide programs specifically tailored to Low Income consumers once they are available.

Guelph Hydro does not have customers in the Agricultural Facilities category in their franchise. Therefore, Guelph Hydro's plan assumes no participation from this customer category.

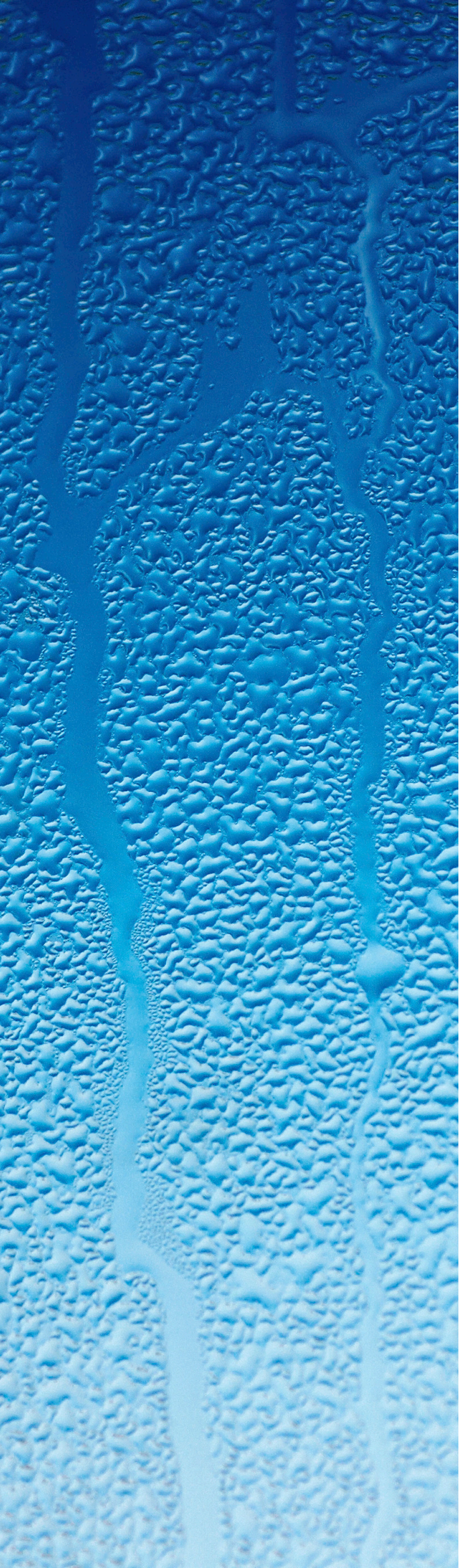
Finally, Guelph Hydro will continue to visit larger commercial, institutional and industrial customers to promote the CDM programs that are appropriate for each customer. Approval of the Roving Energy Manager is a key component in meeting the targets described above.

8. CDM Programs Co-ordination

Guelph Hydro plans to pursue administrative efficiencies and co-ordinate its CDM activities with other electric and natural gas LDCs as well as the OPA. Partnerships are being developed with the City of Guelph and social service agencies, especially those who can identify Low Income customers and potentially assist in program delivery. The Business Improvement Agency and Chamber of Commerce are two avenues of partnership that Guelph Hydro intends to utilize to promote CDM programs to their members. Guelph Hydro plans to engage local elementary schools and the University of Guelph's Environmental Science and Sustainability Projects and other groups such as the Elora Environment Centre to encourage awareness and participation in CDM programs. Non-profit groups and property management firms will be approached, when appropriate, to identify the CDM needs of specific customer segments.

Appendix A

Please see the attached study *"Ontario's Water-Energy Nexus: Will We Find Ourselves in Hot Water... or Tap into Opportunity?"* by Carol Maas of The POLIS Water Sustainability Project



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Ontario's Water-Energy Nexus:

Will We Find Ourselves in Hot Water… or Tap into Opportunity?

By Carol Maas

POLIS Project on Ecological Governance
watersustainabilityproject

Ontario's Water-Energy Nexus

Will We Find Ourselves in Hot Water… or Tap into Opportunity?

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Preface

This research and report was inspired by an emerging interest worldwide in the water-energy nexus and, in particular, an interest in identifying opportunities for water conservation to reduce energy use. A comprehensive understanding of the water-energy nexus in Ontario has been hampered by the lack of a synthesized dataset that describes the energy used for water-related services. In recent years it became clear that a comprehensive provincial review of the energy embedded in water across all major water-using sectors was needed to provide a strong foundation for future work in this area.

The report is highly quantitative in nature and was therefore written with a technical audience in mind. The study has been structured in three pieces – an executive summary, a main report and a technical appendix. Given the importance and wide reaching implications of the water-energy nexus both the executive summary and the main report body have excluded many of the technical details and assumptions in the interest of providing a concise, accessible report and summary. The appendices have been drafted with the intention of providing a clear statement of the methodological approach, including equations used and assumptions made, for the benefit of readers looking for specific technical details or to replicate this study elsewhere for other contexts. To avoid excessive length, the narrative and graphic representation in the Appendices has intentionally been kept short and direct, with summary tables included in Appendix A.

Prior water-energy studies have typically focused on the energy used for pumping and heating water as these are prime targets of municipal water conservation programs. However, this report also includes an analysis of the energy for steam used both for manufacturing processes and space heating and the waste heat from power generation. A soft path approach to water and energy demands holistic thinking; quantifying this energy lost in cooling water or through boiler inefficiencies is a first step in understanding how innovative processes and ideas may reveal the water and energy saving opportunities that these sectors have to offer. Analyses of the energy used to pump, treat and heat water are also provided separately from the energy used to generate steam and produce power (Figure 6 for example) with the intention of offering the information required by different types of practitioners.

It is the sincere hope of the author that this report will not only help to fill this research gap, but also stimulate future dialogue on this important topic.

Introduction

What is the water-energy nexus?

Water used to produce energy and the energy used to provide water-related services together have been coined the "water-energy nexus" in recent times. Water is essential for generating energy - to power the turbines in hydro-electric facilities, for cooling in thermal or nuclear energy plants, and to extract oil from tar sands. Indeed, collectively, the energy sector is the single largest user (though not the largest consumer) of water in Canada (Environment Canada, 2007). At the same time, energy is required to pump, treat and heat water and to generate steam for urban, industrial and agricultural use and to deal with the resulting wastes. Together, the two sides of this nexus (depicted in Figure 1) are generating new research, policy proposals and public dialogue that will be critical as societies struggle to address the intersecting challenges of climate change, energy security and water scarcity.

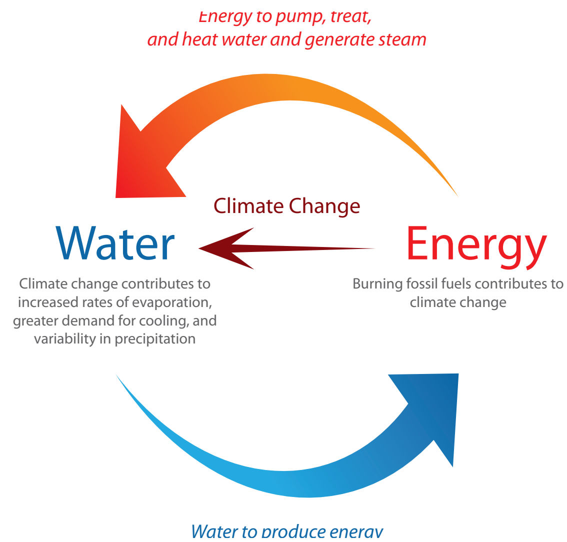

Figure 1 - The water-energy nexus in the context of climate change.

Climate Change and the Water-Energy Nexus

The water-energy nexus is deeply embedded within the context of climate change, a concern that is front and centre for many Canadians and that the Ontario Government has identified as a priority (Pembina, 2008; Office of the Premier, 2004). Burning fossil fuels to generate electricity and heat for provision of water services creates greenhouse gas emissions, heat-trapping gases that contribute to global warming and ultimately to climate change. Climate change will in turn impact water availability, increase water temperature and alter the frequency and duration of rainfall.

> *"Climate change may have been created by energy use, but it will be felt through water."*
>
> —Oliver Brandes, POLIS' Water Sustainability Project Leader

Indeed, this changing "waterscape" is likely to impact all aspects of our relationship with water and energy, as described by Thirwell *et al.* (2007) in a discussion of the water-energy nexus in Canada:

> *"It is anticipated that as climate changes, water resources will be altered; potentially reducing their quality, quantity, and accessibility. This in turn will require increased energy inputs to purify water of lower quality or pump water from greater depths or distances. Increased energy use will potentially lead to greater greenhouse gas emissions. Additionally, Canada's hydroelectricity sector could be affected forcing Canada to turn to other energy sources with higher emissions. All of this would ultimately reinforce climate change and create a vicious circle."*
>
> —Thirwell *et al*. (2007)

Warmer water temperatures will furthermore reduce the efficiency of cooling in thermal and nuclear power generating stations, and industrial settings, necessitating increased water withdrawals. A discussion of the energy associated with water use is therefore also necessarily a discussion of climate change and power generation.

Integration of Water-Energy Policy & Research

New research reveals strong linkages between water and energy consumption. A study by the Energy Policy Research Institute (EPRI) in 2002 provided a first estimate of the total energy associated with water in North America (EPRI, 2002). The report estimated that 4% of the electricity consumed in the United States is used to move and treat water and wastewater. Other studies in the U.S. have since built on EPRI's work and have suggested that energy consumption for water use is even greater. Most recently, an updated examination of the energy to pump, treat and heat water suggested that total water-related energy use is equivalent to 13% of all electricity produced in the U.S.[1] (Griffiths-Sattenspiel & Wilson, 2009). This nationwide survey reflected results from prior studies of individual states including California, where water-related services account for 19% of electricity consumption and 30% of the state's natural gas demand (Cohen *et al*., 2004). A study in the United Kingdom revealed that 6% of the UK's annual greenhouse gas emissions are related to water, 90% of which are associated with hot water use in the home (Environment Agency, 2009).

As we elucidate the implications of the water-energy nexus, new opportunities for more integrated approaches emerge. The United States has included minimum water efficiency standards for fixtures and appliances in its Energy Policy Act since 1992 (Energy Policy Act, 1992). In October 2006, the California Public Utilities Commission (CPUC) issued a ruling which directed each energy utility to develop a one year pilot program, together with a water provider, to "implement a jointly-funded program designed to maximize embedded energy savings per dollar of program cost" (CPUC, 2006). The University of Delaware conducted a jurisdictional review of water-energy programs in other states to inform the Delaware General Assembly of how water-energy initiatives may be applied in the state (Young-Doo Wang *et al.*, 2008).

The U.S. passed the Energy and Water Research Integration Act to "ensure consideration of water intensity in the Department of Energy's energy research, development, and demonstration programs to help guarantee efficient, reliable, and sustainable delivery of energy and water resources" (Bill H.R. 3598, 2009). Most recently, the Great Lakes Commission launched a Great Lakes Energy-Water Nexus initiative that aims to better integrate water and energy decision making processes, including a new project that will develop tools to better understand the impacts of power generation on water resources (Great Lakes Commission, 2010).

Relevance of the Water-Energy Nexus to Ontario

Ontario's energy use for water services is likely to rise on a steep trajectory in coming years. A rapidly growing population means increased demands for water. Declining water quality and availability in our watersheds could require more energy intensive treatment processes, and pumping from greater distances and depths, to maintain a reliable water supply while protecting public health and the environment. In fact, the Electric Power Research Institute estimates that the energy to pump and treat a litre of water in the U.S. will increase by 5-10% over 10 years (EPRI, 2002) and the energy consumption of municipal water utilities is predicted to double within the next 40 years (Alliance to Save Energy, 2002). The anticipated rise of energy intensive treatment processes, the need to pump water greater distances and depths and population growth together suggest an exponential increase in the energy used to provide water services. Future energy use for water could conceivably outstrip our ability to provide renewable energy if wasteful water practices continue to go unchecked.

1 this estimate includes hot water uses but excludes steam

Our previous report, *The Greenhouse Gas and Energy Co-benefits of Water Conservation*, highlighted water and wastewater services as the single-largest consumer of electricity in Ontario municipalities, comprising between one to two thirds of electricity costs (Maas, 2009). The rising cost of electricity, combined with Ontario's commitment to eliminate coal-fired power and a $30-40 billion water and wastewater infrastructure deficit, suggest that communities across the province will seek to minimize their use of both electricity and water to save money and to promote environmental sustainability (RCCAO, 2006).

Higher fuel costs coupled with an increased need for cooling and irrigation could also mean steep increases in operating costs for manufacturers, farmers and homeowners. TD Canada Trust (2008) found fuel prices were a top concern of small business owners. However, a recent report by the Canadian Business for Social Responsibility revealed that businesses often fail to recognize the water-related risks within their supply chain (CBSR, 2009). Declining water quality, for example, could mean significant increases in capital and energy costs if advanced treatment or importing of water were required to manufacture materials.

The anticipated rise of energy intensive treatment processes, the need to pump water greater distances and depths and population growth together suggest an exponential increase in the energy used to provide water services.

The agricultural sector is similarly prone to water and energy related risks. Drought conditions and high fuel prices could put irrigators at increased financial risk and North America has recently seen an increasing prevalence of both. Farm fuel prices in Canada increased by 66% between 2004 and 2008 (Agriculture and Agri-Food Canada, 2009) and drought conditions plagued prairie farmers in 2001 / 2002 in what was called one of the most expensive natural disasters in Canadian history (CBC News, 2009). In seven short years these same farmers were faced with yet another year of drought in 2009. Shortt *et al*. (2004) suggest that Ontario's farmers are facing mounting pressure to irrigate, stemming from an increased frequency of low rainfall during the growing season and demands for consistent quality products. Although irrigation offers a reduced risk of crop losses, irrigators are not immune to other risks. For example, high fuel prices coupled with a drought in 2004 left cotton farmers in West Texas facing an additional $10,000 per pivot irrigator in a single growing season; this could be illustrative of times ahead in Ontario given the uncertainty of climate change impacts (Associated Press, 2004).

Rising energy costs, the imperative to reduce greenhouse gas emissions and a changing waterscape implies that water and energy conservation are fundamental to creating sustainable communities, farms and businesses in Ontario.

Opportunities for Water and Energy Savings

Encouragingly, researchers and practitioners around the globe are recognizing the potential for efficient use of water and energy to mitigate greenhouse gas emissions, work towards adapting to climate change and reduce the environmental, social and economic costs of our water use (Maas, 2009; Cohen *et al*., 2004; Griffiths-Sattenspiel & Wilson, 2009). The water-energy nexus is leading to new opportunities to save water, energy and costs. Griffiths-Sattenspiel & Wilson (2009) revealed that if every household in the U.S. installed water efficient fixtures and appliances, 38.3 million tonnes of carbon dioxide emissions could be avoided. Tellinghuisen (2009) estimated that retrofitting half of Denver's households with water efficient faucets, showerheads, dishwashers and clotheswashers could prevent 274,000 tonnes of CO_2 being released each year.

Water recycling has also been found to be highly energy efficient in places like California, where recycling wastewater is typically half of the energy consumption of new surface or ground water supplies (Cohen *et al*., 2004). In Ontario, A recent report identified water saving opportunities that could reduce water use by 46% for the residential sector, 36% for the commercial and institutional sector, 41% for municipal water loss and 16% for the manufacturing sector (RMSi, 2009). And these estimates exclude water savings from process integration, water recycling and low impact development.

California's story of leadership on the water-energy nexus, outlined in Box 1, has led other States to follow suit and devote resources towards better understanding and acting on the conservation opportunities that lie at the nexus of energy and water.

Box 1: California - Leading the Way to New Energy Savings

Bob Wilkinson, at the University of California, Santa Barbara, first published a methodology for quantifying the energy used for water services and applied the method to California water systems in 2000 (Wilkinson, 2000). Dr. Wilkinson's report inspired the Natural Resources Defense Council and Pacific Institute to generate a joint report entitled Energy Down the Drain (Cohen *et al*., 2004). This report in turn generated sufficient interest to launch a seminal report, California's Water-Energy Relationship, by the California Energy Commission in 2005 (Klein *et al*., 2005). During this study, the CEC found that "the energy savings [from water conservation programs] would achieve 95 percent of the savings expected from the 2006-2008 energy efficiency programs, at 58 percent of the cost."

Energy efficiency programs have historically been funded to a much greater extent than water efficiency programs in North America. In recognizing this inequity, the CEC was able to direct funds to energy saving, economical water conservation projects and reduce costs. Water-energy studies and reports are increasing in number, reinforcing the notion that energy used for water services, and the potential for conservation of both, is significant beyond California (Young-Doo Wang, 2008; Tellinghuisen, 2009; Griffiths-Sattenspiel & Wilson, 2009; Pourkarimi, 2007; Young and Koopman, 1991; Iowa Association of Municipal Utilities, 2002; Cheng, 2002).

Purpose & Overview of Methodology

This study provides a first estimate of the total energy required for water-related services in Ontario. Specifically, it aims to quantify the energy to heat, treat, deliver, and remove water from communities, farms, businesses, institutions and power plants. The purpose of this research was to illuminate the energy inputs to water in Ontario, Canada, and to provide a platform for future research into opportunities for water and energy conservation.

Five broad sectors were examined in this study: residential, commercial/institutional (CI), manufacturing, agriculture and power generation. The municipal sector was also examined in terms of the energy used to pump and treat water. A detailed technical description of the methodology employed for calculating energy demands for water is presented in Appendices B through J. The base year for the analysis was 2006.

Water Use

Annual water and wastewater volumes for each sector were determined using the analysis completed by Resource Management Strategies Inc. for the Province of Ontario (RMSi, 2009: Table 36). Water withdrawals for each sector were then further disaggregated to assess the volume of water that was heated and the volume of water that was discharged as wastewater. Water withdrawal volumes reported by RMSi (2009) were cross-checked with the Great Lakes Data Regional Water Use Database and found to vary considerably in certain sectors; however the Great Lakes data have not been updated since 2000 (Great Lakes Commission, 2009). Since 2008, actual water takings in Ontario must be reported through the provincial permit to take water system and so it is likely that a more accurate re-assessment of the energy demands for water can be conducted when these data become available. A summary of estimated water takings by sector in 2006 is presented in Table 1.

Table 1 - Water withdrawals by sector in Ontario, 2006

	Sector	Water Withdrawals in 2006 (m^3/d)
Municipal Supply	Residential	966,600,000
	Commercial/Institutional	132,300,000
	Manufacturing	1,647,188,790
	Municipal Water Loss	374,466,653
Private Supply	Power Generation	26,687,000,000
	Agriculture - Irrigation	108,210,000
	Agriculture - Livestock	61,500,000
	Agriculture - Aquaculture	39,192,000
	Residential	171,700,000
	Manufacturing	1,622,811,210
	TOTALS	**31,810,968,653**

Energy Use

The energy intensity, i.e., the energy applied (in kWh) to 1 m^3 of water, was determined for each of pumping, treating and heating water within each of the given sectors. Total energy demand was estimated for each sector by multiplying the energy intensity by the applicable volume of water. For example, the energy intensity to heat water from 12°C to 60 °C was estimated using basic heat calculations and then multiplied by the volume of water heated.

Where either the energy intensity or the respective volume of water used was unavailable, a combination of assumptions and alternative methodologies were employed. In particular, the energy estimates for hot water use and steam were primarily extracted from the Comprehensive Energy Use Database published by the Office of Energy Efficiency within Natural Resources Canada (NRCan, 2007).

The energy used to drive turbines in nuclear and thermal electric power plants is first applied to water to generate steam and then released as waste heat into cooling water and into the atmosphere. The waste heat energy from generating steam in power plants was estimated using an assumed thermal efficiency and the annual power output and crosschecked using the known differential between the ambient lake temperature and the cooling water discharge.

Given the heavy reliance on a national database of energy use, and conservative estimates for the majority of remaining assumptions, the energy estimates presented herein are anticipated to represent a reasonably accurate first estimate of energy used for water-related services in Ontario and should be considered a mid-range approximation at this time.

Total Energy Used for Water Services in Ontario

The total energy consumed in Ontario for water-related services, including pumping, treating and heating water and generating steam (including steam used to generate electricity) was estimated to be 976 Petajoules per year (PJ/yr or 271,600,000 MWh/yr).[2]

What does 976 PJ/yr of Energy Input to Water Look Like?

Figure 2 disaggregates the 976 PJ/yr of energy that is applied to water in Ontario annually into energy used for steam, hot water and pumping and treatment. The energy used to pump treat and heat water and to generate steam could heat every home in Canada.[3] The waste heat from generating steam in nuclear and fossil-fuel fired power plants accounts for approximately half of this energy.

The energy used to pump treat and heat water and to generate steam could heat every home in Canada.[3]

However, as discussed in later sections, the energy for heating water, pumping and treating water and wastewater and generating steam in other sectors should not be overlooked. Consider the energy demand used to provide hot water, cold water and steam services in all sectors except power generation (460 PJ/yr); if this energy were provided by electricity alone, water-related services would consume all power produced by every hydro-

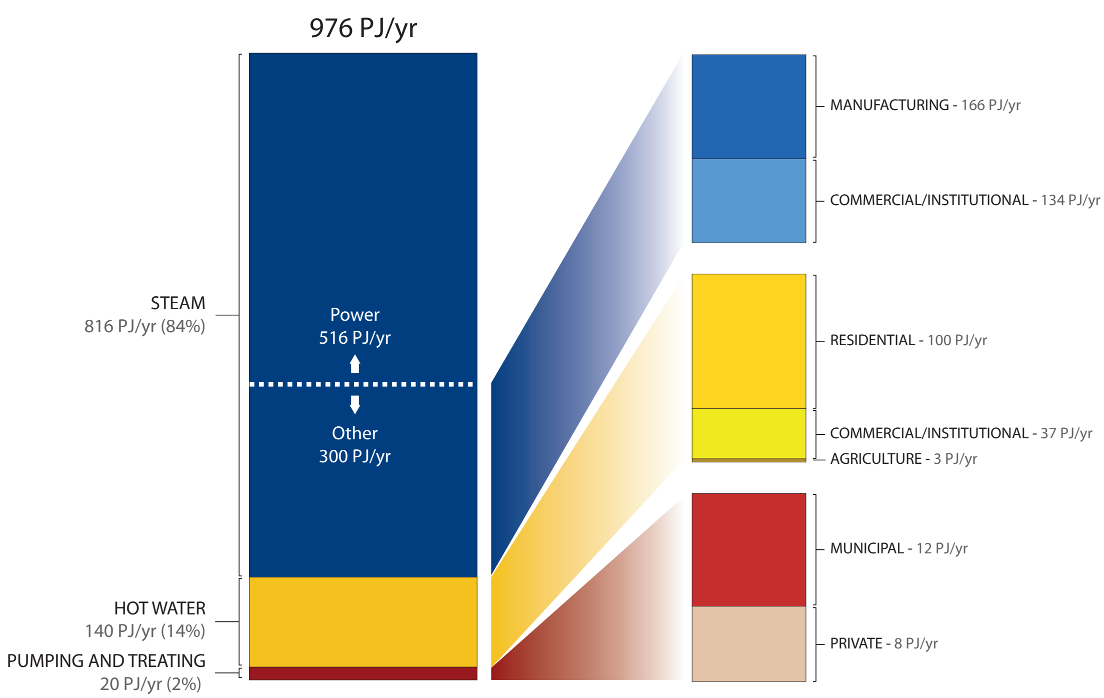

Figure 2 – Summary of energy inputs to water, including (left) and excluding (right) the power sector.

2 Note that for clarity, reported energy numbers excluded line and production losses, estimated at 6% for electricity and as much as 10% for other fuels.

3 Space heating in the residential sector consumed 805 PJ/yr in Canada in 2006 (NRCan, 2006)

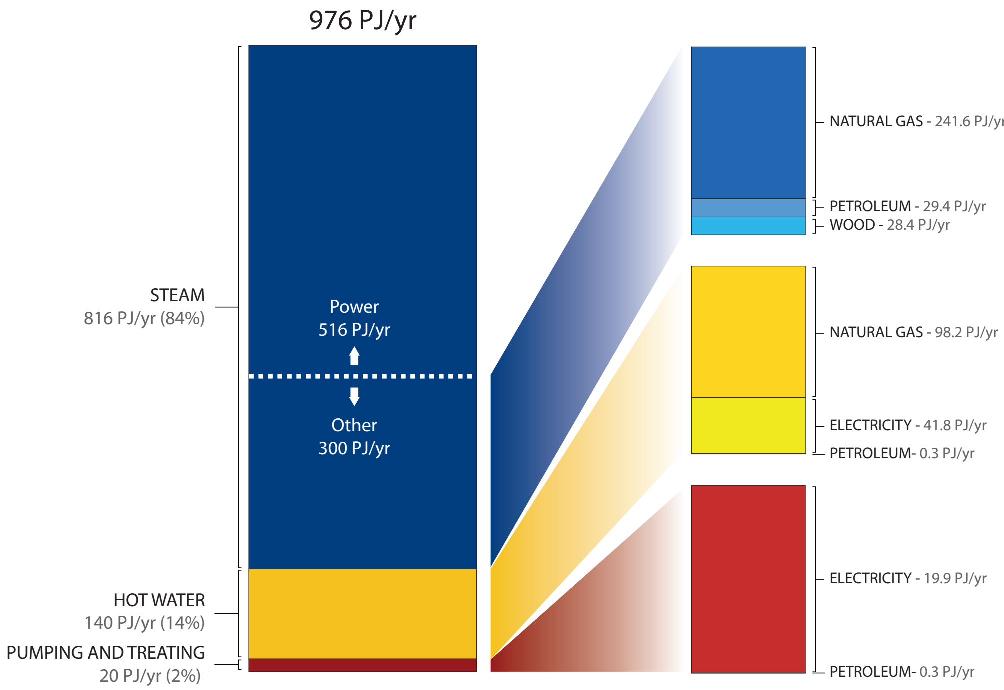

Figure 3 – Fuel type for each use of water.

electric, coal and nuclear power plant in Ontario.[4] Importantly, 80% of this energy is actually provided by fossil fuels largely as a result of Ontario's heavy reliance on natural gas for firing boilers to produce steam and hot water as illustrated in Figure 3 (refer to Table A.2 in Appendix A for further details of energy use by fuel type).

When steam was excluded entirely, the energy for pumping, treating and heating water alone was estimated at 161 PJ/yr. In fact, pumping, treating and heating water in Ontario's homes businesses, institutions and farms consumes significantly more energy than the power produced by the largest coal-fired power plant in North America.[5]

How Does Energy Used for Water Services Compare with Other Sectors?

Powering pumps, treatment plants, hot water heaters and boilers was found to consume 12% of Ontario's total demand for electricity and 40% of the natural gas demand.[6] This corresponds well with California's use of energy for water services, estimated at 19% of electricity and 30% of natural gas use (Cohen *et al.*, 2004).

Economic sectors such as agriculture, commercial/institutional, industry and transportation individually represent between 3% and 47% of the total demand for natural gas and between 1% and 37% of the electricity demand in Ontario. Energy consumption for water

Pumping, treating and heating water in Ontario's homes businesses, institutions and farms consumes significantly more energy than the power produced by the largest coal-fired power plant in North America.[5]

4 490 PJ/yr of electricity were produced in Ontario in 2008 (OPG, 2008)
5 Nanticoke power generating station in operating at full capacity produces 115 PJ/yr (OPG, 2010a)
6 Note that these values exclude the energy for steam in the power sector. 840 PJ/yr of natural gas energy is used in Ontario by all sectors (NRCan, 2007); 339 PJ/yr is used for water

intersects each of these economic sectors; however it is interesting to note that on a percentage basis water-related energy usage is comparable in magnitude to the energy consumed by individual economic sectors. For example, Figure 4 illustrates the breakdown of natural gas use in Ontario by economic sector. Clearly, the relative volume of natural gas used for water-related services, 40% of total demand, is comparable to the individual residential, commercial, institutional and manufacturing sector's fraction of natural gas demand in Ontario. Arguably, the energy used for water services is sufficiently large to warrant consideration of water as a "sector" of sorts. Investigation of opportunities to conserve water across traditional economic sectors could elicit innovative ideas and programs with new opportunities for reduction of energy use.

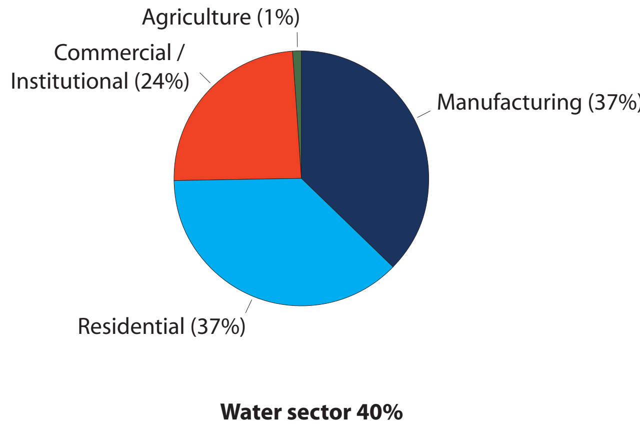

Figure 4 – Ontario's natural gas demand by sector, contrasted with the natural gas demand for water-related services.

Embedded vs. End-use Energy

The energy input upstream of the end-use, primarily the energy for pumping and treatment[7], is commonly referred to as the embedded or embodied energy of water. Energy input at the point of use is defined as end-use energy and for the purpose of this report is generally the energy to heat water and generate steam. End-use energy may also be applied for water cooled chillers and on-site treatment systems such as water softeners and UV disinfection.

End-use energy is often under private control, whereas embedded energy inputs tend to be publicly managed – at least in the case of municipally supplied water services. For example, a homeowner can install a water efficient clothes washer (hot water / end-use energy), while only a municipality can reduce leakage in the water distribution system (pumping / embedded energy). Energy inputs for hot water and steam also tend to employ a wider variety of fuels such as natural gas and petroleum products in comparison to pumping and treatment, which generally rely on electricity. In addition, though the embedded energy may appear small in comparison to end-use energy, the energy consumption for water-related uses relative to other activities may still be significant to an individual or sector. For these reasons, a separate examination of embedded and end-use energy is warranted. As illustrated in Figure 2, steam (including waste heat from power generation) accounts for 84%, hot water use 14%, and pumping and treatment 2% of total energy inputs to water in Ontario.

Hot Water & Steam (End-Use Energy)

The energy for heating water and generating steam together was estimated to be 440 PJ/yr in the residential, CI and manufacturing sectors, with an additional 516 PJ/yr of energy stemming from nuclear and fossil-fuel inputs to generate steam in the power sector, as previously illustrated in Figure 2. The energy

The energy for heating water alone, 141 PJ/yr, could keep close to half of all Ontarians warm in the winter.[8]

7 energy for manufacturing of chemicals may also be considered, but a study by Maas (2009) suggested that this energy was negligible in comparison to pumping and treatment.

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Pumping & Treatment (Embedded-Use Energy)

The 20 PJ/yr required for pumping and treating Ontario's water could light every home in the province.[10]

Despite the predominance of energy for heating water and generating steam in the water-energy nexus, as depicted in Figure 2, the electrical energy[9] required for pumping and treatment is not inconsequential. In fact, the 20 PJ/yr required for pumping and treating Ontario's water could light every home in the province.[10] About half of this embedded (electrical) energy for water in Ontario is used to power municipally operated water and wastewater systems across the province.

Box 2: Hot!!! Water Savings

The second largest consumer of energy - and producer of GHG emissions - in both the residential and commercial sectors, is hot water (NRCan, 2007). Importantly, with a payback period of 0-3 years for a number of measures, hot water savings are readily available for residential and commercial end-uses such as showering/bathing, clothes-, dish- and vehicle-washing (SeeLine Group Inc., 2005).

The economic rationale for including hot water conservation is seen in programs such as Manitoba Hydro's provincial commercial clothes-washer rebate (Manitoba Hydro, 2010), the U.S. Energy Policy Act (1992) that establishes minimum standards for pre-rinse spray valves and the free showerhead retrofits and boiler audits offered by gas companies.

New opportunities to save hot water are continually emerging such as hot water recirculation within homes and recycling and reuse of hot washwater in farms, car-washes and industry (Ally *et al.*, 2002; Vickers, 2001). Washwater reuse and recycling in milking operations, for example, have been demonstrated to save 65% of water, 60% chemicals and 40% of energy (Havard, 2002).

Energy Used for Water Services by Sector

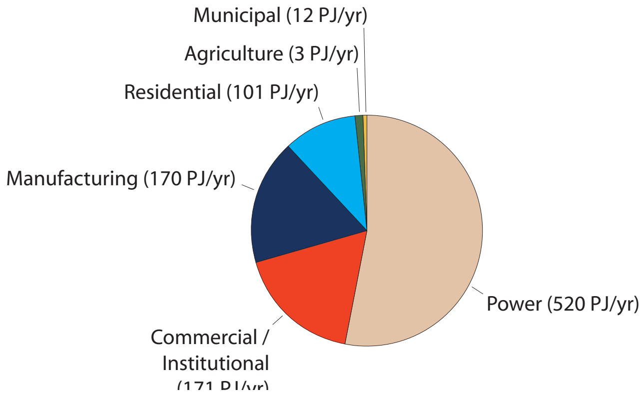
The total energy and water use in the province of Ontario was disaggregated by sector in Figures 5a and 5b respectively and Table A.1 in Appendix A includes additional details. The power generation, residential, commercial/ institutional and manufacturing sectors clearly dominate the energy demand for water because of the large amounts of energy required to heat water and generate steam. The municipal sector represents the energy for pumping and treatment of public water supplies, including water losses.

Given the large amounts of energy used for steam in the manufacturing, commercial / institutional and power generation sectors - and the general exclusion of steam from traditional water conservation programming - it can be helpful to separate steam from other end-uses of water to better illustrate the energy required for heating, pumping and treating water. Figure 6 excludes steam and disaggregates the energy required for pumping, treating

8 Hot water heating includes both residential and commercial sectors. Residential space heating in Ontario used 310 PJ/yr in 2006 (NRCan, 2006)

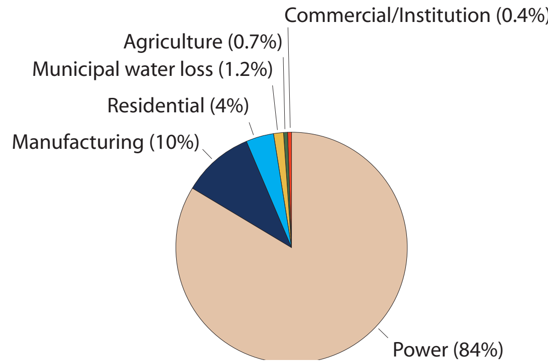
9 For the purpose of this report, all water and wastewater pumping is considered embedded energy, even if the water is being pumped from a well on the property.

10 Residential lighting in Ontario consumes 20.8 PJ/yr (NRCan, 2007)



Total energy - 976 PJ/yr

Figure 5a – Energy used for water services in Ontario, 2006, PJ/yr.



Total withdrawals - 31.8 billion m³/yr

Figure 5b – Water withdrawals in Ontario, 2006, m³/yr.

and heating water by sector.

Residential

The residential sector in Ontario uses an estimated 1,138,300,000 m³/yr of water (RMSi, 2009). Water-related energy consumption in the residential sector is predominantly used to heat water for clotheswashers, showers and faucets (101 PJ/yr), with the remaining energy (0.25 PJ/yr) used for pumping from private wells, which supply 15% of Ontario's homes with water (RMSi, 2009).

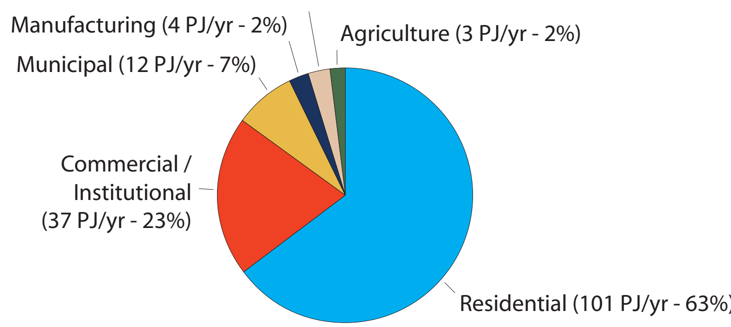


Figure 6 – Energy used for water services, by sector, excluding steam.

The residential sector was estimated to heat approximately 30% of its total water use. Residential water heating consumes more energy than appliances, lighting and space cooling combined, 70% of which is provided using natural gas (NR Can, 2007; NR Can, 2003). Not surprisingly then, greenhouse gas emissions for water heating in the residential sector are second only to space heating.[11]

Commercial / Institutional

The commercial sector in Ontario includes businesses, hotels, golf courses and restaurants while the institutional sector includes hospitals, schools, universities and government buildings among others. Together, commercial and institutional facilities use an estimated 132,300,000 m³/yr of water (RMSi, 2009). Energy for water within the commercial institutional (CI) sector fuels the hot water required for kitchens, laundry, car washing, showering,

11 A portion of space heating energy is assumed to be provided by boilers in the residential sector. However, no information about boiler use in residences was available for Ontario, so this energy for water was excluded at tthis time. 4.6 million tonnesCO_2/yr emitted from residential hot water heating (NRCan, 2006)

cleaning and steam generated in boilers in addition to cold water services such as process cooling, toilets and irrigation (Vickers, 2001).[12]

Energy for hot water heating in the CI sector was estimated at 36.9 PJ/yr based on NRCan (2006) estimates. Approximately 47% of hot water energy is fueled by natural gas, making it the second largest source of GHG emissions in the CI sector (NR Can, 2006). Steam generation for space heating was estimated to consume 133.7 PJ/yr based on an assumed 56% of heating energy supplied by boilers (CIBEUS, 2003). The heavy dependence on boilers in Ontario can be explained by Ontario's relatively large number of universities, large corporations and other institutions that rely on steam for both space and water heating.

Manufacturing

Manufacturing consumes an estimated 3,270,000,000 m^3/yr in Ontario, 20% of which is used for generating steam (RMSi, 2009). Water is used to replace steam lost through leakage, blowdown[13] and other losses in applications where steam is not fully condensed and returned to the boiler. Griffin and Johnson (2006) identified the automotive, pulp-and -paper, petrochemical, food and beverage and steel industries as particularly large steam users in Ontario. In the United States, major industrial energy users such as food processing and pulp and paper devote 20-80% of their fossil fuel consumption to steam production (Einstein *et al*., 2001).

Steam generation in Ontario was estimated to consume 20% of the total energy demand of the manufacturing sector.[14]

In fact, generating steam to provide process heat, hot water for process reactions and space heating, consumes between 20-45% of industrial energy use in the United States, the Netherlands and by extension other industrialized countries (ETSAP, 2009; Blok and Worrell, 1992; Ellis *et al*., 2009; US DOE, 2009). Ontario's manufacturing sector is anticipated to have similar energy use patterns, and a recent study reported that steam and hot water use

Box 3: Steaming Hot Opportunities

97 Ontario Steam Saver audits were completed between 1997 and 2005 by Enbridge Gas, which identified natural gas savings of 156 million m^3/yr with an average project payback period of only 1.2 years (Griffin & Johnson, 2006). Significant reductions of both water and energy can be achieved by increasing the rate of condensate return in boiler systems, however these improvements may, in some cases, be more expensive than other measures (payback period of 5.9 years) (Marbek, 2009). Lower cost measures that save both water and energy include optimizing and automating blowdown rates and improving feedwater treatment to reduce the frequency of blowdown (North Carolina, 2010). The Hamilton, Ontario based company Day and Campbell provides an excellent example of the water and energy savings potential of steam audits:

> Day and Campbell have been producing autoclaved concrete for over 60 years. An energy audit by Union Gas revealed an opportunity to re-circulate steam condensate from the autoclaves to the boiler. The wastewater from the auto-clave was too contaminated for the storm sewers and too hot to discharge to sewer. Re-circulating the steam therefore seemed an ideal solution, except the water was too contaminated to return directly to the boiler without treatment. Union Gas then engaged water specialists, who proposed a cost effective treatment solution, with a total retrofit payback period of only 2.5 years. The energy cost savings were $103,000 annually, water and sewer charges were reduced 70%, and water treatment costs were reduced by 25%. Greenhouse gas savings from the project were equivalent to removing 568 cars from the road.
>
> ***Excerpted from Enercase: Condensate and Flue Gas Heat Recovery (Union Gas, 2010)***

12 CIBEUS (2003) estimated that 47% of CI buildings utilized central chillers, but no additional information was available on the type of chillers employed. Water cooled chillers are known to be energy intensive, but were excluded at this time because of a lack of information about their use in Ontario.

13 blowdown refers to the discharge of water from a boiler to remove built up contaminants that reduce boiler efficiency

Box 4: Brewing Up Savings

The Energy Guide for the Brewers Association of Canada suggest that inefficiently operated breweries could reduce their water consumption from a ratio of 20 L of water purchased per L of beer produced down to a ratio of less than 4.5:1 with efficient practices. "Breweries usually pay for water twice: in purchase costs and in sewer chargers. A large brewery with a water-to-beer ratio of 9:1 had an incoming water temperature of 9 °C, but the combined effluent temperature averaged 28 °C. The use of water in a brewery has a strong energy consumption connotation. It makes sense to save these costs through conservation measures that can normally be accomplished more easily than direct energy-saving activities."

Excerpted from the Brewers Association of Canada's Energy Guide (1998: pp40)

consume 34% of the natural gas used in Ontario's industrial sector (Marbek, 2009). Steam generation in Ontario was estimated to consume 20% of the total energy demand of the manufacturing sector.[14]

Approximately 50% of manufacturing water in Ontario is obtained by private withdrawals of nearby groundwater, lakes and rivers. Annual electrical energy demands of 4.28 PJ/yr are required for industries such as paper, coal and petroleum and primary metals manufacturing that rely on privately-supplied sources of water.

Agriculture - Irrigation

An estimated average of 108,210,000 m^3/yr is used for irrigating crops, greenhouses, sod and nurseries (RMSi, 2009). In Ontario, irrigated crops primarily include field fruits and vegetables, tobacco, and greenhouse floriculture and vegetables (RMSi, 2009; Shortt, 2010: PC). Irrigation of crops is highly dependent on weather patterns and can vary greatly year to year. Irrigated water for non-greenhouse crops is primarily delivered using overhead (60%) and drip (40%) irrigation powered

Although the energy for irrigation is only 5% of the total energy use in the agricultural sector[16], the impact of wasted energy and water for individual farmers can be significant given the rising costs of fuel.

Box 5: Saving Energy by Managing Irrigation

The state of Idaho is paying farmers to not irrigate crops during hot afternoons when peak energy demand is highest. This measure has been estimated to shave 5% of peak electricity demands, with the potential to save water by reducing evaporative losses by irrigating when temperatures are cooler (Galbraith, 2009). Other examples corroborate the agricultural water-energy link illustrated in Idaho:

> "A Kansas study found that irrigation scheduling reduced water use by 20% while also reducing energy, fertilizer, and labor costs. The study found that the benefits of irrigation scheduling exceeded the costs, with a net return of nearly $13 per acre (Buchleiter *et al*. 1996). Kranz *et al*. (1992) found that irrigation scheduling reduced the applied water by 11% and energy use by 17% while improving yields by 3.5%."

Excerpted from Cooley, H., J. Christian-Smith and P. Gleik (2009) Sustaining California Agriculture in an Uncertain Future, Pacific Institute pg. 46.

14 166 PJ/yr for steam generation; 844 PJ/yr for all end-uses in manufacturing sector (NRCan, 2006)

Box 6: "Hot"house Savings

Over half of Canada's greenhouses are located in Ontario, making the province North America's largest greenhouse sector (Enbridge Gas, 2010). Fuel for heating, primarily delivered using steam or hot water, comprises more than 15-35% of a growers operating budget. Enbridge Gas has a dedicated greenhouse program offering to cover 50% of energy audits and a $0.05-0.10/m3 of gas saved as an implementation incentive (Enbridge Gas, 2010). Growers, such as Albert Grimm- the head grower at Jeffery's Greenhouses in St. Catharines, Ontario – are recognizing the relevance of water conservation to their bottom line:

> "In some very arid climates, the cost of irrigation water is beginning to exceed the cost of fuel, and I would speculate that water efficiency is going to be one of the keywords in the future of crop production. I believe that major trends for the future of greenhouse technology are going to be revolving around water conservation technology, especially because this is going to be a very profitable business".

> ***Excerpted from Grimm (2010) Irrigation Water Quality Challenges. Greenhouse Canada.***

by diesel fuel, whereas electricity is generally used to power irrigation systems in greenhouses (Shortt, 2009: PC).[15] Energy use for crop irrigation in Ontario was estimated at 0.18 PJ/yr. Although the energy for irrigation is only 5% of the total energy use in the agricultural sector[16], the impact of wasted energy and water for individual farmers can be significant given the rising costs of fuel.

Heating water in greenhouse operations is likely the most significant energy input related to agricultural irrigation. The energy used for heating water in greenhouses, 1.75 PJ/yr, was estimated by assuming all water withdrawals for irrigation were heated to 20 °C. This particular estimate is preliminary in nature, and should be refined when improved water use estimates and additional information on boiler use in the greenhouse sector become available.

Agriculture - Livestock

Livestock operations in Ontario include beef, dairy, swine and poultry with smaller operations of goat and sheep (OMAFRA, 2009). Water use requirements for livestock operations were estimated at 62,031,000 m^3/yr, and are generally used for drinking (80%), sanitary and equipment washing (10%) and animal cooling (1%) (RMSI, 2009: Table 60). Spillage and losses are reported to account for another 9.5% of total water use. An annual electricity demand of 0.03 PJ/yr was required to pump water given livestock operations were assumed to be privately supplied.

Energy requirements for heating water have been recognized as significant in livestock operations such as milking. Half of the water used for sanitary washing and cleaning was assumed to be heated based on a study of dairy farms, resulting in an estimated energy demand of 1.0 PJ/yr (OMAFRA, 2006).

15 Greenhouses, sod and nursery were assumed to be irrigated using the same energy intensity as drip irrigation in the absence of sector specific data. Land-based aquaculture was excluded because of both low energy inputs and lack of data on pumping energy.

16 Total agricultural energy consumption is 48 PJ/yr (NRCan, 2007)

Aquaculture

Water withdrawals for land-based aquaculture of rainbow trout, tilapia and other fish species in Ontario were estimated to be 39,192,000 m^3/yr in the Water Taking Reporting System (Ministry of the Environment, 2009).[17] The vast majority of land-based aquaculture relies on gravity flow surface water sources or artesian wells to minimize the energy costs of pumping (Naylor, 2010:PC). A first estimate of the energy use for aquaculture was obtained by estimating the water pumped from groundwater sources, assuming all surface water takings required negligible energy inputs. Estimates of actual groundwater takings for land-based aquaculture were 13,925,000 m^3/yr in 2008.

The electrical energy demand for water pumping in aquaculture was then estimated to be 0.01 PJ/yr. However, the water and energy demands reported herein provide only a first estimate given the known inaccuracies in both water use estimates and energy assumptions (refer to Appendix I for details).

Power Generation

Ontario Power Generation supplies approximately 70% of Ontario's electricity needs. Forty-five percent of this energy is supplied by nuclear, 34% by hydroelectric and 22% by fossil fuelled generating stations (OPG, 2008). Both thermal and nuclear power generation require large volumes of water for cooling, an estimated 86% of the total withdrawals in Ontario today (RMSi, 2009). Cooling water is withdrawn with large, highly efficient, axial flow (propeller) pumps that have lower energy intensities than, for example, municipal pumps where a higher lift

Box 7: Powering into the Future

Kalundborg, Denmark is considered the gold standard of industrial ecology practices internationally. Over a period of 20 years, this community increased synergistic linkages between power generation, industry, greenhouses and heating of homes and businesses. Since 1987, cooling water has been piped from an oil refinery to the coal-fired power plant to be used as boiler make-up water. Steam from the power plant was piped to both the oil refinery and a pharmaceutical manufacturing plant in 1982, a 2 mile pipeline that paid for itself in two years. Reuse of the steam reduced thermal pollution from the power plant in a nearby fjord. In 1991 the same oil refinery began treating wastewater to a sufficient quality that the power plant could utilize this water for cleaning purposes. Overall this innovative approach has been estimated to save 1,200,000 m^3 of water every year, and avoided 130,000 tonnes of carbon dioxide emissions (Ehrenfeld & Gertler, 1997).

Closer to home, the Bruce Energy Centre in Tiverton, Ontario, has been applying the concept of industrial ecology since 1998. Steam from the Bruce Nuclear Power plant is used within local industries such as an ethanol and biodiesel plant, a food processor and a biodegradable plastics manufacturer. Bruce Tropical Produce Inc. uses low grade steam for space heating of an 8-acre greenhouse, after which the cold water condensate is recycled to the power plant (Canadian Eco Industrial Network, 2010). Greenhouses have been identified by a number of studies as an ideal user of waste heat from cooling water, which could utilize the energy for space heating (Connecticut Academy of Science and Engineering, 2009; Lawrence National Centre for Policy and Management, 2009). Depending on the configuration, using greenhouses or other industries to "cool" the cooling water could simultaneously reduce the volume of raw water withdrawn from local ecosystems.

(pressure) is required (OPG, 2010b: PC). The energy associated with pumping cooling water in power plants in Ontario was estimated to be 3.6 PJ/yr.

17 RMSi (2009) estimated aquaculture water withdrawals at 96,200,000 m^3/yr based on an Ecologistics (1993) study. However, Steve Naylor (2010:PC) suggested that both the volume of water withdrawn for land-based aquaculture may have decreased since 1993.

An estimated 35-48% of energy inputs in nuclear and fossil-fuel fired power plants are converted to electricity, the remaining energy is converted to waste heat that is lost to the atmosphere and cooling water (Roth, 2005). The energy associated with steam generation in the power sector was difficult to ascertain. However, the energy for steam was approximated by estimating the energy lost as waste heat in Ontario's nuclear and thermal power generation facilities (refer to Appendix J for methodology). The energy associated with generating steam was found to be approximately 516 PJ/yr. This energy cannot necessarily be directly reduced through efficiency, however many places in the world have demonstrated innovative ways to capture this waste heat for use in district heating of homes and businesses, greenhouses and in other industrial processes while simultaneously reducing water use (refer to Box 7).

The energy associated with water loss in municipal infrastructure incurs an estimated $15,000,000 every year in electricity expenditures.[19]

Municipalities

Municipalities supply water to the CI sector and a portion of the residential and manufacturing sectors. The energy for pumping and treatment of water and wastewater is typically provided by electricity, and the associated energy intensity for water treatment and distribution and for wastewater treatment and collection was assessed in detail in a prior study (Maas, 2009). Municipally provided water was estimated at 3,120,555,443 m^3/yr with a total electrical energy use estimated at 11.6 PJ/yr.

Box 8: Municipal Dollars in the Bank

The existing water conservation programs in Ontario, involving a wide range of measures ranging from toilet rebate programs to industrial capacity buy-back programs, saved approximately 6,500,000 m^3 of water each year in 2006 (RMSi, 2009: Table 130). If investment in conservation continues at the current rate, in 10 years these municipalities will reduce electricity use by 44,000,000 kWh and save $2.6 million municipal dollars in energy costs each year across the province for pumping and treatment alone (see assumptions below); a cumulative savings over ten years of 243,000,000 kWh and $15 million in energy costs. Importantly, the residents of these communities also benefit by decreasing their home and business energy costs (if hot water or steam use is reduced), keeping water rates low by avoiding new water infrastructure and reducing their carbon footprint.

The opportunities for reduction of water losses in the municipal distribution system were estimated at 40% (RMSi, 2009). Water loss management techniques in municipalities can include water audits, leak detection and repair and pressure management. At only a fraction of the cost per litre saved of typical toilet rebate programs, water loss management is known to be a highly cost effective water conservation measure for municipalities (RMSi, 2009). Energy savings from infrastructure upgrades may be further amplified by the reduced friction losses as corroded pipes are replaced and the lower pressure requirements as leaks are minimized (Lahlou, 2001).

Assumptions: 0.68 kWh/m^3 water saved from (Maas, 2009); today's electricity prices $0.06/kWh

Municipal water providers have to contend with water loss through treatment plants and distribution piping estimated at 12% of municipal water takings in Ontario (Environment Canada, 2007) representing an average annual volume of 374,500,000 m^3.[18] The energy associated with water loss in municipal infrastructure incurs an estimated $15,000,000 every year in electricity expenditures.[19]

18 Note that this estimate differs from RMSi (2009) due to a difference in assumed total municipal volume. See Appendix for details

19 0.91 PJ/yr of electricity lost (252,000,000 kWh/yr) and assumes an electricity rate of $0.06 / kWh

Recommendations & Conclusion

This study offers the first provincial estimate of the total energy used for water-related services in Canada. In Ontario, an estimated 976 PJ/yr of energy was used for all water-related services in 2006. Excluding the power generation sector, water-related services were found to consume 40% of our natural gas usage and 12% of our electricity use in the province. And the energy for pumping, treating and heating water alone would require North America's largest coal-fired generating station running all day, every day to supply an equivalent amount of energy.[20] Clearly, the energy used for water-related services is both significant and worthy of future investigation into synergistic opportunities to save water and energy simultaneously.

Consideration of a "water sector" could offer a new lens with which to integrate energy reporting, research and conservation strategies across traditional economic sectors.

Natural Resources Canada already evaluates the energy consumed in residential and commercial/institutional sectors for water heating. Expanding the measurement and reporting of energy consuming activities to include water-related activities such as generating steam, heating water and pumping and treatment for <u>all</u> sectors including manufacturing, agriculture and power generation would help to build the capacity to investigate solutions that benefit both water and energy resources. The energy use for water was found to be comparable in magnitude to the energy used by individual economic sectors[21]. This suggests that consideration of a "water sector" might offer a new lens with which to integrate energy reporting, research and conservation strategies across traditional economic sectors.

An encouraging number of studies have revealed how water conservation and efficiency can reduce energy demands and provide a myriad of co-benefits including reduced infrastructure costs, maintenance costs and greenhouse gas emissions (Maas, 2009; Cohen *et al*., 2004; Griffiths-Sattenspiel & Wilson, 2009; Tellinghuisen, 2009). By seizing water conservation and efficiency opportunities, Ontario could reduce energy consumption, free up funds for struggling municipalities and greatly contribute to Ontario's fight against climate change. While many of these opportunities are available at minimal cost and with payback periods of less than two years, barriers

Box 9: Opportunities for Integrated Thinking and Action on Water and Energy

1. **CHOOSE THE WATER AND ENERGY SOFT PATH** by prioritizing conservation of water and energy over new infrastructure. Recognize the impacts of new water infrastructure on energy use, and new energy infrastructure on water.
2. **BETTER INTEGRATE** water and energy monitoring, reporting, management and efficiency programs. Examine energy use and efficiency opportunities <u>across</u> economic sectors through a "water sector" lens that includes cold water, hot water & steam.
3. **COLLABORATE** by bringing together water and energy expertise together to encourage development of innovative, synergistic solutions.
4. **INFORM** the public, policy makers and practitioners of the mutual benefits of reducing water and energy use.

20 actual energy used for water services is provided by a variety of sources including natural gas and electricity
21 sectors are defined as residential, manufacturing, commercial/institutional, agricultural and power generation

remain for homeowners, business owners and municipalities alike. New thinking and action is therefore required to increase participation in conservation programs and thereby build a more resilient future for Ontarians.

Linking water and energy conservation efforts offers one such new way of thinking. Box 9 highlights several opportunities to encourage a more integrated approach to water and energy.

This research offers a comprehensive depiction of the energy inputs to water in Ontario, offering a basis for future work to identify measures, policies and programs that offer both water and energy savings. The energy inputs to water in Ontario suggests that water conservation and efficiency is likely to be the next frontier of energy saving opportunities in Ontario. Furthermore, the simultaneous water and energy impacts that stem from development of new water treatment plants and new power plants emphasize that energy conservation remains the best fuel and water conservation the best source of new water.

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The POLIS Project

Created in 2000, the POLIS Project on Ecological Governance is a research-based organization housed at the University of Victoria in British Columbia. Researchers who are also community activists work together at POLIS to dismantle the notion of the environment as merely another sector, and to make ecological thinking and practice a core value in all aspects of society. Among the many research centres investigating and promoting sustainability worldwide, POLIS represents a unique blend of multidisciplinary academic research and community action.

Visit www.polisproject.org to learn more.

Water Sustainability Project

The Water Sustainability Project (WSP) is an action-based research group that recognizes that water scarcity is a social dilemma that cannot be addressed by technical solutions alone. The project focuses on three themes crucial to a sustainable water future:

- Water Conservation and the Soft Path
- Water-Energy Nexus
- Water Law, Policy and Governance

WSP works with industry, government, civil society and individuals to develop and embed water conservation strategies to benefit the economy, communities and the environment. WSP is an initiative of the POLIS Project on Ecological Governance at the University of Victoria.

Visit www.poliswaterproject.org to learn more.

POLIS Project on Ecological Governance

watersustainabilityproject