REGION OF DURHAM EFFICIENT COMMUNITY

FINAL REPORT

MAY 2008

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Mississauga, Ontario

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This study has been produced with the assistance of the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the author(s), and the Government of Canada and the Federation of Canadian Municipalities accept no responsibility for them.

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EXECUTIVE SUMMARY

The Region of Durham, located immediately east of Toronto, is experiencing growing demands for water and energy related to the significant economic development and population growth in the Region. In an effort to manage this growth more efficiently, the Region, in conjunction with Tribute Communities[1], Natural Resources Canada (NRCan), and the Federation of Canadian Municipalities (FCM), completed a project to quantify the potential water, energy, gas, and CO_2 savings that could be achieved if home builders in the Region began including efficient fixtures, appliances, and landscape designs in their new home packages.

A total of 175 homes participated in this study. Upgrades included efficient clothes washers, dishwashers, toilets, showerheads, fridges, and landscape packages. Approximately half of the homes received the upgraded package (Study Group), while the other half received the typical fixture and appliance package offered by the builder (Control Group). The main water, gas, and electricity meters for all 175 homes were read semi-monthly for one year.

Ten homes in each of the Study and Control Groups had sub-meters and data loggers installed on fixtures and appliances to segregate electricity, water, and gas demands within the home.

The average water, electricity, natural gas, and CO2 savings achieved by the Study homes in this research project were significant.

- **Water Savings:** **132 L/day per household (22.3%)**
- **Electricity Savings:** **2.6 kWh/day per household (13%)**
- **Natural Gas Savings:** **0.59 m3/day per household (9.1%)**
- **CO_2 reduction:** **1.19 tonnes / year per household (10.7%)**

While savings directly related to the use of efficient fixtures and appliances was expected and achieved, a significant portion of the savings identified in this study was related to homeowners practicing efficient water and energy use habits.
The annual utility cost savings for the Study homes is projected to be slightly more than $200 per year, and the payback period associated with providing the upgraded package was calculated as only 3.4 years.

This study shows that it is both cost-effective and environmentally responsible for new home builders to begin including only water-efficient fixtures, appliances, and landscape packages in their new home designs – the homeowner wins, the Region wins, and, perhaps more importantly, the environment wins.

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[1] http://www.tributecommunities.com/

1.0 INTRODUCTION

The Region of Durham is experiencing the increasing demands for water and energy that are associated with significant economic development and population growth. Linked to this type of growth is a need for costly infrastructure expansion. The Region of Durham has recognized that improving the overall water and energy efficiency of their population will have three significant impacts:

- It will reduce or defer the need for capital expenditures related to infrastructure expansion,
- It will help maintain the Region's position as one of Canada's most proactive municipalities regarding water efficiency, and
- Perhaps most importantly, it will help reduce the Region's environmental footprint.

In other words, improving efficiency within the Region is not only considered cost-effective and a best management practice, it is also considered environmentally responsible.

This research project was initiated by Durham Region in conjunction with Tribute Communities[2], Natural Resources Canada (NRCan), and the Federation of Canadian Municipalities (FCM), to assess the potential to improve efficiency in new homes by offering buyers a *high-efficiency upgrade* option. The location of this "efficient community" was within Tribute's *Hamlet* development at the junction of Audley and Taunton Roads in Ajax Ontario. The upgrade included efficient plumbing fixtures (toilets and showerheads), ENERGY STAR® appliances, and drought-tolerant landscaping packages.

OBJECTIVE: To quantify the water, energy, natural gas, and CO_2 reductions related to the installation of efficiency fixtures and appliances in new homes.

[2] http://www.tributecommunities.com/

2.0 RESEARCH METHODOLOGY

The goal of the project was to evaluate and quantify the impact that installing efficient fixtures and appliances (vs. builder's models) in new homes could have on residential water and energy demands and, therefore, on the environment.

A total of 175 homes participated in this study – 85 homes in the Control Group and 90 homes in the Study Group[3]. The Study Group homes received the upgrade package; the Control Group homes received the builder's typical fixtures and appliances[4].

Electricity, water, and gas meters for all 175 homes were read semi-monthly for one year. Detailed water and energy demand data was obtained by installing sub-meters and data loggers in 10 homes in each of the Study and Control Groups (Sub-Metered Homes). Radio frequency (RF) sub-meters were used to facilitate easier and more frequent downloading.

Hose Bibb Sub-metering

Water sub-meters were installed on:

- water heater inlet (record total hot water demand),
- clothes washer hot water supply,
- clothes washer cold water supply,
- dishwasher, and
- front and rear outdoor hose bibbs.

Electrical Sub-metering

Energy sub-meters were installed on:

- fridge,
- range[5],
- dishwasher,
- clothes washer, and
- clothes dryer.

It was important to collect sub-metered data as part of this project to better assess savings related to individual fixtures and appliances as the savings identified by ENERGY STAR appliances are currently based on manufacturer-supplied data and not on actual field data.

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[3] The original intention was to have the same number of homes in each group, however, the process of garnering participation is not an exact science.
[4] A small percentage of homeowners supplied their own appliances. The effect of a few self-supplied appliances on the overall water and energy savings is expected to be minimal.
[5] Same model used by both Groups. There is currently no ENERGY STAR qualified range.

3.0 DATA ANALYSIS

Data was collected from October 2006 to August 2007. While overall water and energy savings related to the installation of the upgraded fixtures and appliances in this study have been determined by comparing demands in the relatively large number of non-sub-metered Control and Study homes, the savings related to individual fixtures and appliances are based on the detailed data collected only in sub-metered homes.

3.1 OVERALL WATER CONSUMPTION

Domestic water consumption is influenced both by lifestyle (personal habits, showering frequency/duration, laundry frequency, irrigation practices, etc.) and the technology used (type of toilet, showerhead, clothes washer, etc.). Typically, about 75% of indoor water use is related to just three elements: toilet flushing (31%), laundry (25%), and showers (19%)[6]. Unlike toilets and clothes washers, however, shower preference is highly personal and there is no "one size fits all" when it comes to selecting efficient showerheads. Fortunately, all showerheads used by home builders meet the Ontario building code requirement of having a maximum flow rate of 9.5 litres per minute (Lpm). The Study homes received what would be considered upgraded 9.5 Lpm showerheads (Niagara Conservation's *Earth* showerhead). Theoretically, a "better" showerhead would provide a higher level of performance without increasing the flow rate, saving water and energy by reducing the length of time participants spend in the shower. Water and energy use related to showering was not monitored as part of this study.

Identifying the real water and energy savings available to new home construction is important in terms of planning future developments and home construction.

[6] Aquacraft, Residential End Use Study, http://bcn.boulder.co.us/basin/local/heaney.html - household leakage not considered (accessed October 2007).

3.1.1 NON-SUB-METERED HOUSEHOLDS:

Water demand data was collected via reading each home's main water meter from October 1, 2006 until August 7, 2007. Table 1 below identifies the overall average daily water demands, the base (winter) demands, and the summer demands of the non-sub-metered homes. Although the outdoor (or, more precisely, seasonal) water demands in the Study Group are slightly greater than the corresponding demands in the Control Group, the Study Group of homes used significantly less water overall.

Table 1 - Average Daily Water Demands – Non-Sub-Metered Homes

Group	Overall	Nov. – Apr. (base)	May - Aug. (summer)	Outdoor Use
Control	632	591	695	104
Study	504	456	577	121
Savings	128	135	118	-17

Table 2a and 2b below include the number of persons per household (based on survey data) and illustrate seasonal water demands in litres per capita per day (Lcd).

Table 2a - Average Indoor Demands – Non-Sub-Metered Homes

Group	Indoor Demands (Nov. – Apr.)	pph	Lcd
Control	591	3.1	190
Study	456	3.1	147
Savings	135		43

Table 2b - Average Outdoor Demands – Non-Sub-Metered Homes

Group	Outdoor Demands (May – Aug.)	pph	Lcd
Control	104	3.1	33.5
Study	121	3.1	39.0
Savings	-17		-5.5

3.1.2 SUB-METERED HOUSEHOLDS[7]:

Water demand data for the sub-metered homes was collected from November 1, 2006 until August 31, 2007[8]. Table 3 identifies the overall average daily water demands, the base (winter) demands, and the summer demands of the non-sub-metered homes. The water demands of the sub-metered homes that selected the upgrade package (Study homes) are consistently lower than the demands of the non-upgraded homes.

Table 3 - Average Daily Water Demands, Sub-Metered Homes

Group	Overall	Nov. – Apr. (base)	May - Aug. (summer)	Outdoor Use
Control	581	511	703	192
Study	441	396	519	123
Savings	140	115	184	69

Table 4a and 4b below include the number of persons per household (based on survey data) and illustrate seasonal water demands in litres per capita per day (Lcd).

Table 4a - Average Indoor Demands – Sub-Metered Homes

Group	Indoor Demands (Nov. – Apr.)	pph	Lcd
Control	511	2.50	204
Study	396	2.86	138
Savings	115		84

Table 4b - Average Outdoor Demands – Sub-Metered Homes

Group	Outdoor Demands (May – Aug.)	pph	Lcd
Control	192	2.50	76.8
Study	123	2.86	43.0
Savings	69		33.8

[7] Outliers (i.e., data points that are considered erroneous) have been removed

[8] Data collection commenced in September 2006, however, the data collection process was not finalized until the beginning of November 2006.

Table 2b and Table 4b illustrate that the per capita outdoor water demands in the Study areas are similar in both the sub-metered and non-sub-metered homes, whereas the outdoor demands in the non-sub-metered Control homes are less than half of those in the sub-metered homes. The reason for the relatively low outdoor water demands in the non-sub-metered Control group of homes is not known.

3.2 INDOOR VS. OUTDOOR DEMANDS

As identified above, both Study and Control homes have higher water demands during the summer months because of lawn watering, car washing, etc. The Study homes in this project received a landscape package for their front garden consisting of a single drought tolerant tree, several drought tolerant shrubs, as well as several varieties of hardy perennials. The Control homes received the standard builder-grade front garden consisting simply of non-drought-tolerant shrubs.

Outdoor water demands are often calculated as the difference between demands during winter and summer months (see Table 1 and Table 3 above). To obtain a more precise value for outdoor water use in the sub-metered homes, the front and rear hose bibbs of were metered[9] and logged. Table 5 below compares the outdoor demand in the sub-metered homes using both of these methodologies.

Table 5 - Average Indoor & Outdoor Demands – Litres per Day per Home

Sub-Metered Homes	Nov. – Apr. (winter)	May – Aug. (summer)	Calculated Outdoor Demand	Metered Outdoor Demand
Control Group	511	703	192	198
Study Group	396	519	123	121

As can be seen, the value obtained for outdoor water use was very similar using both of these methodologies. What's more, Study homes used only about 60% as much outdoor water as Control homes. Whether the reduced outdoor water use by the Study homes is related to the difference in landscape packages or to the watering habits of the homes involved – or both - was not verified as part of this project.

[9] The hose bibb meters were installed inside the home, hidden between floor joists as to be out sight.

3.3 WATER HEATER

The data analysis covers the time period of November 1, 2006 to August 31, 2007. The total volume of hot water used by the participating sub-metered households was measured via a sub-meter installed on the inlet to the home's water heater. Hot water demands in the Study homes were expected to be lower than those of the Control homes because of the installation of an efficient clothes washer, premium showerhead, and premium dishwasher. The results of hot water consumption through this period are summarized in Table 6. Hot water accounted for about 36 percentage of total water demand in the Control homes and about 42 percent in the Study homes.

Table 6 - Average Hot Water Demands – Litres per Day per Home

Group	Hot Water Demand	Savings	Percentage Savings
Control	184	17	9.2%
Study	167		

3.4 CLOTHES WASHER

3.4.1 COLD WATER USE – CLOTHES WASHER

The volume of cold water used to wash clothes was recorded in the sub-metered homes from November 1, 2006 to August 31, 2007. The results for the monitoring period are presented in Table 7 below. Cold water clothes washing demands account for about 20 percent of total indoor water demands in the Control homes and about 15 percent in the Study homes.

Table 7 - Clothes Washer Cold Water – Litres per Day per Home

Group	Cold Water Demand L/d/H	Savings L/d/H	Percentage Savings
Control	102	42	41%
Study	60		

3.4.2 HOT WATER USE – CLOTHES WASHER

The volume of hot water used to wash clothes was recorded in the sub-metered homes from November 1, 2006 to August 31, 2007. The results for the monitoring are presented in Table 8 below. Hot water clothes washer demands account for about 3.1 percent of total indoor water demands in the Control homes and about 2.5 percent in the Study homes. As can be seen by comparing Table 7 and Table 8, participants used far less hot water than cold water to wash clothes.

Table 8 - Clothes Washer Hot Water - Litres per Day per Home

Group	Hot Water Demand L/d/H	Savings L/d/H	Percentage Savings
Control	16	6	38%
Study	10		

3.4.3 TOTAL WATER USE – CLOTHES WASHER

The total water demand for the clothes washer is the sum of hot and cold water demands, as presented in Table 9.

Table 9 - Total Clothes Washer Water - Litres per Day per Home

Group	Cold Water	Hot Water	Total Clothes Washer	Savings	Percent Savings
Control	102	16	118	48	41%
Study	60	10	70		

- These results are similar to the predicted savings achieved by "ENERGY STAR" qualified clothes washers[10], i.e., between 35 to 50 percent water savings vs. conventional top-loading washers.

[10] Office of energy efficiency: www.oee.nrcan.gc.ca/publiccations/infosource/pub/appliances/2007/page10.cfm?attr=4 accessed October 2007)

3.5 DISHWASHER:

The volume of hot water used by the dishwasher was recorded in the sub-metered homes and is illustrated in Table 10 below (note that there is no cold water supply to residential dishwashers). Hot water dishwasher demands account for about 1.3 percent of total indoor water demands in the Control homes and about 3.4 percent in the Study homes.

Table 10 - Dishwasher Water Demands - Litres per Day per Home

Group	Hot Water	Savings	Percentage Savings
Control	6.7	-6.8	-50.4%
Study	13.5		

The results show that dishwasher demand was actually greater in the Study homes. Section 4.6 shows that the energy demands related to dishwasher use are also greater in the Study home. The reason for higher dishwasher use in Study homes is not known but may be related to: 1) people with a high level of interest in efficiency, i.e., people in the Study area, eat a greater number of meals at home (vs. at restaurants) than people in the Control area and, therefore, use the dishwasher more often, or 2) people in the Study area are aware that using the dishwasher can be a more efficient way of cleaning dishes than by hand washing and, therefore use the dishwasher more often.

3.6 TOILETS

While all new homes constructed in Ontario are required to be fitted with toilets that flush with no more than six liters of water, it is not uncommon for builders to install toilet models that provide marginal performance at best. Toilets that perform poorly can result in people changing their flushing habits in an attempt to improve performance, e.g., they may hold the flush handle longer to increase the flush volume or they may double-flush more often.

While homes in the Control Group were fitted with typical builder-grade toilets, homes in the Study Group were fitted with one high-performance six litre per flush toilet[11] and

[11] Performance levels determined via the Maximum Performance (MaP) Testing program for toilets.

one of two types of High-Efficiency Toilets (HETs). HETs have an effective flush volume of no more than 4.8 liters[12]. These HET toilets are described as follows:

- 4-litre Pressure-Assist: In traditional residential toilets water stored in the toilet tank is released via gravity into the bowl when the user activates the flush handle. Regardless of the water pressure of the water supply to the toilet, all of the energy available to flush the waste is provided by the difference in elevation between the water level in the tank and the water level in the bowl (approximately 0.5 PSI). Pressure-assist toilets take advantage of the water supply pressure by storing the water used for flushing in an air-tight pressure vessel, e.g., if the water is supplied at 50 PSI the water pressure in the pressure vessel will also be 50 PSI. Because pressure-assisted toilets take advantage of the "free" energy available in the pressurized water supply they are able to flush with less water and still achieve high-performance results. The pressure-assisted toilet models used in this project flushed with only four liters of water. Pressure-assisted toilets were installed in the second floor washrooms of 48 homes.

- The remaining second floor bathrooms were outfitted with high-performance 6-litre toilets[13] that cost about the same as the builder standard toilet. It is hoped that the improved performance of this toilet will yield further water savings and offer the builder insight into the efficacy of installing better quality fixtures. Better performing toilets should reduce customer callbacks and increase buyer satisfaction at little or no additional cost to the builder.

- A total of 48 four-litre pressure-assisted toilets were installed and 23 six-litre high-performance toilets were installed. On average, these toilets use 4.65 liters per flush (Lpf), calculated as follows:

  (48 units x 4.0-Lpf + 23 units x 6-Lpf) ÷ (48 + 23) = 4.65 Lpf

- Dual-Flush: This type of toilet has been popular in Europe for many years and is even mandated in Australia and Singapore. Because it takes less energy (and therefore less water) to flush liquids vs. solids, this type of toilet offers the user a choice between flush volumes: a full six liters to flush solid waste and a reduced three liters to flush liquid waste. Based on a ratio of two reduced flushes for every full flush, the effective flush volume of a 6-L/3-L dual-flush toilet is

[12] The "effective flush volume" of a single-flush toilet is simply the measured flush volume, and for a dual-flush toilet is the mathematical average of two reduced flushes plus one full flush.
[13] Performance based on MaP testing scores.

approximately 4 liters. Dual-flush toilets were installed in all first floor powder rooms and in the sole second floor bathrooms of three of the Study homes because it was expected that these washrooms would experience a large percentage of "liquid" flushes.

Previous monitoring studies[14] have determined that residential toilets are flushed an average of approximately five times per day per person. The average occupancy of the non-sub-metered homes in both the Control and Study Groups was 3.1 persons. This analysis assumes that HETs and 6-L models are flushed equally, thereby providing an average flush volume of 5.325 litres. An expected water savings of 10.5 liters per home in the Study Group of homes is calculated as follows:

<u>Control Group:</u>
3.1 persons x 5 flushes/day x 6 liters per flush = 93 liters per homes per day

<u>Study Group:</u>
3.1 persons x 5 flushes/day x 5.325 litres= 82.5 liters per homes per day

<u>Savings:</u>
(93 – 82.5) liters per home per day = 10.5 liters per home per day

3.7 WATER SAVINGS SUMMARY

The data analysis for the sub-metered homes indicates that participants in the Study area are saving about 66 litres per capita per day indoors (during non-irrigation months) and 34 litres per capita per day outdoors (during summer months)[15]. In the non-sub-metered Study homes indoor savings were slightly less at 43 litres per capita per day while outdoor water demands were actually greater at about 39 litres per capita per day.

Of course, weather conditions can change significantly from year to year – subsequent summers may be much hotter and dryer or much cooler and wetter. As such, the outdoor savings of between 34 - 39 litres per capita per day achieved in the Study homes should be viewed as an indication only and not a guarantee of future savings.

[14] One example is the AWWA RF Residential End Use Study by Aquacraft.
[15] The 34 Lcd savings is calculated based on data collected via sub-metering the hose bibbs.

Water savings achieved in the sub-metered homes are summarized in Table 11 below.

Table 11 - Indoor Water Demands & Savings: Sub-metered homes - liters/day

	Overall Demands	Hot Water Total	Clothes Washer (cold)	Clothes Washer (hot)	Clothes Washer (combined)	Dishwasher (hot)	Toilet
Control Group	511	193	102	16	118	6.8[16]	90.0
Study Group	396	176	60	10	70	13.5[17]	79.5
Volumetric Savings	115	17	42	6	48	-6.7	10.5
Percentage Savings	**22.5%**	**8.8%**	**40.4%**	**37.5%**	**40.7%**	**-50%**	**11.7%**

The volume of indoor water savings achieved by the sub-metered homes is slightly less than that achieved by the non-sub-metered group of homes (115 litres vs. 135 litres respectively), however, the per capita savings is greater (66 Lcd vs. 44 Lcd respectively).

Of the total **115** liters saved per household per day in the sub-metered Study homes, only **51.8** liters (45 percent) can be directly attributed to the installation of the efficient fixtures and appliances. The remaining **63.2** liters may be related to the upgraded showerhead given to the Study Group, the result of an increased awareness of water efficiency by homeowners participating in the Study group, or it may be the result of something else. Information gathered during the homeowner interviews completed at the end of the monitoring period did not clearly indicate the reason behind these additional savings.

While it was hoped at the outset of this project that the projected water savings (from the installation of efficient fixtures and appliances) would be verified by the metering and monitoring program, it was not expected that the savings achieved would be far greater than projected. More than half of the water savings achieved in this project appears to be from changes in participant lifestyle and habits vs. improvements in technology. These results are very positive and indicate that the potential to reduce water and energy demands is even greater than we anticipated.

[16] equates to 1.3% of total household indoor water consumption
[17] equates to 3.4% of total household indoor water consumption

4.0 ENERGY DEMANDS

Modern homes contain a wide variety of electrical appliances, each with an associated electrical demand. As energy costs continue to increase and people become more and more aware of the effect that unchecked energy demands can have on our environment, there is a growing demand for energy efficient fixtures and appliances. One program that was initiated to identify and promote energy efficient fixtures and appliances was the U.S. EPA's ENERGY STAR® program. This program is administered by NRCan in Canada.

Appliances typically have life spans ranging from 13 years for a dishwasher to 21 years for a freezer[18]. As such, the energy savings over the life of the appliance can be significant. This project compared the energy demands in the upgraded Study homes with the energy demands in the Control homes.

4.1 ENERGY DEMAND; NON-SUB-METERED HOMES

Energy consumption in the non-sub-metered homes was monitored from October 1, 2006 to August 7, 2007. The data analysis revealed the Study Group of homes consumed approximately 13% less energy than the Control Group of homes during this period (see Table 12 below), even though there were 2.86 persons per home in the Study Group and only 2.50 persons per home in the Control Group.

Table 12 - Average Energy Demands: Non-Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	19.8
Study	17.2
Savings	2.6 (13.1%)

[18] Source: Office of Energy Efficiency, Natural Resources Canada (accessed October2007) at http://one.nrcan.gc.ca/publications/infosource/pub/appliances/2007/page4.cfm?attr=4life_expectency

4.2 ENERGY CONSUMPTION SUB-METERED HOMES

Energy consumption in the sub-metered homes was also monitored from October 1, 2006 to August 7, 2007. Average household energy demands were similar in both the sub-metered and non-sub-metered homes. The data analysis revealed the Study Group of homes consumed approximately 19% less energy than the Control Group of homes (see Table 13).

Table 13 - Average Energy Demands: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	20.9
Study	17.0
Savings	3.9 (18.7%)

4.3 CLOTHES WASHER ENERGY DEMAND

Clothes washer energy demands are presented in Table 14 below.

Table 14 - Energy Demands: Clothes Washer: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	0.21
Study	0.11
Savings	0.10 (47.6%)

The savings agree with predicted savings of between 40 and 50 percent, although the actual cost savings per year (about 36 kWh) related to the reduced energy demands of front-loading washers is quite small[19].

[19] A software program produced by a major clothes washer manufacturer estimates an energy savings of approximately 46%, or almost exactly what was achieved in this study

4.4 CLOTHES DRYER ENERGY DEMAND

Clothes dryer energy demands are presented in Table 15 below.

Table 15 - Clothes Dryer Energy Use: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	2.36
Study	1.84
Savings	0.52 (22.0%)

Front-loading clothes washers have much faster spin rates than top-loading machines. As such, clothes are dryer when removed from front-loading washers and require less time in the clothes dryer. The energy savings because of the shorter drying times is approximately ten times greater than the energy saved by the clothes washer itself[20].

4.5 STOVE ENERGY DEMAND

At this time there is no such thing as an Energy Star rated stove, as such, the same model stove was installed in both the Study and Control homes. On average, the stoves in the Study homes were used slightly more than the stoves in the Control homes (Table 16 below). The reason for higher energy demands related to stove use in the Study homes is not known but, as was postulated earlier, may be related to people in the Study group eating more meals in their home (vs. restaurants) than people in the Control group of homes.

Table 16 - Stove Energy Use: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	1.02
Study	1.12
Savings	-0.10 (-9.8%)

[20] A software program produced by a major clothes washer manufacturer estimates an energy savings of approximately 22%, which agrees with what was achieved in this study

4.6 DISHWASHER ENERGY DEMAND

Dishwasher energy demands are presented in Table 17 below.

Table 17 - Dishwasher Energy Use: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	0.29
Study	0.41
Savings	-0.12 (-41%)

Energy demands related to dishwasher use are greater in the Study group of homes. As stated earlier, greater dishwasher use and greater stove use in the Study homes indicate that people in the Study group eat 'in house' more often than their counterparts in the Control group. The NRCan website indicates that Canadians have reduced dishwasher use in recent years and now wash an average of approximately 215 loads per year.

The dishwasher energy use identified above includes only the motor energy used during washing and the drying energy used during power drying, but does not include energy related to heating the water used by the washer. The energy used to provide hot water to the dishwasher (which is a component of natural gas demands, Section 5.0) may be as much or more than the energy used to operate the pump and dry the dishes. As such, the dishwasher energy demands identified in Table 17 are significantly less than the energy use predicted on the NRCan website.

4.7 FRIDGE ENERGY DEMAND

Fridge energy demands are presented in Table 18 below.

Table 18 - Fridge Energy Use: Sub-Metered Homes

Group of Homes	Average Energy Demands kWh per household per day
Control	1.53
Study	1.30
Savings	0.23 (15%)

While fridges in the Study homes used less energy than the units installed in the Control homes, both groups of homes used slightly more than the 1.21 kWh per day value identified by NRCan for energy efficient fridge models.

4.8 ACTUAL VS. PROJECTED SAVINGS

The following table identifies the average daily energy demands of the sub-metered appliances in this study along with an estimate of the expected energy demands based on data from National Resources Canada (NRCan).

Table 19 - Energy demand & Savings: Sub-metered homes: kWh/home/Day

	Main Meter	Clothes Washer	Dryer	Dishwasher[21]	Fridge	Stove
Control Group	20.9	0.21	2.36	0.29	1.53	**1.02**
Study Group	17.0	0.11	1.84	0.41	1.30	**1.12**
kWh Savings	3.9	0.10	0.52	-0.12	0.23	**-0.12**
% Savings	**19%**	**48%**	**22%**	**-41%**	**15%**	**-9.8%[22]**
Standard	-	0.20[23]	2.51	1.25[24]	1.41	**2.01**
NRCan - Efficient	**-**	**0.11[25]**	**2.51**	**1.17[26]**	**1.21**	**2.01**

As can be seen in Table 20, average total energy savings in the sub-metered Study homes was 3.9 kWh per day, or 19 percent saving vs. the Control Group. Average energy savings in the non-sub-metered Study Group was slightly less at 2.6 kWh per day or about 13 percent vs. the Control Group.

Table 20 - Energy Demands

Group	Sub-metered	Non-sub-metered
Control Group	20.9	19.8
Study Group	17.0	17.2
Savings m^3	3.9	2.6
Savings Percentage	**19%**	**13%**

[21] Note that the energy demand data does not seem to correlate with the water demand data for the dishwasher, i.e., the energy demand seems to be only 20-25% as high as it is expected to be.
[22] Note that the same model of stove was used in all homes.
[23] Based on calculator spreadsheet developed by Maytag Appliances, assumes one load per day.
[24] http://www.oee.nrcan.gc.ca/publications/infosource/pub/appliances/2007/page9.cfm?attr=4
[25] Ibid
[26] As stated earlier, the energy demand identified by sub-metering dishwashers does not include the energy used to heat the water supplied to the washer, whereas the NRCan value does include this energy.

It is interesting to note that, like the water savings, the total average energy savings achieved in the Study Group is far greater than can be explained via the installation of the efficient appliances. For example, the clothes washer, dryer, and fridge combine for a savings of 0.85 kWh per day, whereas the stove and the dishwasher combine for a *negative* 0.24 kWh per day. When the savings from all of the appliances are combined the net result is an average savings of 0.61 kWh per day per home – far less than the 3.9 kWh per day savings achieved in the sub-metered Study homes or the 2.6 kWh per day savings achieved in the non-sub-metered homes.

In fact, the energy savings achieved by the installation of the efficient appliance package accounts for only about 16 – 24 percent of the total energy savings achieved by the sub-metered Study group of homes.

The reason for this "additional" savings has not been confirmed but may be related to a greater use of other efficient appliances and equipment (e.g., microwave, toaster, kettle, computer, lighting, etc.), to a higher level of energy-efficiency awareness in the Study group (e.g., they may be more prudent at turning off lights when they leave a room), to a combination of both, or to some other factor(s).

5.0 NATURAL GAS

The primary difference in natural gas demand between the Study and Control groups of homes was expected to be related to a reduction in hot water demand in the Study Group (i.e., less gas used to heat water for clothes and dish washing, and showering).

Table 21 - Natural gas demand (winter & summer months), m^3/day

Group	Sub-metered	Non-sub-metered
Control Group	7.43	6.50
Study Group	6.55	5.91
Savings m^3	0.88	0.59
Savings Percentage	**11.9%**	**9.1%**

It is estimated that it takes approximately 8.0m^3 of natural gas to heat to heat 1,000 litres of water by 50^o C. The total hot water savings in the Study homes of about 17 litres per day would theoretically save 0.14 m^3 of natural gas per day, whereas the average natural gas savings in the sub-metered and non-sub-metered homes is approximately 0.74 m^3 per day – much greater than can be explained via reduced hot water demands alone.

To eliminate the effects of increased natural gas use during the winter heating season (i.e., furnace use), an analysis was also completed on natural gas demands during the summer months only (table 22 below). The estimated gas savings related to reduced water heating accounts for almost half the gas savings observed in both the sub-metered and non-sub-metered Study homes during the summer months. Approximately 15 percent of the homes included in this study have natural gas ranges (stoves) – it is assumed that the remainder of the natural gas savings comes from reduced use of the range during the hot summer months – perhaps by eating out more frequently or via a greater use of the BBQ, though these assumptions have not been verified.

Table 22 - Natural gas demand (summer months only), m3/day

Group	Sub-metered	Non-sub-metered
Control Group	1.32	1.46
Study Group	1.02	1.16
Savings m^3	0.30	0.30
Savings Percentage	**23.3%**	**20.8%**

6.0 GREENHOUSE GAS SAVINGS

The estimated reduction in CO_2 emissions resulting from reduced energy, and natural gas demands in the Study group of homes is calculated based on the following conversions taken from the U.S. EPA website[27]:

- Energy Savings: 0.08 tonnes of CO_2 per 100 kWh of energy savings
- Natural Gas Savings[28]: 0.18 tonnes of CO_2 per 100 m^3 of gas savings

The estimated reduction in CO_2 emissions resulting from reduced water demands is based on the assumption that it takes approximately 1.0 kWh of electricity to treat, pump, and distribute 1.0 m^3 of water in a municipal system[29].

- Water Savings: 0.08 tonnes of CO_2 per 100 m^3 of water saved

The estimated reductions in CO_2 emissions achieved in the Study homes are illustrated in Table 23 below:

Table 23 - Average CO2 Reductions in Study Homes

Resource	CO^2 Savings Tonnes per Year
Water	
48.2 m^3 x 0.08 tonnes of CO_2 per 100 m^3	0.04
Electricity	
949 kWh x 0.08 tonnes of CO2 per 100 kWh	0.76
Natural Gas	
215 m^3 x 0.18 tonnes of CO_2 per 100 m^3	0.39
TOTAL	1.19

It has been estimated that the average Canadian produces about 3.7 tonnes of CO_2 per year within their home[30] - or roughly 11 tonnes per family of 3 per year. A savings of 1.19 tonnes of CO_2 per household per year equates to a savings of approximately 10.7 percent.

[27] http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html
[28] Based on conversion of 0.36 therms per 1.0m^3 of gas
[29] Via communications with City of Toronto and Region of Durham
[30] Wikipedia - http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions_per_capita

7.0 COST-EFFECTIVENESS

The average savings achieved by homes in the Study Group are identified in Table 24.

Table 24 - Daily and Annual Savings in Study Homes

Resource	Daily Savings	Annual Savings
Water Savings	132 L	48.2 m^3
Energy Savings	2.6 kWh	949 kWh
Natural Gas Savings	0.59 m^3	215 m^3

Water and sewer rates vary from municipality to municipality, and some water billing systems include meter or service charges which are not affected by changes in demands. As such, the cost-effectiveness calculations presented in this report should be viewed as an indication of savings only, and not a guarantee of savings.

Total cost of indoor fixture and appliance upgrades for homes in the Study Group was approximately $735, broken down roughly as follows:

- Clothes washer upgrade: $318
- Dryer upgrade: $160
- Refrigerator upgrade: $218
- Dishwasher upgrade: $39
- Toilet upgrade: minimal
- Showerhead upgrade: minimal

Total cost of outdoor plant upgrade for homes in the Study Group was approximately $100.

Utility costs in the Region of Durham are approximately as follows:

- Water & wastewater: $1.60 per m^3
- Electricity: $0.07 per kWh
- Natural Gas: $0.35 per m^3

Table 25 - Annual Cost Savings in Study Homes

Resource	Annual Resource Savings	Cost per Unit	Annual Cost Savings
Water Savings	48.2 m^3	$1.60 per m^3	$77.12
Energy Savings	949 kWh	$0.07 per kWh	$66.43
Natural Gas Savings	215 m^3	$0.35 per m^3	$75.25
Total Average Annual Savings per Study Home			**$218.80**

Payback period

- $735 one-time cost ÷ $218.80 savings per year = 3.4 year pay back.

8.0 CONCLUSION

The water, energy, and CO2 savings achieved by the Study homes in this research project are significant.

- **Water Savings: 132 L/day per household (22.3%)**
- **Energy Savings: 2.6 kWh/day per household (13%)**
- **Natural Gas Savings: 0.59 m3/day per household (9.1%)**
- **CO_2 reduction: 1.19 tonnes / year per household (10.7%)**

These savings were the result of two elements:

1. use of efficient fixtures, appliances, and gardens in the Study homes, and
2. efficient customer habits regarding water and energy use in the Study homes.

Since the homeowners that agreed to participate as Study homes were largely self-selected (i.e., they had a choice of whether or not they wished to participate in the program), it would not be surprising if their 'normal' water and energy use habits also reflected a level of efficiency greater than what would be expected by the general public. That said, the water and energy savings identified in both the sub-metered and non-sub-metered groups of homes was far greater than could be predicted based on the use of efficient fixtures and appliances alone.

These results clearly indicate that municipal efficiency improvement programs should promote both physical changes to fixtures, appliances, gardens, etc., through rebate and give-away promotions, as well as habitual changes regarding how these fixtures, appliances, and gardens are used (through education and outreach programs).

The calculated payback period associated with upgrading the Study homes is approximately 3.4 years. This payback period is very reasonable, especially when you consider that the efficient fixtures and appliances installed in these homes will last much longer than 3.4 years. After the 3.4 year period the homeowner will start to save more than $200 each year in utility costs.

The calculated reduction in CO_2 is about 10.7 percent vs. the average Canadian home. If all new home builders adopted the practice of providing upgraded water-efficient fixtures, appliances, and landscapes the CO_2 savings on a national basis would be significant.

Durham Region is a rapidly growing municipality. Improving the overall water and energy efficiency of the new homes being constructed in the Region will have three significant impacts:

- It will allow the Region to reduce the size of, or defer the need for, capital expenditures related to infrastructure expansion,
- It will help maintain the Region's position as one of Canada's most proactive municipalities regarding water efficiency, and
- It will help reduce the Region's growing environmental footprint.

The results of this project help quantify the potential for water, energy, natural gas, and CO_2 reductions related to the installation of efficiency fixtures and appliances in new homes. For example, while many Canadian references and websites identify indoor per capita demands of 250 litres per day or greater, this study has shown that demands of as low as 147 litres per capita per day can be achieved in new homes – a demand rate that challenges that of many European countries. What's more, with the potential to incorporate further efficiencies into new homes, such as hot water recirculation systems, rainwater harvesting systems, grey water harvesting systems, etc., this demand could be even further reduced.

I would be pleased to answer any questions about this report.

Sincerely,

Bill Gauley, P.Eng., Principal

Veritec Consulting Inc.

Appendix A

Upgraded Fixtures and Appliances

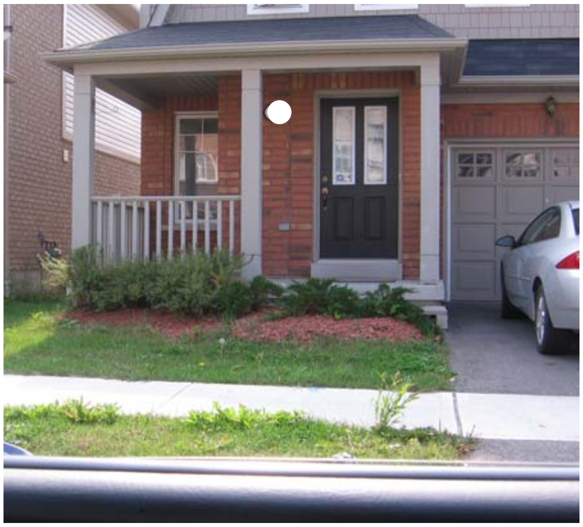
Water Efficient Toilets

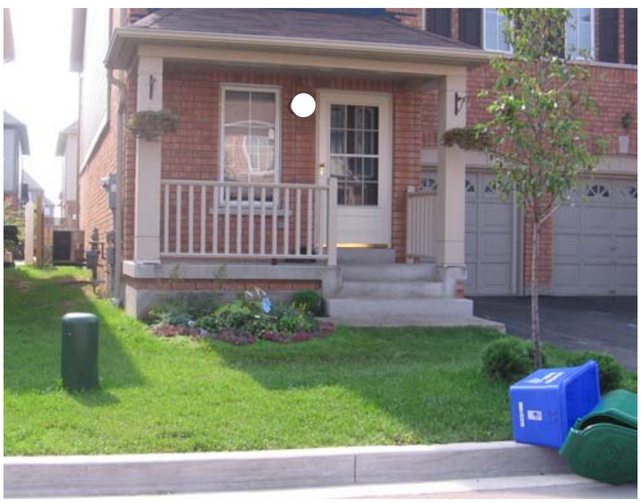
- Capizzi 4-L per flush pressure-assist
- Foremost Premier 6-litre per flush
- Caroma Tasman dual-flush (6L & 3L)

Energy Efficiency Appliances

Appliance	Manufacture	Model Number	Colour	Energy	Size	Misc.	Energy Star
Fridge	Frigidaire	FRT18HS6DW0	White	Electric	18cu.ft	Top Freezer	Yes
		FRT21P6CSB5	Stainless	Electric	21cu.ft	Top Freezer	Yes
		FRT18P6BSB4	Black	Electric	18cu.ft	Top Freezer	Yes
		FSC23R5DSB5	Stainless	Electric	23cu.ft	Side-by-side	Yes
Stove	Frigidaire	CFEF312CS2	White	Electric	30in	Electric burners	Yes
		CFEF372CB2	B / W	Electric	30in	Electric smooth top	Yes
		CFEF372BC2	Stainless	Electric	30in	Electric smooth top	Yes
		CFGF366DCB	Stainless	Gas	30in	Open Flame	Yes
		CFGF366CCB	B / W	Gas	30in	Open Flame	Yes
		CFGF337ASE	Black	Gas	30in	Open Flame	Yes
Dishwasher	Frigidaire	FDB750RCC0	Stainless	Electric	24in		Yes
		GLD3450RDS1	Black	Electric	24in		Yes
		GLD3450RDS0	White	Electric	24in		Yes
		FDB510LCS	White	Electric	24in		Yes
		FDB510LCB0	Black	Electirc	24in		Yes
Washer	Frigidaire	GLTF1240AS0	White	Electic		Front Loader	Yes
Dryer	Frigidaire	GLEQ332CAS2	White	Electic		Front Loader	Yes
		GLGQ64CAS4	White	Gas		Front Loader	Yes
Toilets	Caroma Tasman	Bowl: 609162	White	N/A		Round Bowl	HET
		Tank: 800032		N/A	6.0/3.0L	Dual Flush	
	Foremost Premier	Bowl: LL-8207	White	N/A		Round Bowl	
		Tank: T-8207		N/A	6.0L	Gravity	
	Capizzi, Turbo Capizzi	Bowl: 0778-1	White	N/A		Elongated Bowl	HET
		Tank: 1277		N/A	4.0L	Pressure Assist	
	Eljer Toronto Savoy	Bowl: 131-2120	White	N/A		Round Bowl	
		Tank: 141-0220		N/A	6.0L	Gravity	
Showerhead	Niagara	N2925N	White	N/A	2.35GPM		Yes

Appendix B - Typical Control Homes





Appendix B - Typical Study Homes