Community Based Education Partnership
Trent University and the Township of Minden Hills

S.G. Nesbitt Memorial Arena

Moving towards Sustainable Consumption and Heating of Water

A Project by:

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Purpose

The purpose of this report is to make recommendations to the Township of Minden Hills for more sustainable approaches to water management and heating.

The municipality runs an arena that has diverse energy needs. One element of the system is the heating and cooling of water – generating hot water for showers and making ice for the skating surface. This project is intended to explore creative options for heating and cooling to maximize efficiency and minimize waste.

We have investigated energy saving and water conservation options for the arena's water usage. These include showers, sinks, toilets and the water used to make ice. Technologies to reduce water use and energy requirements for water heating were researched as a way to make the arena more sustainable.

Project Collaborations

This project was facilitated by the Trent Centre for Community Based Education(TCCBE) / U-Links and supervised by a Trent University instructor as part of the Community Based Natural Resource Management class of the Environmental Science undergraduate program. The project agreement was formed between the authors and the manager of the S.G. Nesbitt Memorial and Community Centre Arena.

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The project was part of a larger collaboration with two other student groups also working with the arena. Their reports can be obtained through U-Links.

Project Design and Methods

Data Collection

The first step of the study was to collect information on the current water usage and heating/distribution infrastructure. Data was collected in a number of forms. There was a site visit and tour of the arena's infrastructure to become familiar with the water system. During the visit we measured the maximum flow rate from all the sink and shower fixtures to establish some base line measurements of consumption. The measurements were done by filling a container from the water fixture at full flow for five seconds and using a 500 mL and a 100 mL graduated cylinder to measure the volume of water collected. Toilets and urinals were checked for labels indicating their flush volume.

Mr. Cox provided his utility cost files for the years 2005 to 2010 and the blueprints of the building. Another useful resource was a report done by Trent students through TCCBE in 2009 which looked at the feasibility of solar photovoltaic panels for the arena (Ferguson-Martin and Heyden-Thomas).

Research

Research was then conducted on market available technologies for reducing water consumption and increasing heating efficiency. This research was based largely in academic and grey literature, as well as commercial supplier catalogues. An initial report was drafted summarizing the research topics studied. This was distributed to all project collaborators to generate feedback and dialogue to further direct the research.

RETscreen

The RETscreen component was completed using RETscreen4 under the project type heating. The solar hot water heater technology was selected and using the information received from Mr. Cox regarding water consumption and heating requirements for the showers' hot water tanks in the arena was filled in. This information along with some financial repayment methods allowed RETscreen to determine a payback time period, displaying the time until the project breaks even, as well as the amount of money which will be saved in the end of the 20 life span.

Presentation and Outreach

One component of this project was a poster presentation in Haliburton County presenting our initial findings and project goals to academic and professional individuals, politicians, and community members. This was an opportunity to talk to the public about green technologies and water conservation.

Constraints

Many of the toilets and urinals in the building are not labelled, making it necessary to estimate or omit flow rates in our analysis. Also, we were not able, due to time constraints, to study water usage in the arena for trends over days or weeks, or to study the arena in the summer months.

Faucets and Shower Heads

Faucets

One of the first steps taken in the research process was to measure the flow rate from the existing fixtures to establish a baseline from which to reduce consumption. The results are shown below (Figures 1 and 2) and give a clear representation of the potential for savings. It is also to be noted that all water consumption rates are based on the values which will be in place after the 5% increase that will be put in place next year (Ingram, 2011).

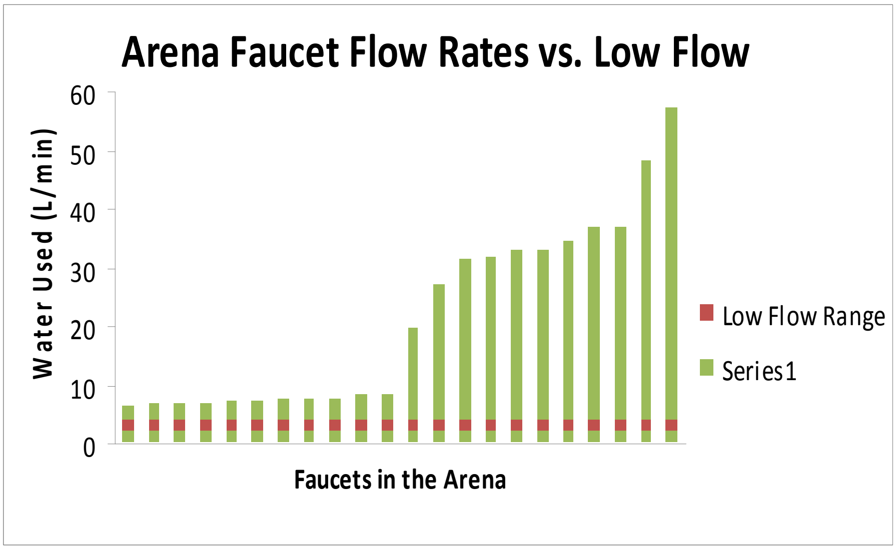

Figure 1: Arena faucet flow rates measured in L/min. The average range of low flow faucets are shown in red.

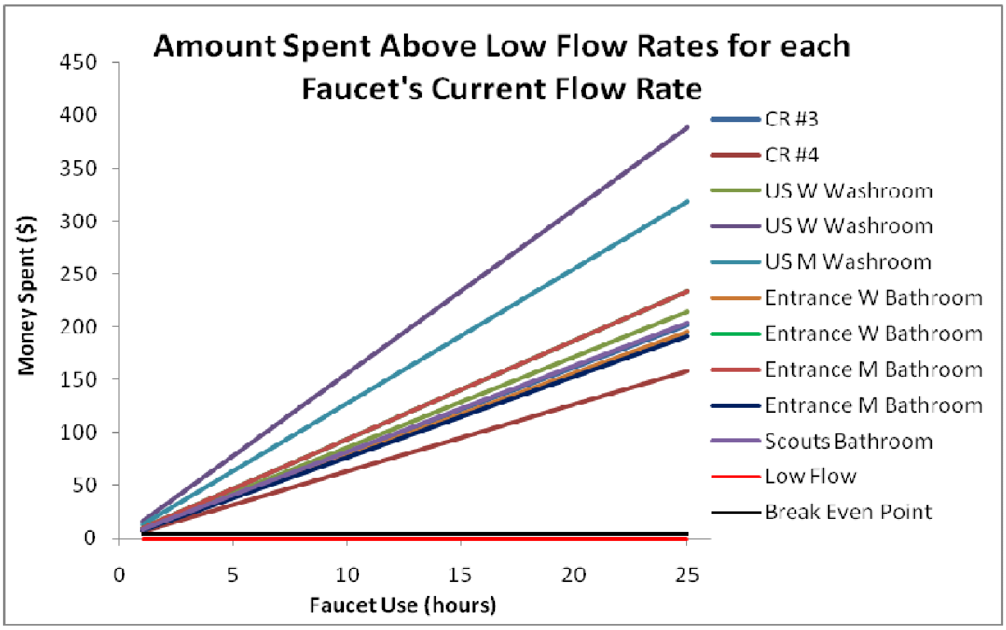

Figure 2: The arena faucet flow rates were analyzed by the extra amount of money spent when using the current fixture instead of a low flow faucet (low flow = 6L/min). The low flow line is on the x-axis because this chart displays the amount of money spent on the flow which exceeds this low flow rate, and the breakeven point ($4.00) is where the black line meets the shower lines. In these charts, CR always stands for change room, W is for women's, M for men's and US stands for upstairs.

Installing low flow technologies can easily result in water savings of 25 to 60 percent (DOE, 2011). The flow rate of a sink faucet is determined by the aerator piece on the end of the faucet with most new designs for bathrooms being 1.9 to 5.7 litres per minute (DOE, 2011). Replacing aerators is an inexpensive and effective way to reduce water consumption if pieces are chosen with Lpm rates of 3.8 or less (DOE, 2011).

Only those faucets having extra cost on top of low flow rates of more than $1.00/hr were used as there are far too many faucets in the building for one graph, so we focused on the worst wasters. However, 6L/min is a very generous amount for low flow technology in taps and some can be below 2L/min, but simply installing an aerator does not always bring the flow rate down this low so we used a higher value to be safe. Aerators are inexpensive as represented by the black line in Figure 2, and every faucet tested exceeded the payback period within one hour when used at max flow. Aerators are therefore strongly suggested as a very easy solution financially and to install.

Aerator, Faucet: Ultra Dual Third
Item # 3302802
Model # M3552
$3.29 each (Home Depot, 2011)

Figure 3: Aerators are available at low cost (Home Depot, 2011)

Showers

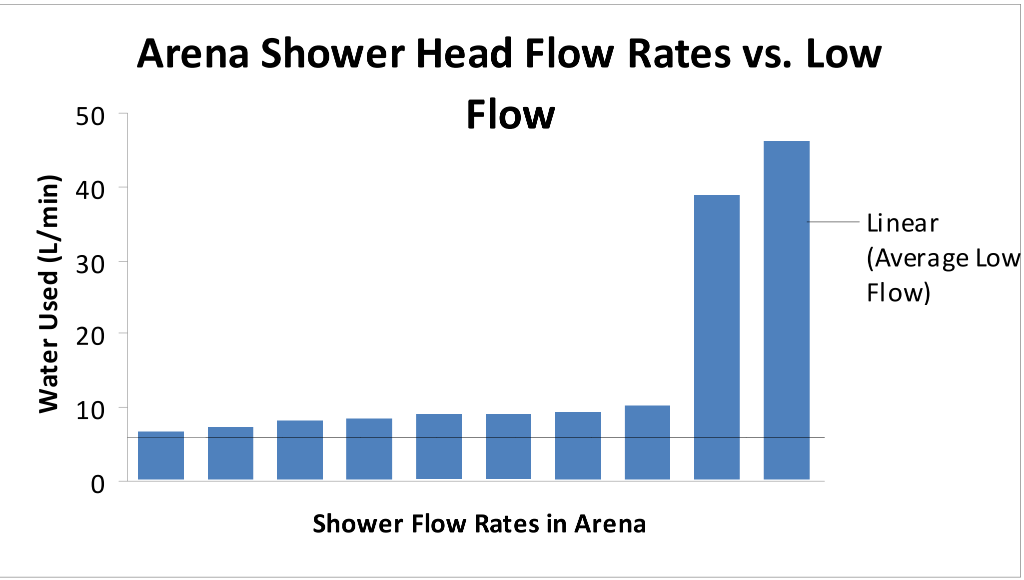

Figure 4: Arena shower head flow rates measured in L/min. The average flow rate of low flow shower fixtures is shown as a black line.

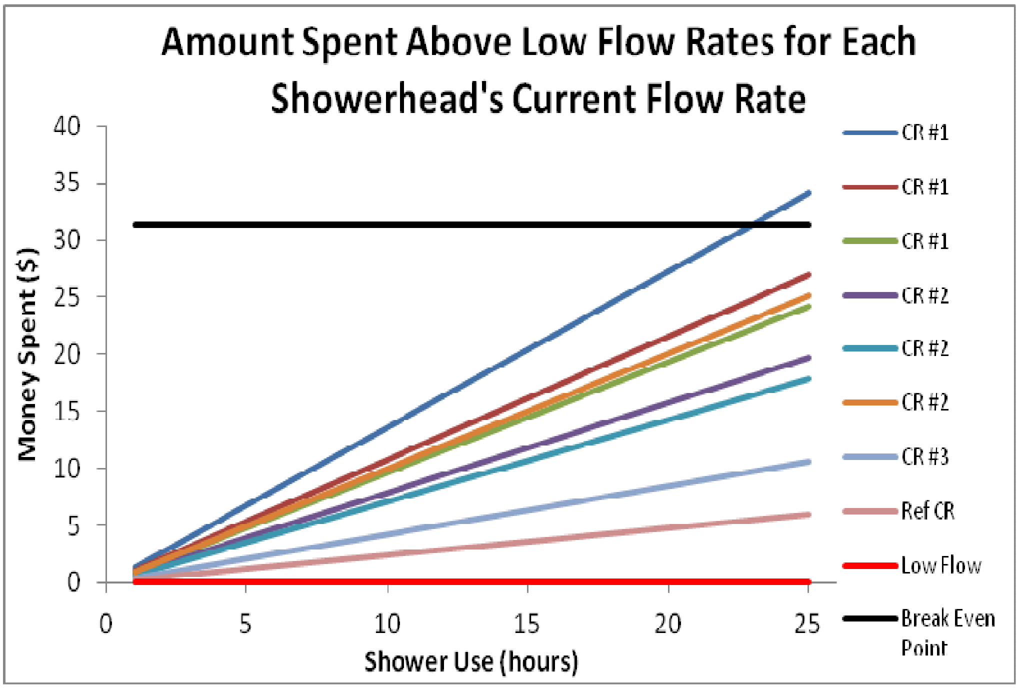

Figure 5.1

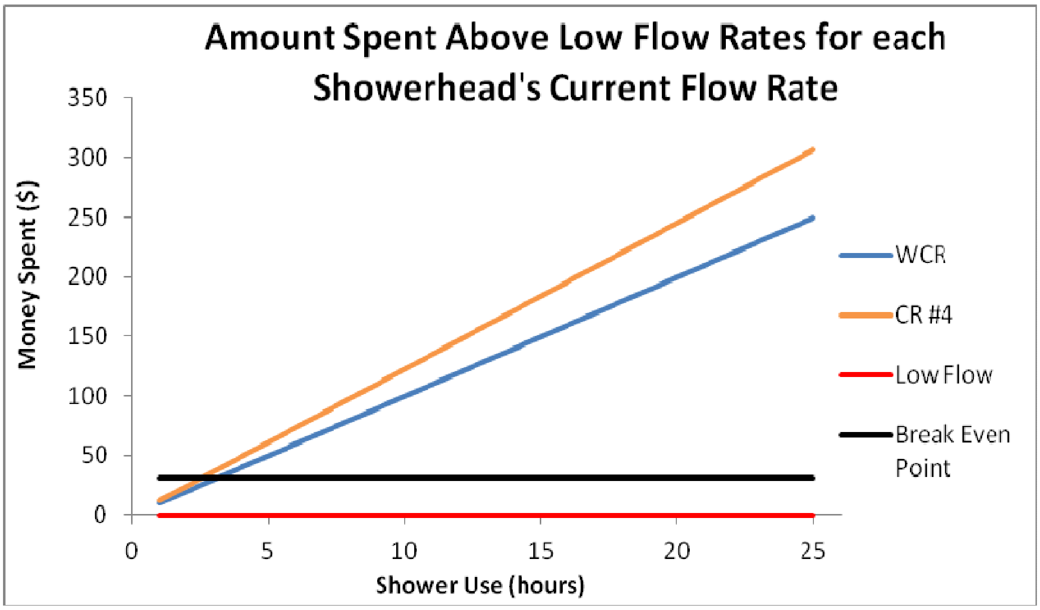

Figure 5.2

Figures 5.1 and 5.2
The arena showerhead flow rates were analyzed by the extra amount of money spent when using the current fixture instead of a low flow showerhead (low flow = 5.68L/min). The low flow line is on the x-axis because this chart displays the amount of money spent on the flow which exceeds this low flow rate, and the breakeven point ($31.36) is where the black line meets the shower lines. In these charts, CR always stands for change room, W is for women's and Ref stands for referee.

Two options exist for low flow showerheads, aerators and laminar-flow (DOE, 2011). Aerators mix air into the water to create a 'misty spray' while laminar-flow heads form streams of water and result in less humidity (DOE, 2011). Below are some market examples of low flow showerheads.

Some of the showerheads in the arena are not bad for wasting water; some are even very close to the low flow values used. Figure 5.1 shows the values of the showerheads which were low to medium flow, these showing pay back periods of in most cases well over 25 hours of use at full flow. For this reason, many of these do not need replacing. This being said, Figure 5.2 shows the two showerheads that could not be put on the same graph as the rest due to the excessive water flows which resulted in money spending being extremely larger per hour for them. These showerheads are very strongly recommended to be replaced as it is shown that the cost of a new showerhead will be reached in savings quickly, that being roughly after 3 hours of use at full flow rate.

Moen: Single Function Low-Flow Showerhead
Industrial use model including vandal resistant set screws (5 year limited warranty on product).
max flow = 6.1L/m or 102mL/sec
Model: 52716LF16
$37.15 each (Home Depot, 2011)

American Standard: FloWise Water Saving Showerhead
Model: 1660.710.002
5.68L/min or 95mL/sec
Range of water savings: 13 to 675mL/s or 780 to 40500mL/min of shower use (depending on the shower, some not needed to be replaced because flow rates are already fairly low)
$27.75 each (Home Depot, 2011)

American Standard: single on/off valve and cover for showers
This is the single handle, turn counter clockwise to turn on water valve type.
Valve Model: R711
Coverings have many options for models
$36.75 for each ($73.50 for both the valve and handle cover) (Home Depot, 2011)

Toilets

Option 1: Replacing Old, Large Toilets

The first option is to replace all old toilets with high flush volumes with modern, dual flush and/or low flow technology. The benefit of this option is having the most current, efficient technology available. However, a large initial investment is required to replace all of the toilets at once and a large amount of waste will be generated in the form of the old toilets.

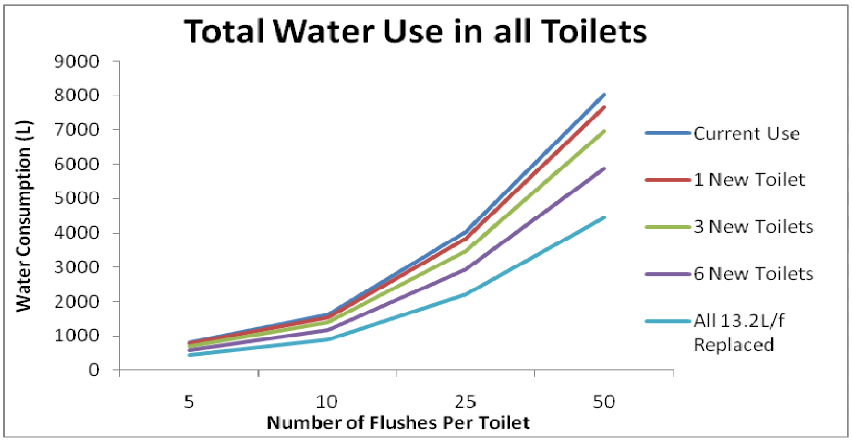

Figure 6: Arena toilet water use values are shown by number of flushes. "Current Use" is the amount used with all ten 13.2 L/f toilets, every subsequent line being the new usage if the specified number of these high flow toilets were replaced with 6L/f toilets.

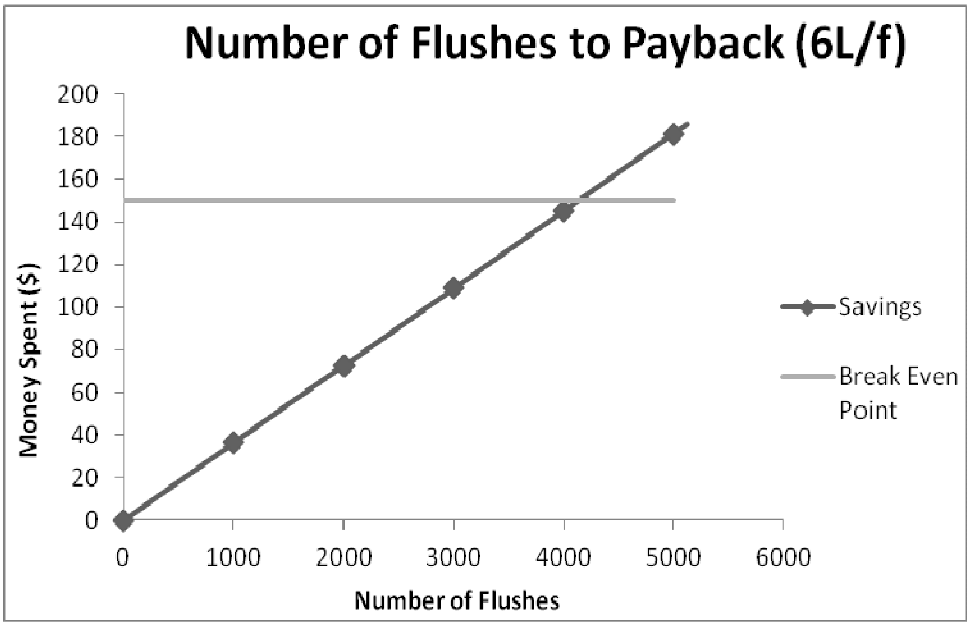

Figure 7: The payback period for replacing a 13.2L/f toilet with a 6L/f toilet priced at $150 is displayed. The increasing line shows the money saved over the number of 6L flushes (saving 7.2L a flush). The breakeven point is where the two lines meet, anything above that is savings.

The arena's toilets are large users of water, mainly due to those which are older, high flow models. The extra use of all the 13.2L/f toilets in the arena is seen when you look at Figure 6 and how much the amount of water consumption decreases with the removal of these high flow models. Nevertheless, replacing the toilets should be done to those used most first as they do take a fairly longer period to pay off as shown in Figure 7 (over 4 000 flushes). Therefore, those which do not see as much use may only need to be altered in order to become more efficient than they currently are as this can be done for virtually nothing as discussed in Option 2 below. It also should be noted that the 6L/f models were used in this case because it is a public arena, not a household bathroom, and the worry is that the smaller 4.8L/f models may clog, resulting in extra costs, but if a dual flush toilet was purchased as they have the same price range, the breakeven point would be reached faster. This would be due to the 4.1L flushes which are to be used for liquids.

Below are some market examples of low flow toilet technology.

Windham(TM) 2-piece Toilet with Elongated Bowl in White
Model: 404700-0 - $139
5 year warrantee, 4.8L/f (Home Depot, 2011)

Home Depot Glacier Bay : Dual Flush 2 Piece All-In-One Toilet
Model: TL-2005-WL-GB
4.1/6.0 L/f
$149 (Home Depot, 2011)

Home Depot Glacier Bay : 4.1/ 6.0 LPF Dual Flush Elongated High Efficiency All-In-One Toilet.
Liquids flush at 4.1 LPF, solids flush at 6.0 LPF.
Model: N2316-IN
$169 (Home Depot, 2011)

Option 2: Replace Old Large Toilets When Needed and Reduce Tank Volume Manually

If the township does not choose to replace the existing toilets all at once, or chooses to wait until they become worn or damaged and require replacement, the flush volume of the existing toilets can be manually reduced. Professional toilet dams can be bought from a hardware store, or alternatively a simple device using readily available materials can be used.

A plastic bottle filled with water and fixed to the inside of the tank will reduce the flush volume by the volume of the bottle. It is important that the bottle be fixed somehow within the tank so that it does not damage or obstruct the flushing mechanisms. This can be done by emptying the tank and gluing the bottle to the inside of the tank or by partially filling the bottle with heavy gravel. Bricks should not be used to displace water as they will deteriorate. and may clog the pipes.

Solar Water Heating

Currently, the arena uses a combination of oil and propane water heaters to meet its hot water needs. There is one large holding tank near the oil water heater and two electric heaters which have been converted into holding tanks near the propane heater. The already existing storage system makes a solar water heating system ideal for the S.G. Nesbitt Arena.

The sun offers great potential as a renewable resource, as the irradiative energy it supplies is greater than any other available energy source, and is eight thousand times as great as our current primary energy supply (Philibert, n.d.). It would take an area of less than one percent of the emerged land covered in solar energy capturing technologies to meet the next decade's energy demand (Philibert, n.d.). This great amount of available energy can also be harnessed and used to heat water. The installation of a solar water heating system can reduce water heating bills from 50 to 80 percent as well as protect against fluctuating energy costs (DOE, 2011). Currently in Canada, 600 000 square metres of solar water heaters exist (OMAFRA, 2011).

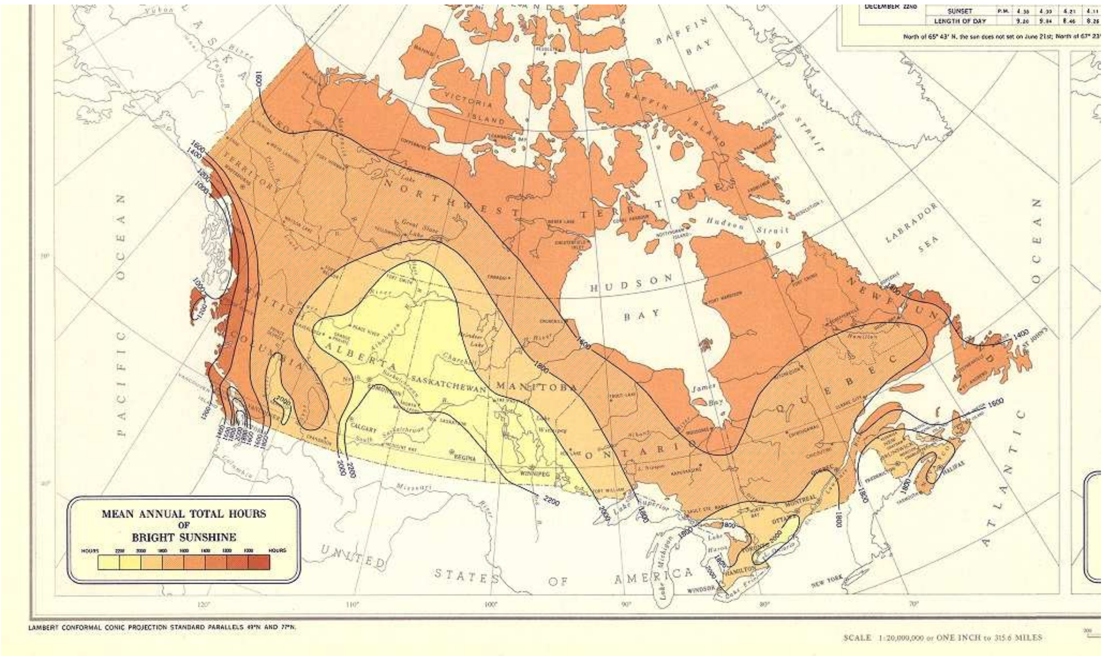

Figure 8: Mean annual total hours of bright sunlight received across Canada with Minden in the 2 200 to 1 800 hour ranges (Natural Resources Canada, 2003).

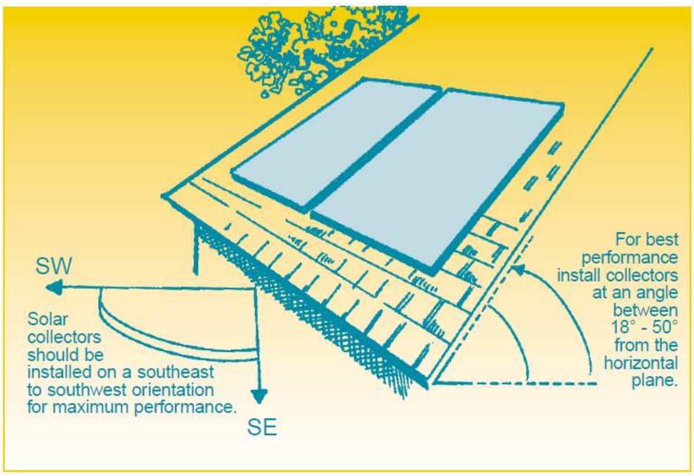

Figure 9: Diagram showing the optimal placement of solar collectors (Natural Resources Canada, 2000).

Solar water heating systems can be divided into two main categories: passive and active. Passive systems use the natural movement of water as it heats and cools. These systems tend to be less expensive than active systems, but are also less efficient and most suitable for warm, sunny climates as opposed to our northern Canadian climate (Philibert, n.d.). Active systems depend on a mechanical pump to force the water up to the solar collector and can be either direct or indirect. For this application an indirect system has to be used to prevent freezing in the cold climate. They do this by using a heat transfer substance to travel between the collectors and heat exchanger, then heating the water (DOE, 2011).

Table 1: Applications of various solar thermal collectors where DWH is domestic hot water, CHW is commercial hot water, VAH is ventilated hot air, ISP is indoor pool heating and OSP is outdoor pool heating (OSEA, 2008).

Applications of Various Solar Thermal Collectors					
Collector	DHW	CHW	VAH	ISP	OSP
Air-Based					
Back-Pass or Single-Pass Open			✔		
Unglazed Perforated Flat-Plate			✔		
Glazed Flat-Plate			✔		
Liquid-Based					
Unglazed Flat-Plate					✔
Batch, Bread-Box or Integral	✔				
Evacuated or Vacuum Tube	✔	✔		✔	(✔)
Glazed Flat-Plate	✔	✔		✔	(✔)

As can be seen in Table 1, there are two models of collectors appropriate for commercial scales: evacuated or vacuum tube collectors and glazed flat plate collectors. Evacuated tube collectors are far more expensive than a glazed flat plate collector.

Therefore, the most appropriate system for Minden is a glazed flat plate collector with an antifreeze transfer fluid, positioned on the southern roof side.

Permits

Table 2: Permits required for the solar water heater project (Clean Air Foundation, 2009).

Permit Required	Rational	Permitting Authority
Municipal Building Permit	A collector 5 or more square metres large is considered a 'designated structure'	Minden Building Officials
Municipal Plumbing Permit	The solar heating system will be connected to the domestic water system.	Minden Building Officials

Green House Gas Reductions

The project would be able to reduce the carbon footprint of the arena by 9.5 tCO_2, which is equivalent to 19.6 barrels of crude oil. This will make the S.G. Nesbitt Memorial Arena an environmental leader in the Kawarthas. By investing in renewable energy that is visible to the community, the Township of Minden Hills can model the potential of solar power in the region.

Payback Period

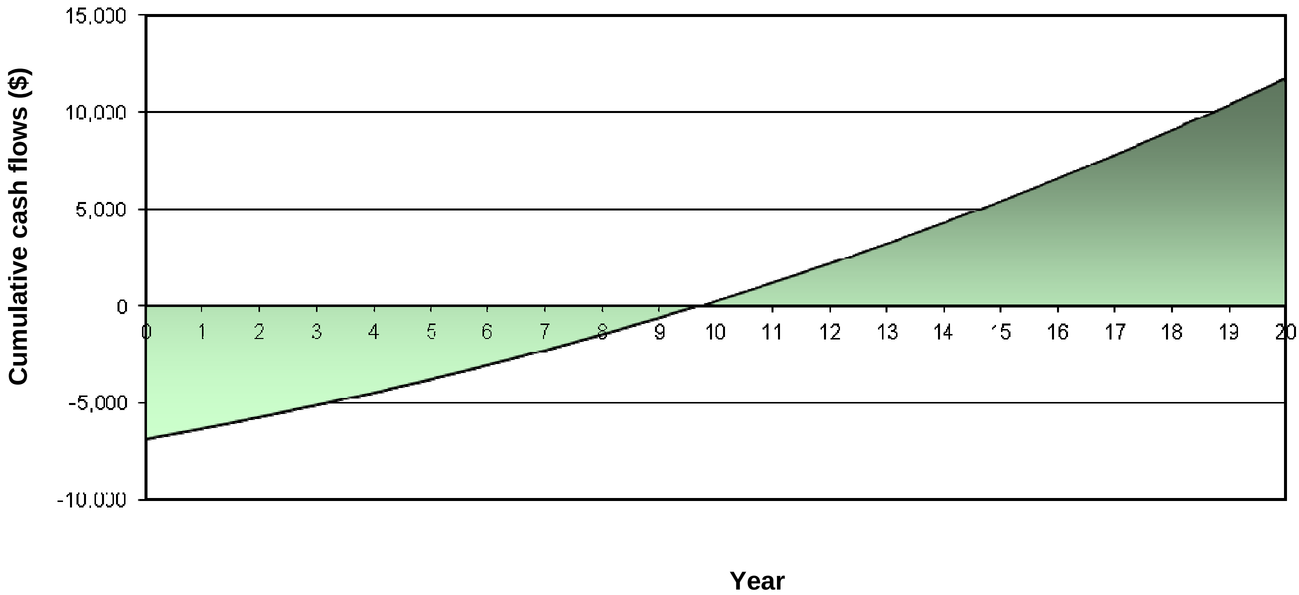

Figure 10 : Payback period on the solar hot water system for the dishwasher, showers and faucets is displayed. The point in which the line reaches the x-axis is the breakeven point for the project, and everything above the x-axis is money saved.

As can be seen in Figure 10, the payback period on the system is 9.7 years with a 20 year debt repayment program of $1 272 annually (See Appendix). An average for the volume of water used daily was calculated using the last year's quarterly water consumption values for the front, oil heated hot water tank. A RETscreen analysis was not completed on the propane water heater for the Zamboni water because a storage tank would be needed with the heat exchanger inside. In addition, the higher temperature of the Zamboni water would require an evacuated tube system which comes with a much higher initial cost and because the propane heater is already more efficient we decided to mitigate the effects of the oil heater. The cost of the solar collectors used in the analysis was a mid-range estimate per m^2 of the solar collectors. Also to be kept in mind is that the more the water flow rates of the arena's fixtures are reduced, the less hot water will be used and the longer the payback period on a solar hot water project would be. It may even be a good idea to complete all of the water saving technology installations and wait to see the new amounts of water used and re-evaluate the project.

Next Steps

The next step is to contact a contractor to perform an estimate and do the installation. Below are some local companies specializing in renewable energies.

Renewable Energy Alternatives Limited
705-743-8061
www.realenergyalternatives.ca
realenergy@sympatico.ca

Sun Volts Unlimited
Sundridge, ON
1-800-558-7939
sunvolts@sunvoltssolar.com

The roof must be assessed for structural stability. If it is found to be unsuitable to hold a collector, a ground mounted collector can be considered. Below is the contact information for structural engineers in the Kawarthas.

Greer Galloway Inc.
973 Crawford Dr.
Peterborough, ON
(705) 743-1351

McShane Engineering
317 Reid St
Peterborough, ON
(705) 749-0003

Trow Associates Inc.
2517 Denure Dr.
Peterborough, ON
(705) 741-1105

Ongoing Maintenance of a Solar Heating System

Beyond the initial costs of installing a solar water heating system exist the ongoing maintenance requirements, described below (DOE, 2011):

- ✓ Check for vegetative growth or development shading the collector throughout the day, annually.
- ✓ Periodic cleaning of the collector.
- ✓ Check the glazing for clarity and the seals for leaks or punctures.

- ✓ Check the plumbing, ducts and wiring for leaks or faulty connections.
- ✓ Check insulation for degradation.
- ✓ Check seal around roof penetrations.
- ✓ Check support structures for stability and strength.
- ✓ Check pressure relief valve.
- ✓ Check pump functions.
- ✓ Heat transfer fluids (if an antifreeze solution is used) must be replaced regularly.
- ✓ Storage tanks must be checked for cracks or leaks.

Grey Water Heat Recovery

With all the energy invested in heating water for showers and appliances, 80 – 90% of the energy literally goes down the drain as wasted heat (DOE, 2011). This system is compatible with all heating models, particularly solar heating systems (DOE, 2011).

Grey water heat recovery systems work by spiralling the incoming cold water around the drainage water which, if hot water is being used, will be higher in temperature. The incoming water is then preheated by the waste water before entering the heating system. The heater therefore, doesn’t have to use as much energy to reach the desired temperature. The grey water heat recovery system can be used for the dishwasher and showers. The dishwasher would be an especially appropriate set up as a smaller, more inexpensive model could be purchased to capture some of the heat from the super heated water before reaching the super heater. Also, this installation would probably be the easiest as it would be on the pipe in the wall directly below the dishwasher, also eliminating distance travelled in which the hot water will lose heat. These systems are easy to install; just replace a vertical section of drain pipe with the heat recovery pipe which is copper piping tightly looped around the drain pipe, and there is no maintenance needed.

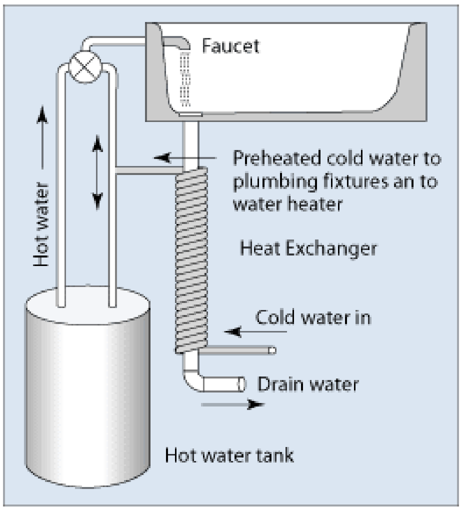

Figure 11: Diagram of a grey water heat recovery system (DOE, 2011).

Grey water heat recovery systems typically cost $300 to $500 with a payback period ranging from 2.5 to 7 years, dependant on use (DOE, 2011).

Insulation

Insulating water tanks is an easy and effective way to conserve heat on models with R values less than 24 (DOE, 2011). A water tank that is warm to touch would benefit from insulation with potential reductions in heat loss of 25 to 45 %, resulting in a 4 to 9% reduction in water heating costs overall (DOE, 2011). Pre-cut covers with an R-8 minimum value range from $10 to $20 and pay themselves off within a year of purchase (DOE, 2011). Another 4 – 9 % reduction in energy requirements can be achieved by placing a firm insulating board underneath electric water tanks as well (DOE, 2011). Propane water heaters can also be insulated, but are slightly more difficult as care must be taken not to obstruct the flues, drains, and burner; the top should also be left uncovered (DOE, 2011).

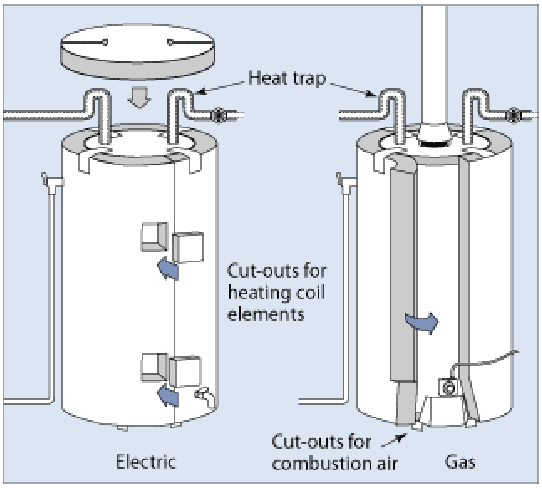

Figure12: Diagram showing insulation of electric and gas water heaters (DOE, 2011).

Hot water pipes which are accessible should also be insulated, particularly within three feet of the heater to result in a 2 to 4 degree increase in water temperature (DOE, 2011). This allows the water temperature to be set several degrees lower and results in a faster delivery of hot water throughout the facility meaning less water will be run while waiting for the desired temperature (DOE, 2011). Cold water pipes should also be insulated within the first 3 feet (DOE, 2011).

Fibreglass strips may be used but the most common type of insulation involves polyethylene or neoprene pipe sleeves chosen to fit the pipes snugly and strapped down every couple feet (DOE, 2011). The sleeves should be placed with their seam down (DOE, 2011). Special considerations must be made for the propane heater in that insulation must be at least 6 inches from the flue and for pipes less than 8 inches from the flue fibreglass insulation at least 1 inch thick without facing should be used and wired down (DOE, 2011).

Heat Traps

While newer water heaters often come equipped with heat traps, it's worth checking older models and installing the traps on those without them. A simple purchase of about $30 will pay itself back in a bill or two by reducing the flow of hot water out of the holding tank (DOE, 2011). The only other requirement is the ability to solder the joint properly following installation.

Reduced Hot Water Temperature

Every reduction of the water thermostat by 10 degrees translates in a 3 to 5 percent savings in water heating costs (DOE, 2011). Most water heaters are preset to 140 degrees Celsius, a temperature which exceeds that needed for showers or kitchen use with the exception of the dishwasher, which at the arena has its own superheater. An added benefit of a reduced water temperature is a slowing of mineral buildup and corrosion in the system (DOE, 2011). Also, too hot of water can be dangerous to young children. This is an easy step to reducing water energy costs and the adjustment can be done manually having read the system's operating instructions. Typically, electric heaters have thermostats behind panels and often have more than one thermostat, while gas heaters have thermostats located lower on the unit on the gas valve (DOE, 2011). To ensure adequate heating, the furthest taps should be checked with a thermometer after any adjustments to the thermostat are made (DOE, 2011).

Funding

- **Green Municipal Fund**
  Federation of Canadian Municipalities
  http://oee.nrcan.gc.ca/commercial
  Check availability after July 31st, 2011

- Incentives for solar water heaters, for commercial use up to $400 000 depending on size and production of the system (Juneau, 2010).

- Potential government incentive programs: Sustainable Technologies Development Canada (SDTC) and The Community Power Fund (Ministry of Energy, 2010)

Summary of Recommendations

In conclusion, our project has lead us to a number of recommendations for the S.G. Nesbitt Memorial Arena.

I. Due to the low cost and high efficiency of aerators, we recommend installing them in all the faucets with high flow rates (exceeding the costs of a low flow faucet by more than $1 per hour).

II. The two shower heads with exceptionally high flow rates (See Figure xXx) must be replaced; the decision to replace the others is at your discretion but should be in order of decreasing flow rates (See Figure xXx).

III. Toilet replacements should prioritize large (13.2 L/f) toilets in high traffic areas. Until replacement, large toilets are replaced, some of the flush volume should be displaced with a toilet dam.

IV. To pursue a solar water heater, the township should first contact structural engineers, installation companies, and sponsors, as provided in the text.

V. A grey water heat recovery system should be installed for the superheated dishwater as it is an easy and effective small scale project. The layout of shower piping must be considered to assess the feasibility of a shower drain heat recovery system.

VI. All accessible hot water pipes and cold water pipes within three feet of the source should be insulated as well as old, not insulated heaters and storage tanks.

VII. If either of the water heaters do not have heat traps installed, they should be purchased.

VIII. The heaters should be set to the lowest hot water temperature which still meets the arena's hot water needs.

In conclusion, we feel that the S.G. Nesbitt Memorial arena has many opportunities to conserve water and energy, save money, and establish the Township of Minden Hills as an environmental and technological leader. The recommendations outlined above are intended as guidelines and must be further considered, but already hold the potential for positive economic and environmental impacts. Also, keep in mind that the savings outlined in the solar water heating section are lower than truly expected because of the reduction in hot water use as a result of lowered water consumption, meaning less oil used to heat the water if these water saving technologies are installed.

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Appendix: RETscreen Analysis Results of Glazed Flat Plate Collector Hot Water System\

RETScreen Energy Model - Heating project

Heating project

Technology — **Solar water heater**

Load characteristics

Application: Swimming pool / Hot water

	Unit	Base case	Proposed case
Load type		Industrial	
Daily hot water use	L/d	2,500	2,500
Temperature	°C	52	52
Operating days per week	d	7	7

Percent of month used

Supply temperature method		Formula			
Water temperature - minimum	℃	1.0			
Water temperature - maximum	℃	9.6			
	Unit	**Base case**	**Proposed case**	**Energy saved**	**Incremental initial costs**
Heating	MWh	49.6	49.6	0%	

Resource assessment

Solar tracking mode		Fixed
Slope	°	21.0
Azimuth	°	202.5

☐ **Show data**

Solar water heater

Type	Glazed	$ 18,650	See technical note

Manufacturer	ACR Solar International		See product database
Model	Fireball Fireball 2001		
Gross area per solar collector	m²	1.87	
Aperture area per solar collector	m²	1.72	
Fr (tau alpha) coefficient		0.60	
Fr UL coefficient	(W/m²)/℃	3.73	
Temperature coefficient for Fr UL	(W/m²)/℃²	0.000	

Number of collectors		25	25
Solar collector area	m²	46.63	
Capacity	kW	30.10	
Miscellaneous losses	%	6.0%	

Balance of system & miscellaneous

Storage		Yes
Storage capacity / solar collector area	L/m²	6
Storage capacity	L	276.7
Heat exchanger	yes/no	Yes
Heat exchanger efficiency	%	80.0%
Miscellaneous losses	%	5.0%
Pump power / solar collector area	W/m²	10.00
Electricity rate	$/kWh	0.120

Summary

Electricity - pump	MWh	0.6
Heating delivered	MWh	12.4
Solar fraction	%	25%

Heating system

Project verification

	Base case	Proposed case
Fuel type	Oil (#6) - L	Oil (#6) - L
Seasonal efficiency	35%	35%

Fuel consumption - annual	L	12,581.9	9,424.6	L
Fuel rate	$/L	0.900	0.900	$/L
Fuel cost	$	11,324	8,482	

Emission Analysis

Base case electricity system (Baseline)		GHG emission factor (excl. T&D)	T&D losses	GHG emission factor
Country - region	Fuel type	tCO_2/MWh	%	tCO_2/MWh
Canada	All types	0.196		0.196

GHG emission

Base case	tCO_2	38.1			
Proposed case	tCO_2	28.7			
Gross annual GHG emission reduction	tCO_2	9.5			
GHG credits transaction fee	%				
Net annual GHG emission reduction	tCO_2	9.5	is equivalent to	19.6	Barrels of crude oil not consumed

GHG reduction income

GHG reduction credit rate	$/$tCO_2$	

Financial Analysis

Financial parameters

Inflation rate	%	2.0%
Project life	yr	20
Debt ratio	%	70%
Debt interest rate	%	5.00%
Debt term	yr	20

Initial costs			
Heating system	$	18,650	82.3%
Other	$	4,000	17.7%
Total initial costs	$	22,650	100.0%
Incentives and grants	$		0.0%
Annual costs and debt payments			
O&M (savings) costs	$	1,000	
Fuel cost - proposed case	$	8,551	
Debt payments - 20 yrs	$	1,272	
Other	$		
Total annual costs	$	10,823	
Annual savings and income			
Fuel cost - base case	$	11,324	
Other	$		
Total annual savings and income	$	11,324	
Financial viability			
Pre-tax IRR - equity	%	10.0%	
Pre-tax IRR - assets	%	-1.6%	
Simple payback	yr	12.8	
Equity payback	yr	9.7	